retaste

RETHINK food resources, losses, and waste

Athens, September 27-29, 2023

Hellenic Mediterranean University

RETASTE 2023 is co-organized by Harokopio University

RETASTE 2023 is organized with the financial support of the External Actions Program 2023 of the Green Fund.

GREEN FUND

RETASTE:

Rethink Food Resources, Losses, and Waste

3rd International Conference

Athens, September 27-29, 2023

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The Mission of RETASTE

The global food chain system is the single largest source of greenhouse gasses in the world, and the largest cause of biodiversity loss, terrestrial ecosystem destruction, freshwater consumption, and waterway pollution due to the mismanagement of biocides and nutrients. On top of these deficiencies, approximately 40% of all produced food is wasted throughout the farm to fork processes, while more than 900 million people remain undernourished.

Thus the margin for improvement of the global food chain system is huge, and may unlock pathways towards the stability of the Earth system and the future of humanity. Against this background, the **RETASTE** Conference initiates the dialogue for innovative solutions and optimization schemes that exploit significant opportunities for food waste reduction, reuse, and recycling at all stages of the food life cycle, as well as their scalability and commercial translatability. In parallel, **RETASTE** aims to address the social aspects of food waste issues, as well as to highlight ways to tackle social and perception barriers against reducing our environmental footprint, thus shifting the evolving future of social, market, and global megatrends.

Through the conservation of resources, the strengthening of the social fabric, and the development of new value chains, **RETASTE** supports the implementation of Circular Economy concept.

The audience of **RETASTE** includes academia, industry, and stakeholders, and is truly transdisciplinary as the topics of the conference dictate.

Join us to Rethink Food Waste!

The presidents of the RETASTE Organizing Committee,

Katia Lasaridi

Professor
Harokopio University

Thrassyvoulos Manios

Professor
Hellenic Mediterranean University

The Municipality of Halandri (Dimos Chalandriou, Greek: Χαλάνδρι, Ancient Greek: Φλύα, Phlya) is one of the northern suburbs of the Athenian metropolitan area. Its population is approximately 74.000 inhabitants. Home to numerous Small Business Enterprises (SBEs) ranging from restaurants to all day café bistros, Halandri is known for its bustling commercial center. It is also known for its idyllic countryside spots, mainly the “Rematia '' where visitors and citizens may enjoy the accessible riverbank. This mixture of urban and rural environment constitutes the Municipality of Halandri as one of the most desired places to live in Athens.

The public authority of Halandri is dedicated to constantly improving the quality of everyday life of its citizens. For this reason, the public authority constantly supports and expands its solidarity, humanitarian and sustainable development actions by making use of multiple financial supporting tools (EU and national funding schemes) as well as by carrying out societal research and developing citizen engagement hubs. The Municipality is currently participating in three EU funded research projects, HORIZON 2020 FoodRUs, Horizon ToNoWaste and Erasmus+ Food Connections that focus on food waste prevention and management. In the past the EU Horizon Waste4Think project was successfully implemented in Halandri in (2016-2020). During Waste4Think it was proven that household food waste can be collected separately and subsequently utilized in a number of ways, thus lightening the burden of urban waste management. The product FORBI that was produced in Waste4Think has been successfully tested as an alternative fuel for cement producers and has also been used as a composting enhancer and for the production of bioCNG via anaerobic digestion.

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The International Conference Rethink Food Resources, Losses, and Waste is organized with the financial support of the External Actions Program 2023 of the Green Fund.

Keynote speakers

Katia Lasaridi

Professor, Department of Geography, Harokopio University

Katia Lasaridi is Professor in Environmental Management and Technology at Harokopio University, Athens, Greece. She works on all aspects of waste management in the context of Circular Economy with emphasis on food waste prevention, valorization and treatment, WEEE management, and Extended Producer Responsibility (EPR), where she has extensive research and consultancy experience. She has served as President of the Board of the Hellenic Recycling Agency, and in Harokopio University as member of the Governing Board, Deputy Rector, and Head of the Geography Department. She is currently member of the Scientific Committee of the Hellenic Institute of Local Authorities.

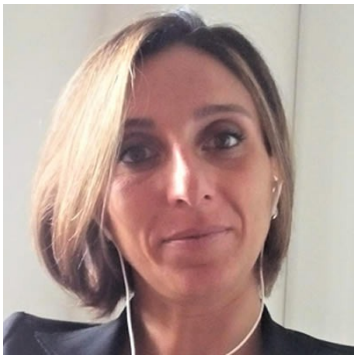
Thrassyvoulos Manios

Professor, Hellenic Mediterranean University, Heraklion, Greece

Thrassyvoulos Manios is Professor at the Department of Agriculture, Hellenic Mediterranean University and Vice-Rector of Finance, Planning and Development of the Institute. With a degree in Agricultural Biology and Biotechnology (Agricultural University of Athens), Chemical Engineering (University of Patras) and a Doctoral -Degree in Environmental Engineering (University of Leeds), his research interests include management and treatment of biowaste and wastewater. To date he has more than 85 publications in international scientific journals, 150 presentations in international conferences, and has managed more than 35 research projects, funded with over 10 million euros.

Clara Cicatiello

Assistant Professor, Department for Innovation in Biological Systems, Food and Forestry, University of Tuscia



Tenure track Assistant Professor of agricultural economics at University of Tuscia, Viterbo, Italy, since 2022. Formerly, fixed term assistant professor and research assistant at different departments of the same university. PhD in Economics and Local Development (obtained in 2012) with a background of agricultural studies. Coordinator of a consortium of 27 partners in the ongoing H2020 project LOWINFOOD, focusing on the demonstration of innovations for food loss and waste prevention. Research areas include the sustainability of food supply chains and food loss and waste prevention at different levels of the chain, with an applied approach and several long-term collaborations with actors of Italian food chains. Lecturer of Food marketing and Food economics. Member of the organising committee of the international summer school “Design of sustainable food systems”. Author of 34 Scopus-indexed articles, counting about 750 citations and a h-index of 15.

Gerasimos Lyberatos

Professor, School of Chemical Engineering National Technical University of Athens, Greece

Prof. Gerasimos Lyberatos is currently Professor in the School of Chemical Engineering, National Technical University of Athens and a collaborating faculty member of the Institute of Chemical Engineering and High Temperature Chemical Processes (Foundation of Research and Technology Hellas). He obtained his B.S. at M.I.T. and his M.S. and Ph.D. at CALTECH (USA). His research interests are in Biochemical Engineering and Environmental Technologies for liquid and solid waste treatment and valorization. He has over 240 publications in International refereed Journals, and over 330 participations in International Conferences, 9 Chapters in books and two books. He has supervised 45 PhD theses. He has organized three International Conferences. Prof. Lyberatos has been Editor of the Journal of Hazardous Materials (Elsevier) and Associate Editor of Waste and Biomass Valorization (Springer). Since 2014 Professor Lyberatos has also served as City Counselor for the Municipality of Halandri.

Despina Papanikolaou

Head of Animal By-Product Department of Veterinary Public Health Directorate. Hellenic Ministry of Rural Development and Food

Despina Papanikolaou is Veterinarian Hygienist and Head of Animal By-Product Department of Veterinary Public Health Directorate in Veterinary Services General Directorate at the Hellenic Ministry of Rural Development and Food (MRDF). She studied the Veterinary Science at Aristotle University of Thessaloniki and has also two masters (M.Sc.), her first M.Sc. in Public Health from National School of Public Health of Athens and her second one in Waste Management from Hellenic Open University of Patras. Her main responsibilities at the Ministry are related to the European and national regulation in the management of animal by-products from the point of their production until their final use or disposal.

Panagiotis Karanis

Professor, University of Nicosia Medical School Cyprus

Panagiotis Karanis is a Professor and Head of Anatomy at the Department of Basic and Clinical Sciences of the Medical School, Nicosia University in Cyprus. Formerly, Professor and PI at the medical Faculties at Bonn and Cologne Universities in Germany, at the National Research Center for Protozoan Diseases School, Agriculture University and Veterinary Medicine of the Obihiro University in Japan and Professor and Director of the Center for Biomedicine and Infectious Diseases at the State Key Laboratory for Plateau Ecology and Agriculture at the Qinghai University, Xining, China. PhD in Parasitology (Bonn University) with a background in disinfection of protozoan parasites. Habilitation in Parasitology (Medical Faculty Bonn University) with knowledge of waterborne parasitic diseases. Has been working in medical, epidemiological and molecular Parasitology, considering both the pathogen and the disease—significant teaching experiences in Medical Parasitology, Tropical Diseases, and Human Anatomy. Author of 160 Scopus-indexed articles, counting about 9152 citations and an h-index of 47, managed more than 40 research projects with over ten million euros. According to a team of researchers at Stanford University in the USA, Prof. Panagiotis Karanis has been included on the annual list of 100,000 top scientists worldwide and in the top 2% of scientists in their field. His research profile focused on developing diagnostic methods to control emerging, reemerging and neglected waterborne, food-borne and vector-borne parasitic diseases, including diagnostic tools for preventing such illnesses combined with climate and demographic changes—worldwide interdisciplinary collaborations to contribute to the “One World – One Health” concept.

Conference Program

rethink food resources, losses, and waste 2023

3rd International Conference

Athens, September 27-29, 2023

PROGRAM

The 2023 RETASTE Conference is co-organized by

the Hellenic Mediterranean University and Harokopio University

Tuesday, 26 September 2023

pre-registration 17:00 – 19:00

Room I — Wednesday, 27 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-27-room-1

8:30 - 9:00		Registration
ROOM I PLENARY SESSION		**Welcome Speeches** **Chair: Katia Lasaridi and Thrassyvoulos Manios**
9:00 - 9:15		Harokopio University Rectoral Authorities *Welcome Speech*
9:15 - 9:30		**Katia Lasaridi**, Harokopio University Professor of Environmental Management and Technology *Welcome Speech*
9:30 - 9:45		**Thrassyvoulos Manios**, Hellenic Mediterranean University Professor of Waste Management and Reuse in Agriculture *Welcome Speech*
9:45 - 10:15		**Manolis Grafakos**, Hellenic Ministry of Environment and Energy Secretary General of Waste Management *Welcome Speech*
10:15 - 10:30		**Gerasimos Lyberatos**, National Technical University of Athens Professor of Chemical Engineering *Separate collection of food waste and composting for an island community*
10:30 - 10:45		Thalis E.S S.A Representative *Biowaste :Time to move forward*
10:45 - 11:00		**Clara Cicatiello**, University of Tuscia Assistant Professor of Agricultural Economics - H2020 Project LOWINFOOD Project Manager *Innovations against food loss and waste: where, why and how they can be effective*
11:00 - 11:30		Coffee Break
ROOM I SESSION 2		**Measurement of Food Loss and Waste** **Chair: Clara Cicatiello and Konstadinos Abeliotis**
11:30 - 11:45		Roberta Pietrangeli*, Clara Cicatiello
	FWM-377	*Lost vegetables, lost value: Assessment of carrots harvest and post-harvest losses in a large italian producer organisation*
11:45 - 12:00		Konstadinos Abeliotis*, Katia Lasaridi, Christina Chroni, Evangelia Sigala
	FWM-560	*Food waste generation in the grocery retail sector*
12:00 - 12:15		Adrià Burniol-Garcia*, Berta Vidal-Mones, Raquel Diaz-Ruiz, Imane Uald Lamkaddam
	FWM-417	*FOLOU Project: Developing a new methodological framework for quantification of food loss in primary production in Europe*
12:15 - 12:30		Berta Vidal-Mones*, Marc Farres-Jansa, Adria Burniol-Garcia, Raquel Diaz-Ruiz
	FWM-418	*Disentangling the roots of food lossess in primary production*
12:30 - 12:45		Christina Chroni*, Stathis Fortatos, Konstantinos Abeliotis, Katia Lasaridi
	FWM-557	*Assessment of food waste generation in the primary production*
12:45 - 13:00	VR	Yueyao Song*, Feng Zhu, Chi Zhang, Dianlei Liu, Shizhao Zhang, Tianhang Li, Jianguo Liu
	FWM-512	*Assessment of food waste generation in China's Dining scenarios and its environmental implications*
13:00 - 13:15		Michelle Klein*, Manfred Tacker, Silvia Apprich
	FWM-424	*Influence of packaging related characteristics on product loss- a case study in the dairy industry*
13:30 - 15:00		Lunch Break
ROOM I SESSION 3		**Prevention of Food Loss and Waste: policy, methods and best practices** **Chair: Ludovica Principato and Christina Chroni**
15:00 - 15:15		Clara Cicatiello, Camilla Comis, Ludovica Principato*, Paolo Rellini, Luca Secondi, Mengting Yu
	PLW-344	*Tracking post-consumption of restaurant food and leftovers: innovative digital solution and preliminary outcomes from H2020 LOWINFOOD and REGUSTO*
15:15 - 15:30		Carlos Martin-Rios*, Julneth Rogenhofer
	CFW-501	*Worth a Thousand Words: Visualizing Food Waste Through the Lenses of Foodservice Professionals*
15:30 - 15:45		Eleni Aretoulaki, Stavros T. Ponis, George Plakas, Dimitra Tzanetou*, Antonis Kitsantas
	PLW-451	*A review of food waste within the food service and hospitality sector: mapping the causes, effects, and technological opportunities for a sustainable future*
15:45 - 16:00		Athanasia Barka*, A. Dimogianni, M. Vitoraki, K. Markouli, E. Desiotou, K. Papadopoulou, G. Lyberatos
	FWM-488	*Waste Prevention: The case of the municipality of Halandri*
16:00 - 16:15		Essam Hebishy, Ayten Aylin Tas*
	PLW-384	*Avocado shelf-life extension using edible active coatings containing 4-hexylresorcinol and sodium metabisulphite*
16:15 - 16:30		Nazli Koseoglu, Tareq Mzek*, Phoebe Somervail, Simon Piras
	PLW-390	*Building a sustainable seafood sector through collaboration: insights from a dialogue between stakeholders of the Scottish value chain*
16:30 - 16:45	VR	Annelies Verspeek-van der Stelt*, Woody Maijers, Evelot Westerink-Duijzer, Ayella Spaapen, Frederike Praasterink, Antien Zuidberg
	PLW-430	*Scoping key opportunities for systemic food waste prevention in collaboration with system stakeholders - an applied methodology*
17:00 - 17:15		Alexandra Neill
	PLW-515	*The Interplay Between Restaurant Food Waste Decisions, Context, and Externalities: Results from a Systematic Mapping Review*

Time in Athens (GMT+3)

Room II — Wednesday, 27 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-27-room-2

8:30 - 9:00			Registration
9:00 - 11:00			**Plennary Session in Room I**
11:00 - 11:30			Coffee Break
ROOM II SESSION 4			**Food Waste Valorisation: Anaerobic Digestion and Materials Recovery** **Chair: Gerasimos Lyberatos and Nikolaos Papastefanakis**
11:30 - 11:45	FLW-445	VR	Emily Tobbell*, Chae Rin Lee, Zhijun Liu, Pram Abhayawardhana *Exploring the valuable compounds and antioxidant activity in the peel of New Zealand grown buttercup squash (Cucurbita maxima)*
11:45 - 12:00	ANA-347		Basem Haroun, Ajay Singh, Michael Beswick, George Nakhla* *Digestion Enhancement of Recalcitrant Food Organics using a Low Temperature Thermo-alkaline Hydrolysis Process*
12:00 - 12:15	AWR-416		Mahmoud Abdallah*, Mahmoud Al-Hindi *Co-treatment of Municipal Wastewater and Organic Wastes in an Up-flow Anaerobic Sludge Blanket (UASB) Reactor*
12:15 - 12:30	ANA-438	VR	Eder José Ordoñez Frías*, Germán Buitrón, Karla María Muñoz Páez *Biohydrogen Production Using Fermented Acidic Cheese Whey*
12:30 - 12:45	ANA-500		Gerasimos Kanellos, Asimina Tremouli*, Michail Antarachas, Gerasimos Lyberatos *The Effects of Hydraulic Retention Time, Applied Potential and Pretreatment Process During the Electrofermentation of Cheese Whey*
12:45 - 13:00	ANA-529	VR	Eudokia Galipidou*, Michail Deligiannis, Andreas Androulakakis, Georgia Gatido, Michail Fountoulakis, Athanasios Stasinakis *Effect of GAC addition and application of voltage on the performance of anaerobic digestion and the removal of persistent and mobile substances*
13:00 - 13:15	FWU-323		Giovanni Dolci*, Floriana Fava, Valeria Venturelli, Arianna Catenacci, Mario Grosso, Francesca Malpei *Experimental Analysis on the Aerobic and Anaerobic Degradation of Paper-Based Boxes for Food Delivery*
13:30 - 15:00			Lunch Break
ROOM II SESSION 5			**Novel Materials from Food Resources** **Chair: Angeliki Maragkaki and Chihhao Fan**
15:00 - 15:15	NOV-311		Nurhan Turgut Dunford*, Muge Alptekin, Melih Soner Celiktas *Conversion of food waste to energy storage materials*
15:15 - 15:30	NOV-497		Adnan Ibrahim Ahmed Ahmed, Gozde Duman, Tamer Karayildirim, Jale Yanik* *Synthesis of magnetic carbon from pomace: It's adsorption performance*
15:30 - 15:45	NOV-396	VR	Fran Nekvapil*, Adina Stegareascu, Maria Mihet, Simona Cinta Pinzaru, Maria - Loredana Soran *A modified crustacean biorefinery approach: Carotenoids extraction and porous magnesian calcite powder*
15:45 - 16:00	ANA-375		Chihhao Fan,* Yi-Chun Chung *Valorization of Kitchen Waste for Gas Production Using Anaerobic Digestion*
16:00 - 16:15	NOV-462		Mirko Magni*, Rita Nasti, Ester Postigliore, Stefania Marzorati, Beatrice Tagliabue, Valentina Re, Giangiacomo Beretta, Stefano Trasatti, Marinella Levi, Stefano Turri, *From food waste to metal protecting agents: the case of green inhibitors and of bio-based polymer coatings*
16:15 - 16:30	NOV-463		Stefania Marzorati*, Giordana Martinelli, Margherita Roncoroni, Alessio Massironi, Luisella Verotta, Mario Trioni, Raffaella Soave, Michela Sugni *Sea urchins waste valorization: Functional collagen-based biomaterials for skin regeneration*
16:30 - 16:45	NOV-472		Rita Nasti*, Stefania Marzorati, Simona Mascitelli, Rossella Dorati, Giangiacomo Beretta *Tomato peel waste: A powerful source of bio-based polymer for innovative biomedical devices*
17:00 - 17:15	W2E-496		Cui Quan, Ningbo Gao, Hakan Cay, Gozde Duman, Xin Tu, Jale Yanik* *Coupling of Steam Gasification of Biomass and Catalytic Plasma Tar Reforming Over Low-cost Catalyst for H2 Production*

Time in Athens (GMT+3)

Room III — Wednesday, 27 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-27-room-3

8:30 - 9:00			Registration
9:00 - 11:00			**Plennary Session in Room I**
11:00 - 11:30			Coffee Break
ROOM III SESSION 6			**Innovations for Sustainable Food Production and Valorization Chair: Giuseppe Mancuso and Dimitrios Papadimitriou**
11:30 - 11:45	AWR-379		Giuseppe Mancuso*, Francesca Valenti, Stevo Lavrnić, Attilio Toscano *Reclaimed Water Reuse Potential in Agricultural Irrigation for Europe*
11:45 - 12:00	AFR-434		Hung Nguyen *Development and sustainability assessment of rice straw-based circular economy*
12:00 - 12:15	FLW-461		Yujun Wei*, Marta Rodriguez-Illera, Xuezhen Guo, Martijntje Vollebregt, Wei-shan Chen *Untangling the complexities of decision-making in food loss and waste valorisation*
12:15 - 12:30	APP-524	VR	Paula Correia*, Clara Vouga, Catarina Coelho, Cristina Costa, Raquél Guiné, Fernando Gonçalves, João Gonçalves *Flour From Drone Broods: A Viable Alternative?*
12:30 - 12:45	FWU-435		Jeremías Vásquez Essus*, Natalia Velastín Osorio, Rodrigo Contreras Núñez *Design of a Sustainable Supply Chain for Fruit Puree Production through Organic Waste Valorization*
12:45 - 13:00	AWR-378		Francesca Valenti*, Giuseppe Mancuso, Stevo Lavrnić, Attilio Toscano *GIS-Based Model to Investigate the Potential of Treated Wastewater for Irrigation*
12:30 - 12:45	AFR-520		N. Adrus*, C.K. Wong, W.Q. See, M.A. Mohd Farizal, N.A.F. Mat Nasir, A. Nasir, J. Jamaluddin, R. Hasham, N. Basar, S.P. Mohd Bohari *Unlocking the Potential of Agricultural Waste in Malaysia for Sustainable Applications as Thin Films*
13:30 - 15:00			Lunch Break
ROOM III SESSION 7			**Sustainable Food Systems Chair: Ioannis Daliakopoulos and Barbara Čeh**
15:00 - 15:15	HAR-559		Barbara Čeh *Unearthing Approaches to Harness the Potential of Hop Waste Biomass*
15:15 - 15:30	NOV-544		Maria Franco *Whey valorization from cheese manufacturing in Switzerland*
15:30 - 15:45	HAR-492	VR	Meryem Assidi, Souad El Hajjaji, Salah-Eddine Laasli, Luwieke Bosma, Rachid Akki, Driss Iraqi*, Slimane khali, Rachid mentag, Rachid Lahlali, Fouad Mokrini *Farmers' Perception, Knowledge, and Control Attitudes of Rodents Infesting Cereal Growing Areas in Morocco*
15:45 - 16:00	AFR-453		Gizem Balmuku*, Asiye Cigdem Artik, Jale Yanik, Tansel Kaygisiz Asciogul, Mehmet Kadri Bozokalfa, Ibrahim Duman *Biochar as a priming agent*
16:00 - 16:15	PLW-433	VR	Elena Domingo-Morcillo*, Elena Escrig-Olmedo and Maria Jesus Munoz Torres *Analyzing the Use of Accounting Methodologies for Assessing Sustainability in Food Waste Prevention and Reduction Actions from ToNoWaste HEurope Project Approach*
16:15 - 16:30	HAR-447		Nathalie Garavito Realpe*, Pedro Brancoli, Andrea Rossi Scalco *Reducing Food Loss and Waste: Unveiling Unfair Trade Practicesand Root Causes in the Brazilian Leafy Products Supply Chain*
16:30 - 16:45	AWR-534	VR	Stylianos G. Gyparakis, S. Dokianakis, E. Karagiannis, F. Galliou, M.S Fountoulakis, A.S Stasinakis, Thrassyvoulos Manios* *From DIANYA to HIPPOCRATES, A Story of Scaling up a Pilot Unit to a Demonstration Unit at a General Hospital in Crete, Greece*

Time in Athens (GMT+3)

Room I — Thursday, 28 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-28-room-1

ROOM I SESSION 8			**Alternative Water Resources, Wastewater Treatment and Sustainable Food Systems Chair: Panagiotis Karanis, Thrassyvoulos Manios and Valentina Beghetto**
9:00 - 9:15			Keynote Speaker: **Panagiotis Karanis**, University of Nicosia Medical School Professor of Anatomy
	RAC-385 [KN]		*Cryptosporidium Implications to Agriculture and Beyond - Risks and Research Needs*
9:15 - 9:30			Francesco Guarino*, Annamaria Gentile, Patrizia Iannece, Angela Cicatelli, Stefano Castiglione
	AWR-465		*Efficiency of Constructed Wetlands in Mitigating Antibiotic Resistance Concern: Safe Water Reuse for Agriculture and Sustainable Food Production*
9:30 - 9:45			Linda Mezule
	AWR-382		*Assessment of Sewage Sludge Hygienization Methods for itsAccelerated Use in Agriculture*
9:45 - 10:00		VR	Argyri Xenaki*, Eirini Zkeri, Michail Fountoulakis, Athanasios Stasinakis
	AWR-530		*Cultivation of the microalgae Chlorella Sorokiniana in variousagro-industrial wastewaters and characterization of biomass extracts for bioactive compounds*
10:00 - 10:15			Valentina Beghetto*, V. Gatto, R. Samiolo, M. Facchin, S. Conca, N. Bardella, Cristina Scolaro, Salim Brahimi, Annamaria Visco
	NOV-340		*Agrifood waste valorization for bioplastic composites and high-value chemicals*
10:15 - 10:30		VR	Dorian Prato-Garcia*, Angélica Robayo
	AWR-328		*Green solutions to reduce the carbon footprint of resource intensive industries*
10:30 - 10:45			Jiftah Ben Asher
	AFR-363		*Potassium, nitrogen and CO2 sequestration*
10:45 - 11:00			Manolis Chatzakis
			Tertiary wastewater treatment for irrigation purpose in tourism intensive areas in Crete.
11:00 - 11:30			Coffee Break
ROOM I SESSION 9			**Compost production, quality and utilization Chair: Angeliki Maragkaki and Yael Laor**
11:30 - 11:40			Yael Laor*, Dayanand Sharma, Shlomi Oazana, Ibrahim Saadi, Ran Lati
	COM-483		*Distribution of residence times in rotary drum composting and implications for sanitary regulations*
11:40 - 12:00		VR	Marco Grigatti
	COM-350		*Nutrient utilization efficiency and soil carbon management index (CMI) following the use of compost in open field field on cereals crops*
12:00 - 12:15			Jennifer Reeve*, Astrid Jacobson, Idowu Atoloye, Kareem Adeleke, Preston Christiensen, Earl Creech
	COM-532		*Compost effects on soil health and yields of organic winter wheat in semi-arid environments*
12:15 - 12:30			Daniel Gonzalez Ale*, Javier Moral-Vico, Marta Garcia-Prats, Cristina Madrid-Lopez, Antoni Sanchez Ferrer
	COM-427		*A systematic study on the greenhouse emissions from a community composting system implemented in a primary school at Univeritat Autonoma de Barcelona, Spain*
12:30 - 12:45			Dimosthenis Tsivas*, Anestis Vlysidis
	COM-421		*Development of an Innovative Compost Maturity Evaluation Method Using the CIELAB Colour Model*
12:45 - 13:00			Yael Laor*, Ran Avidov, Avishai Lublin, Vempalli Sudharsan Varma, Ibrahim Saadi, Israel Yoselewitz, Yona Chen
	ARF-482		*Should composting in polyethylene sleeves with forced aeration be considered a practical solution during disease outbreaks in poultry farming?*
13:00 - 13:15		VR	Vasiliki Kinigopoulou*, Konstantinos Kontos, Evangelos Hatzigiannakis, Stefanos Stefanou, Antigoni Geitona, Efstratios K. Oikonomou
	COM - 365		*Kitchen Plant Waste as Source for Organic Composting Serving Circular Economy - Effects of Vermicompost on the Growth of Greenhouse Vegetables*
13:15 - 13:30			Francesca Villa*, Andrea De Robertis and Mario Grosso
	COM-324		*Assessment of operational and design issues in a municipal solid waste treatment facility in Lebanon with the Project Cycle Management tool*
13:30 - 14:30			Lunch Break
ROOM I SESSION 10			**Food Waste Prevention: Policies and best practices Chair: Katia Lasaridi, Konstadinos Abeliotis and Christina Chroni**
14:30 - 14:45			**Anastasia Arfanakou**, Chemical Engineer, Head of Waste Management Directorate - Hellenic Ministry of Energy and Environment
			National strategies on waste prevention
14:45 - 15:00			**Katia Lasaridi**, Harokopio University Professor of Environmental Management and Technology
			Consumer Food Waste Case Studies
15:00 - 15:15			**Konstadinos Abeliotis**, Harokopio University Vice Rector and Professor of Environmental Management
			Food waste in the retail sector
15:15 - 15:30			**Reneta Mitsi**, Corporate Affairs & Communication Director at Goody's-Everest Group of Companies
			Food waste management challenges for the food-service sector. In view of the national waste management legislation
15:30 - 15:45			**Dia Chorafa,** Policy officer at Boroume, Coordinator of the Alliance for the reduction of food waste in Greece
			Policy intervention and voluntary agreement for food waste reduction in Greece
15:45 - 16:00			**Alexia Macheras, AB Vassilopoulos Corporate Communications and Sustainability Manager**
			Transforming challenges into opportunities
18:00 - 21:00			**Finger Food - Cocktail Party**

Time in Athens (GMT+3)

Room II — Thursday, 28 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-28-room-2

ROOM II SESSION 11		**LCA: Life Cycle Assessment and Social Life Cycle Assessment (S-LCA) of the different components of the farm-to-fork value chain Chair: Konstadinos Abeliotis and Ioannis Vardopoulos**
9:00 - 9:15	VR	Christos Koidis, Athanasios Bantsos, Athanasios Kalaitzidis, Christos Mertzanakis, Christodoulos Savva*, Dimitris Makris, Christos Vlachokostas, Charisios Achillas,
	LCA-345	*Supporting environmental certification in the agrifood sector through online lifecycle assessment tool: Identification of end-users' requirements*
9:15 - 9:30		Pantelis Manakas*, Athanasios T. Balafoutis, Constantina Kottaridi, Anestis Vlysidis
	LCA-428	*Sustainability assessment of biorefineries for waste valorization from juice industries*
9:30 - 9:45		Natalia Velastin Osorio*, Rodrigo Contreras Nunez, Andrea Espinosa Perez
	LCA-466	*Comparison of the environmental impacts of omnivore, vegeterian, and vegan lasagnas using Life Cycle Analysis: An approach to contrast dietary choices and their*
9:45 - 10:00		Ioannis Vardopoulos*, Konstantinos Abeliotis, Katia Lasaridi
	LCA-548	*Exploring sustainable strategies in municipal waste management: A preliminary social life cycle assessment of a pay-as-you-throw pilot program*
10:00 - 10:15		Katerina Synani*, Christina Chroni, Evangelia Sigala, Konstadinos Abeliotis, Katia Lasaridi
	LCA-551	*Environmental assessment of edible parts of wasted food at the household level in Greece*
10:15 - 10:30		Rodrigo Contreras Nunez*, Natalia Velastin Osorio, Andrea Espinoza Perez
	LCA-376	*Research on the environmental impact of massive food services and homemade meals: a case study of stewed chicpeas in Chile*
10:30 - 10:45		Fatemeh Mostashari-Rad*, Marianne Thomsen
	PLW-535	*Economic and environmental sustainability assessment of recycling versus upcycling surplus bread*
11:00 - 11:30		Coffee Break

open to public

ROOM II SESSION 12		**LIFE-IP CEI-GREECE WORKSHOP - Agro-food waste and bio-economy Chair: Katia Lasaridi and Smaragda Sotiraki**
11:30 - 11:35		**Katia Lasaridi**, Harokopio University Professor of Environmental Management and Technology *Welcome*
11:35 - 11:45		**Maria Plati**, Hellenic Ministry of the Environment and Energy LIFE IP CEI Greece Project Manager **Fay Nakou**, Hellenic Ministry of the Environment and Energy Environmenetal Expert *The LIFE-IP CEI-Greece "Circular Economy Implementation in Greece" Project*
11:45 - 12:00		**Napoleon Maravegias**, University of Athens Em. Professor and f. Vice Rector, f. Minister of Rural Development and Food, Hellenic Republic *Policy frameworks for sustainable agriculture*
12:00 - 12:15	AFF-425 [KN]	**Despina Papanikolaou**, Hellenic Ministry of Rural Development and Food, Veterinary Public Health Directorate, Animal By-Product Department Head *Animal Proteins from Human Food to Animal Feed*
12:15 - 12:30		**Thrassyvoulos Manios**, Hellenic Mediterranean University Professor of Waste Management and Reuse in Agriculture *LIFE -Food for Feed: An Innovative Process for Transforming Hotels Food Wastes into Animal Feed*
12:30 - 12:45	VR AFR-348	**Alejandro Barragan-Ocana**, Instituto Politécnico Nacional Researcher-Professor, Mexico City w/ co-author: Paz Silva-Borjas *Advances in science and technology for the production of biofuelas and value-added products from the use of biomass and agricultural residues*
12:45 - 13:00	AFR-346	**Daniel Pleissne**r, Institute for Food & Environmental Research e.V. Head of Science, Bad Belzig + Leuphana University Lüneburg Institute of Sustainable & Environmental Chemistry Adjunct Professor w/ coauthor: Stephanie Schonfelder *Heterotrophic growth of Galdieria sulphuraria on residues from aquaculture and fish processing industries*
13:00 - 13:15	AFR-434	**Hung Nguye**, Scientist II - Mechanization and Postharvest Management Team Leader, International Rice Research Institute, Philippines *Development and sustainability assessment of rice straw-based circular economy*
13:15 - 13:30	AFF-543	**Smaragda Sotiraki**, Veterinary Research Institute Hellenic Agricultural Organisation DEMETER w/ coauthors: Stefanakis Alexandros, Panagiota Ligda, Georgios Maragkakis, Georgios Geourgoulakis *SMARTWASTE: Reusing wastes and by-products of agricultural industry to develop bioactive livestock feeds*
13:30 - 14:30		Lunch Break

ROOM II SESSION 13	**LIFE Program Presentation and Proposal Preparation - Greek LIFE Task Force plus, GREEN FUND Chair: Thrassyvoulos Manios, Nikos Psimmenos and Dimitrios Banousis**
14:30 - 14:45	**Nikos Psimmenos**, *Climate Change officer, Greek Life Task Force plus, Green Fund* *The Life Programme Structure and Aims - Climate Change Adaptation and Mitigation – Clean Energy Transition*
14:45 - 15:00	***Dimitrios Banousis*** *, Climate Change officer, Greek Life Task Force plus, Green Fund* *The Life Programme Structure and Aims - Circular Economy and Quality of LIFE - Nature and Biodiversity*
15:00 - 15:15	**Thomas Maggos**, *Hellenic National Centre for Scientific Research "Demokritos" Research Director* *A Success Story: Innovative Photocatalytic Paints use on the improvement of Indoor Air Quality and Energy Consumption - VISIONS (LIFE19 ENV/GR/000100 VISIONS)*
15:15 - 15:30	**Valentina Beghetto**, *Ca' Foscari University of Venice Associate Professor* *How to win a LIFE Project and survive*
15:30 - 15:45	**Katia Lasaridi**, Harokopio University Professor of Environmental Management and Technology *The Life Integrated Projects and How to Approach Them*
15:45 - 16:00	**Thrassyvoulos Manios**, Hellenic Mediterranean University Professor of Waste Management and Reuse in Agriculture *Successful Application for Life Funding: My Own Meandering Experience*
16:00 - 16:30	*Open Forum*
18:00 - 21:00	**Finger Food - Cocktail Party**

Time in Athens (GMT+3)

Room III — Thursday, 28 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-28-room-3

ROOM III SESSION 14			**Nutrients Recovery and Alternative Fertilizers Chair: Christina Chroni and Ioannis Daliakopoulos**
9:00 - 9:15	NRF-318		Carmo Horta*, Verónica Oliveira, Berta Riaño, María Cruz García-Gonzalez *Are biobased fertilizers an alternative to chemical fertilizers in promoting sustainable and circular economy processes?*
9:15 - 9:30	NRF-367	VR	Cuong Manh Duong*, Teng-Teeh Lim *Aerated Manure-pit Management: A Case Study of Cost and Economic Value*
9:30 - 9:45	NRF-437		Salah Jellali*, Jamal Al-Sabahi, Maram Al-Bulushi, Majida al-Harassi, Yassine Charabi, Hamed Al-Nadabi, Ahmed Al-Raessi, Mejdi Jeguirim *Calcium-rich Biochars Synthesis and Valorization for Phosphorus Recovery from Effluents: Dynamic Investigations*
9:45 - 10:00	NRF-441		Shruti Katti*, Nimisha Edayilam, Bernard Willems, Josephine Cafmeyer, Steven Cafmeyer, Steven DeMeester, Erik Meers *Phosphorous Recovery from Tomato Waste Digestate*
10:00 - 10:15	NRF-493		Efi Levizou*, Christos Athanasiou, Ioannis Karapanagiotidis, Konstantinos Kormas, Eleni Mente, Nikolaos Katsoulas *Circular Economy in Agricultural Production: the Cycle of Nutrition Between Plants, Fish and Insects as a New System of Food Production with Low Environmental Footprint*
10:15 - 10:30	NRF-495		Kieu Trang Trinh*, Dimitrios Kalderis, Minh Ngoc Nguyen, Thinh Thi Hong Nguyen, Toshiki Tsubota *Rice Straw Pyrolysis for Nutrient Recovery: Investigating Silicon and Phosphorus Co-Release as Alternative Fertilizer Components*
10:30 - 10:45	NRF-517	VR	Juliette Monetti, Pablo Ledezma* *Sustainable (De)centralised Recovery of Macro- and Micronutrients From Human Excreta Without Pharmaceuticals/PFAS: a Proposal for the "Green Architecture" of the Brisbane 2032 Olympics*
11:00 - 11:30			Coffee Break
ROOM III SESSION 15			**Advancements in Food Waste Management: From Prevention to On-Site Treatment Chair: Demetris Francis Lekkas and Yannis E. Doukas**
11:30 - 11:45	CFW-547		Stavroula Chatzichristofa*, Peter Coakley, Federica Dallanoce, Matheus Kakaris, Eirini Mani, Imma Mirales, Daithí Ó Murchú, Marco Piscitelli, Alessia Spatafora, Guido Van Dijk *Game-changer in tackling food loss and waste: Minecrafting a sustainable future*
11:45 - 12:00	FWM-395		Margarita Anna Manolia, Eleftheria Klontza, Maria Hatziantoniou, Demetris Francis Lekkas* *Food loss and food waste in hotel sector: Insights from empirical data and strategies for reduction*
12:00 - 12:15	FWU-452		Stavros Ponis, George Plakas, Eleni Aretoulaki, Dimitra Tzanetou, Antonios Kitsantas* *Development of a Blockchain Ecosystem Based on the Tokenization of Food Waste*
12:15 - 12:30	PLW-542		Yannis E. Doukas*, Ioannis Vardopoulos *A pathway to sustainable policy: Unraveling the interplay of socio-cultural factors, local contexts, and indtitutional dynamics in food waste reduction*
12:30 - 12:45	CFW-380	VR	M Nazli Koseoglu*, Simone Piras, Gurneet Kapour *Innovation as an Intervention: How Being Involved in Innovations Against Food Waste Changes the Individuals' Awareness, Attitude, and Behaviours Towards Food Waste?*
12:45 - 13:00	FWU-469		Ahmed Hosney*, Ilja Ignatjev, Karolina Barcauskaite *The Influence of Acidic Demineralization on the Characteristics of Chitosan Extracted from Shrimp Waste*
13:00 - 13:15	FWU-460		Halimat Abdul-Rahman*, Alekhya Dulam, Hans-Peter Weikard, Wei-Shan Chen *Use of Adaptation Pathways for Urban Food Waste Management*
13:15 - 13:30	CFW-491		Francesco La Barbera*, Mario Amato, Maria Rosaria Simeone, Roberta Riverso, Carmela Altamura, Fabio Verneau *Willingness to Pay for a Certification Scheme Against Food Waste: The Influence of Perceived Behavioural Control and Perceived Responsibility*
13:30 - 14:30			Lunch Break
ROOM III SESSION 16			**Composting and Food Waste Valorisation Chair: Katerina Katrini and Ru Liu**
14:45 - 15:00	COM-334		Paul Richard Momsen Miller*, Renato Barreto Barbosa Trivella, Caio de Teves Inacio *Decentralized urban composting as an inititat step to a circular agricultural nutrient economy*
15:00 - 15:15	COM-444	VR	Munawwar Ali Khan *Efficacy of an onsite rotary and fixed bin composting system for food waste management*
15:15 - 15:30	W2E-474	VR	Daniela V. Cabrera, Ingrid Adema-Yusta, María J. Santibáñez, Jefferson W. Tester, Crispin Celis, Rodrigo A. Labatut* *Grease Trap Waste Valorization Through Hydrothermal Liquefaction and Anaerobic Digestion: A Circular Approach to Dairy Wastewater Treatment*
15:30 - 15:45	NRF-343		Ru Liu*, Oded Nir *Recovering high-value P-K fertilizer from effluents by integrating adsorption and electrodialysis with bipolar membranes*
15:45 - 16:00	COM-325	VR	Md Toriqul Islam *Compost Quality Analysis for Crops Productivity, Profitability, and Soil Health Improvement*
16:00 - 16:15	NRF-387		Hamidatu S. Darimani, Noellie W. Kpoda* *Design of Thermal Post-Treatment Unit for the Inactivation of Pathogens in Compost after the Composting Process for Food Production*
18:00 - 21:00			**Finger Food - Cocktail Party**

Time in Athens (GMT+3)

ROOM I Friday, 29 September 2023

You can virtually access the room via this link: https://retaste.gr/retaste-2023-09-29-room-1

ROOM I SESSION 17		**3rd Smart Innovation Symposium (SIS#3)**
9:15 - 9:30		**Thrassyvoulos Manios**, Hellenic Mediterranean University Professor of Waste Management and Reuse in Agriculture *Research projects as a profitable adventure for SME*
9:30 - 9:45		**Riccardo Samiolo**, Chief Financial Officer @Crossing s.r.l. *Different models of start-up, focus on spin-off*
9:45 - 10:00		**Christos Panagiotou,** M.Sc. Computer Engineer, CTO @ TERRA PLUS *A versatile blockchain-based platform for building trust in agri-food sector*
10:00 - 10:15		**Nikolaos Bounakis**, Chief Executive Officer @ Proactive S.A. *CHOICE Plus: System Development for the Collection and Transport of Agricultural and Agro-Industrial Residues for Animal Feed Production*
10:15 - 10:30		**Anna Papadima**, Surveying Engineer Junior Analyst @ Geosystems Hellas S.A. *POTATO2UP: Organic potato cultivation practices for improved production quality and resistance to disease*
10:30 - 10:45	VR	**Michail Borboudakis**, Environmental Engineer @ Medical Waste *A Holistic Approach towards onsite hospital wastewater treatment*
10:45 - 11:00		**Giannis Maurogiannis**, CEO @ Anelixis *Economic Evaluation of Innovative Technologies: Opportunities and Risks*
11:00 - 11:30		Coffee Break
ROOM I SESSION 18		**3rd Smart Innovation Symposium (SIS#3)**
11:30 - 11:45		**Dimitris Papadimitriou**, External Partner @ ALAGRO *OPTIMUS - Alternative cultivation of the wild edible green Scolymus hispanicus L.*
11:45 - 12:00		**Antreas Ntokos**, External Partner @ Labros Fruits S.A. *HydroGrapes: Table grape trading period extension, by hydroponic greenhouse vine cultivation, under the climatic conditions of Crete*
12:00 - 12:15		**Katerina Rousaki,** Head of Entrepreneurship Development and Innovation Unit, Regional Economy Development and Openness Directorate, Region of Crete *Innovation Business Observatory of Crete Region*
12:15 - 12:30		**Christos Tsompanidis,** Partner - Managing Director at ENVIROPLAN SA *Circular Economy Boosts Innovative Actions in Waste Management*
12:30 - 12:45		**Dr. Stefanakis Alexandros,** Veterinarian, member of Bioresearch Laboratories AE & SYPA OE *'Reusing wastes and by-products of agricultural industry to develop bioactive livestock feeds'' - ''Smart-Waste''.*
12:45 - 13:00		**Fenia Galliou**, External partner @ TM Solutions *From composting to solar drying: one machine – two uses*
13:00 - 13:15		**Giannis Papadimitriou,** Chief Executive Officer @ PCM Consultants *CHOICE: Open Innovation Cooperative within Circular Economy*
13:15 - 13:30		*Open Forum*
13:30 - 14:30		Lunch Break
ROOM I SESSION 19		**Rotation Meetings SIS**
16:30 - 17:30		**Closing Ceremony for RETASTE 2023 & SIS**

Time in Athens (GMT+3)

ROOM II — Friday, 29 September 2023

You can virtually access the room via this link:
https://retaste.gr/retaste-2023-09-29-room-2

ROOM II SESSION 20			**HORIZON 2020 FOODRUS WORKSHOP** (in Greek)
9:30 - 9:45			**Simos Roussos**, Mayor of the Municipality of Halandri *Welcome Speech*
9:45 - 10:15			**Gerasimos Lyberatos**, National Technical University of Athens Professor of Chemical Engineering *Horizon 2020 FoodRUs, An Innovative Collaborative Circular Food System to Reduce Food Waste And Losses in the Agri-Food Chain*
10:15 - 11:00			*Waste Prevention: The Case of The Municipality of Halandri*
11:00 - 11:30			Coffee Break

open to public

ROOM II SESSION 21			**HORIZON 2020 FOODRUS WORKSHOP** (in Greek)
11:30 - 11:50			**Katia Lasaridi**, Harokopio University Professor of Environmental Management and Technology *Food loss and waste measurement in Greece and development of prevention actions within the framework of the LIFE IP CEI Greece and H2020 LOWINFOOD projects*
11:50 - 12:10			**Thrassyvoulos Manios**, Hellenic Mediterranean University Professor of Waste Management and Reuse in Agriculture *On-site Production of Animal Feed from Non-Commercial Vegetables and Starchy Supermarket Products*
12:10 - 12:30			**Demetris Francis Lekkas**, University of the Aegean Waste Management Laboratory Director, Associate Professor of Analysis and Simulation of Environmental Systems *Mapping of Food Waste in the Hospitality Sector and Applications of Circular Management Solutions*
12:30 - 12:45			*Best Practice -> Social Grocery of the Municipality of Chalandri*
12:45 - 13:00			*Best Practice -> Boroume Saving Food Saving Life. A Holistic Approach to Reducing Food Waste in Greece*
13:00 - 13:15			*Best Practive -> FoodBag App: The Solution for Food Waste in Greece*
13:15 - 13:30			*Open Forum*
13:30 - 14:30			Lunch Break
ROOM II SESSION 22			**Circular Food Systems and Novel Materials from Food Resources** **Chair: Ioannis Daliakopoulos and Stathis Fortatos**
14:30 - 14:45	RAC-533	VR	Álvarez-Albert Luís*, Ferrero-Ferrero Idoya, Rivera-Lirio Juana María *Assurance of Food Loss and Waste Disclosure. Adoption of a Risk-based Approach to Evaluate the Materiality and Quality of Information*
14:45 - 15:00	HAR-355	VR	Saptashish Deb*, Ram Chandra, Paruchuri M. V. Subbarao *A study on the effect of conventional storage practices on the losses of onions under ambient environmental conditions*
15:00 - 15:15	FLW-503	VR	Alvaro Mayor, Laura Quintana-Gomez, Celia M. Castro-Barros, Teresa Alvarino, Joana Tobella *presenter: Ruben Titos Guillen** *Upcycling polyphenols from industrial olive oil waste*
15:15 - 15:30	POL-330	VR	Angélica Robayo-Avendaño*, Dorian Prato-Garcia *Consumer perception about the adoption of genetically modified foods*
15:30 - 15:45	NOV-358	VR	Mariavittoria Verrillo*, Francesco Antonio Carbone, Silvana Cangemi, Andrea Pasqualini, Catello Pane, Riccardo Spaccini *Molecular features and disease suppressive activity of organic fractions extracted by green composts*
15:45 - 16:00	NOV-352	VR	Ngoc-Thuy Vu*, Tuyet T.A. Nguyen, Dimitrios Kalderis *Biosorption of diesel oil using hydrochar derived from low temperature hydrothermal carbonization of Aloe vera leaf bark*
16:00 - 16:15	NOV-429	VR	Michelina Soccio*, Chiara Siracusa, Felice Quartinello, Mattia Manfroni, Nadia Lotti, Georg M. Guebitz, Alessandro Pellis *Circular recycling of 2,5-furandicarboxylic acid from designed biobased polymers*
16:30 - 17:30			**Closing Ceremony for RETASTE 2023 & SIS**

Time in Athens (GMT+3)

Room III — Friday, 29 September 2023

You can virtually access the room via this link:
https://retaste.gr/retaste-2023-09-29-room-3

ROOM III **SESSION 23**			**Consumer Food Waste Prevention – Awareness and Behaviour Change Models and Interventions** **Chair: Christina Chroni and Piergiorgio Degli Esposti**
9:00 - 9:15			Žvokelj Luka*, Cilenšek Ajda, Škerjanec Mateja, Istenič Darja, Praprotnik Kastelic Jerca, Atanasova Nataša
	UFP-487		*Design and Planning Tool for Circular Urban Food Systems*
9:15 - 9:30			Derya Kahveci
	CFW-401		*Consumers' Awareness and Acceptance Towards Upcycled Foods*
9:30 - 9:45		VR	Marton Kajtor*, András Tóth, Márton Battay, Miklós Süth, András Bittsánszky
	CFW-456		*Food Waste in Hungarian School Catering System*
9:45 - 10:00			David Hidalgo-Carvajal*, Christopher Mejia-Argueta, Ruth Carrasco- Gallego, Mark Hayes
	FWM-471		*Reducing food waste on Universities Campuses*
10:00 - 10:15			Maike Anna van Rooijen*, Johanna C. Gerdessen, G.D.H. Claassen, S.L.J.M. de Leeuw
	FWM-407		*Reducing household food waste by dietary meal planning*
10:15 - 10:30			Evangelia Sigala*, Christina Chroni, Konstadinos Abeliotis, Katia Lasaridi
	CFW-562		*Sociodemographic determinants of household food waste in Greece*
10:30 - 10:45			Nafsika Papacharalampous
	FWU-354		*When is it Really Dead? Ethnographic Reflections on Animals as Food and (Food) Waste*
10:45 - 11:00			Susana Yanez Gutierrez, Ruth Carrasco-Gallego, David Hidalgo - Carvajal*
	PLW-470		*Applying "Design Thinking" to address food waste in University Campus*
11:00 - 11:30			Coffee Break
ROOM III **SESSION 24**			**Waste to Energy + Biodiesel** **Chair: Angeliki Maragkaki and Sanjeev Yadav**
11:30 - 11:45			Sanjeev Yadav*, Musunuri Shriya Krishna, Aayush Raizada
	W2E-388		*Bio-coal Production via Torrefaction of Pelletized Food Waste: Effect of Pellet Size*
11:45 - 12:00		VR	Dorian Prato-Garcia*, Angélica Robayo
	W2E-327		*Hydrogen from biomass: A detailed model to determine the potential of the sugarcane industry in Colombia*
12:00 - 12:15			Brenda Aranda-Jaramillo*, Mirelli Archundia-Amador, Mario Calderón-Prado, Elizabeth León-Becerril, Octavio García-Depraect, Oscar Aguilar-Juárez
	W2E-527		*Biohydrogen Production by Lactate-based Dark Fermentation from Cheese Whey in Continuous Mode*
12:15 - 12:30		VR	Ana Ramos
	W2E-337		*The added-value of food waste: a review of pre-treatments for biofuel production through thermal conversion methods*
12:30 - 12:45			Hillary Onyebuchi Onyishi*, Johannes Neidel, Robert Daschner, Andreas Apfelbacher, Andreas Hornung
	W2E-498		*Thermochemical Conversion of Biowaste to Bioenergy Using the Thermocatalytic Reforming Technology*
12:45 - 13:00		VR	Sameer Ahmad Khan*, Ram Chandra, V. K. Vijay
	W2E-394		*Thermodynamic Study of Bambusa Tulda's Thermochemical Process for Energy Production*
13:00 - 13:15			S'fiso T. Gumbi, Ademola Olufolahan Olaniran*
	BDZ-368		*Biotechnological application of indigenous microalgae chlorella sp. T4 wastewater treatment and biodiesel production*
13:15 - 13:30			Wirasinee Supang*, Somkiat Ngamprasertsith, Winnatta Sakdasri, Ruengwith Sawangkeaw
	BDZ-341		*Optimal production capacity of biodiesel production from spent coffee grounds in supercritical ethyl acetate: Computer simulation*
16:30 - 17:30			**Closing Ceremony for RETASTE 2023 & SIS**

Time in Athens (GMT+3)

POSTERS Wednesday, 27 September 2023

9:00 - 9:30		Registration
9:30 - 11:30		**Plennary Session in Room I**
11:00 - 11:30		Coffee Break
		Any other aspects of FLW prevention across the entire food value chain
	FLW-450	Carlotta Breschi, Silvia D'Agostino, Andrea Signori, Lorenzo Cecchi, Francesco Meneguzzo, Federica Zabini, Cecilia Faraloni, Lorenzo Guerrini, Bruno Zanoni *Apple and Pomegranate Waste Extracts by Hydrodynamic Cavitation for Vegan and Gluten-Free Cookies Fortification*
	FLW-499	Giorgos Vrentzos, Ioannis N. Daliakopoulos, Ioannis Louloudakis, Dimitrios Papadimitriou, Luwieke Bosma, Sukru Esin, Thrassyvoulos Manios *Assessing Rodent-induced Greenhouse Crop Yield Losses and Management Options in Crete, Greece*
	FLW-555	Giorgos Vrentzos, Ioannis N. Daliakopoulos, Ioannis Louloudakis, Dimitrios Papadimitriou, Thrassyvoulos Manios A Review of Endemic Plant Species of Greece for Managing Rodent Damages in Agriculture
		Novel materials from food resources
	NOV-439	Florina Dranca, Silvia Mironeasa *Waste Management in the Sugar Industry: Study of Pectin Extraction from Sugar Beet Flakes by Conventional and Nonconventional Techniques*
	NOV-442	Vasile-Florin Ursachi, Mircea Oroian, Mariana Spinei *Development of Biodegradable Films Based on Cellulose Derivatives and Pectin for Food Packaging*
	NOV-443	Mariana Spinei, Mircea Oroian, Vasile-Florin Ursachi *Characterization of Biodegradable Films Based on Cellulose Derivatives, Pectin and Essential Oil*
	NOV-509	Daniela-Oana Pauliuc, Mirela-Alexandra Macoviciuc, Mircea Oroian *Study on the Extraction of Bioactive Compounds from Beetroot Peels*
VR	NOV-531	Leonidas Koutsellis, Athanasios Stasinakis, Michail Fountoulakis *Effect of pH on volatile fatty acids production during anaerobic fermentation of dairy wastewater*
		Cycle Assessment and Social Life Cycle Assessment (S-LCA) of the different components of the farm-to-fork value chain
VR	LCA-468 [V]	Joana F. J. R. Pesqueira, Marta O. Barbosa, Luís Pinto, Adrián M. T. Silva, Spyridon A. Petropoulos, Ippolitos Gintsioudis, Miguel Azevedo, Lillian Barros, Alexandre Gonçalves *Environmental Hotspots of the Life Cycle of Pumpkin Pulp: Conventional vs Waste-derived Preservatives*
	LCA-539	Katerina Katrini*, Vasiliki Kalogerakou, Asfra Rizwan Toor, Ioannis Daliakopoulos, Ioannis Mavrogiannis, Thrassyvoulos Manios *Comparison of Alternative Life Cycle Assessment Scenarios for the Management of Pruning Residues and Wastewater of Olive Oil Production*
	LCA-553	Akrivi Papadaki, Dimitrios Papadimitriou, Nikolaos Markakis, Michael Sabathianakis, Ioannis Sabathianakis, Ioannis Louloudakis, Georgios Daskalakis, Chryssa Bouki, Fenia Galliou, Ioannis Daliakopoulos, Thrassyvoulos Manios *Environmental Assessment of Integrated Robotic Cultivation System for Greenhouse Tomato Production*
VR		Reina Perez *Environmental impacts derived from a spanish crop producing PGI white bean using Life Cycle Assessment*
		Reducing the environmental Footprint of Agriculture
	AFR-484	Irene Christoforidi, Iordanis Papadopoulos, Dimitrios Papadimitriou, Marios Pnevmatikakis, Maria Tsitsiridou, Ioannis N. Daliakopoulos, Vasileios Tzanakakis, Maria Galliaki, Ioannis Louloudakis, Olga Topa, Manolis Tsichlis, Mariem Bakkari, Eya Marouani, Konstantinos Paschalidis, Antonia Psaroudaki, Ioannis Louloudakis *Pilot Intensive Cultivation of the Mediterranean Native Urospermum picroides*
	AFR-541	T. Manios, F. Galliou, A. Maragkaki, C. Bouki, G. Daskalakis, I. Daliakopoulos, A. Stasinakis, S. Vakalis, D-F., Lekkas, M. Fountoulakis *Utilizing Residues from Olive and Olive Oil Production for Environmental Protection and Soil Fertility Enhancement*
		Harvest and post-harvest management to reduce losses
	HAR-502	Verònica Taberner, María B. Pérez-Gago, Lluís Palou *Preliminary Evaluation of Pomegranate Peel Extracts for the Control of Postharvest Brown and Sour Rots of Nectarines*
VR	HAR-521	Sukru Esin*, Kübra Elmas, Rukiye Oca, Luwieke Bosma *Understanding Rodent-Induced Losses in Turkish Agriculture: Insights from a Farmer Survey*

AFR: Reducing the environmental Footprint of Agriculture

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rethink food resources, losses, and waste 2023 retaste

Heterotrophic growth of Galdieria sulphuraria on residues from aquaculture and fish processing industries

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Abstract

Residues from food and feed processing but also organic waste streams have been intensively investigated as nutrient sources in biotechnological processes. The overall goal was to utilise organic material instead of disposing it. Biotechnological processes allow for the formation of a broad range of products such as organic acids, bioplastics, proteins, or whole cell biomass which can even be applied for food and feed purposes. Depending on the composition different utilisation approaches need to be developed. In the past, the focus was mainly on carbon sources to be recovered and used in biotechnological processes. Nowadays, the focus has been shifted to the use of nitrogen compounds such as proteins and amino acids. This is due to environmental issues linked by its uncontrolled decomposition if not properly handled, but also due to the value of organic nitrogen compounds and the urgency of using it responsibly in circular concepts. The microalga *Galdieria sulphuraria* has been shown to grow on various hydrolysates of organic waste streams and to take up as well as use recovered nutrients for biomass formation. Thus, it was hypothesized that *G. sulphuraria* might also be suitable to convert waste streams appearing from aquaculture and fish processing industries. *G. sulphuraria* is due to its carbohydrate and protein contents highly wanted by respective industries. In the present study wastewater from fish processing, sedimented feed and faces collected from aquaculture ponds, and left-overs from the proteolytic hydrolysis of fish residues have been investigated as nutrient source in *G. sulphuraria* cultivation. The aim was to recover carbohydrates as carbon sources, amino acids as nitrogen sources as well as phosphate to establish a *G. sulphuraria* cultivation. Due to the nitrogen- and phosphate-rich composition of the used waste streams, the focus was on the recovery of nitrogen and phosphorous compounds. Results of this study revealed that from waste streams appearing from fish processing more than 1 g L^{-1} free amino nitrogen (FAN) and 1 g L^{-1} phosphate can be recovered by hydrolysis. *G. sulphuraria* did grow well on the produced hydrolysate and in presence of glycerol, another stream from fish processing, and growth rates of 0.7 to 1.0 day^{-1} were obtained. However, it should be admitted that G. sulphuraria required a proper composition of the nutrient medium. It was shown that the FAN and glycerol concentrations should not exceed 0.5 g L^{-1} and 20 g L^{-1}, respectively, to avoid a long lag-phase. To overcome this drawback and to achieve a high biomass concentrations fed-batch cultivation has been carried out, which resulted in a *G. sulphuraria* dry biomass concentration of more than 70 g L^{-1}. The outcomes of this study are expected to contribute towards an efficient utilization of aquaculture waste streams and a circular aquaculture economy. The controlled recycling of organic waste streams and the avoidance of an uncontrolled decomposition of nitrogen-rich materials contributes to a reduced

environmental impact of aquacultures.

Keywords: Protein residues, Bioeconomy, Algal biomass, Bioprocess, Fish processing

Acknowledgments: The authors acknowledge the German Federal Ministry of Food and Agriculture for providing funding within the Era-Net Cofund “FOSC-ERA” (Project Climaqua 2821ERA12) Program.

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Advances in science and technology for the production of biofuels and value-added products from the use of biomass and agricultural residues

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Abstract

With significant challenges ahead, advances in science and technology are providing various alternatives for the production of biofuels and value-added products. Among these options are the use of biomass and agricultural waste, which through proper management can lead to the generation of management schemes under the principles of sustainable development. The objective of this research was focused on showing a general overview of the scientific and technological trajectory of this field of knowledge through information obtained from the Scopus and Lens databases, which allowed the elaboration of a bibliometric, patent, and network analysis. In the first case, from the following search: (TITLE-ABS-KEY ("agricultural biomass" OR "agricultural residues") AND TITLE-ABS-KEY (biofuels OR "value-added products")), 1,085 documents were obtained and, with this, it was possible to analyse the main bibliometric indicators and to elaborate the network map. In the part of bibliometric indicators, the main results show, for example, that most of the scientific research is in areas such as energy, environmental sciences, chemical engineering, biological and agricultural sciences, and engineering, and that the leading countries in this area are the United States, India, China, Canada and Germany. With respect to the network analysis, a map was obtained consisting of 16 clusters, 244 nodes, 2,059 links and a total link strength of 3,325 where the most recurrent themes mention associated aspects such as enzymatic hydrolysis, lignocellulosic biomass, anaerobic digestion, pre-treatment, among others. In the second case, the patent analysis indicates that through the following search: (Title: ("agricultural biomass" OR "agricultural residues") OR (Abstract: ("agricultural biomass" OR "agricultural residues") OR Claims: ("agricultural biomass" OR "agricultural residues")))) AND (Title: (products OR materials) OR (Abstract: (products OR materials) OR Claims: (products OR materials)))), a total of 272 granted patents were obtained and grouped into 202 simple families. This section shows, for instance, that the relevant jurisdictions in this type of technology are the United States and European patents. Applicants include companies such as Xyleco Inc, Du Pont, Novozymes Inc, US Agriculture, and Virent Inc. Regarding the technological sectors according to the IPC (International Patent Classification), the categories C12P19/02, C12P7/10, and C12P19/14, subclassifications of the subclass C12P focused on fermentation and enzymatic processes for different purposes, predominate. Finally, the co-occurrence analysis generated a network with 8 clusters, 161 nodes, 1,726 links and, a total link strength of 13,645, where relevant nodes related to topics such as enzymes, lignocellulosic material, hydrogen, among others, are observed. In conclusion, the results provide a general overview of the scientific and technological trajectory that could represent a starting point for the generation of policies and

management schemes that promote research and development (R&D) activities to generate different inputs through sustainable schemes.

Keywords: Biofuels, value-added products, biomass, agricultural residues, innovation.

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Potassium, Nitrogen and CO2 Sequestration

Jiftah Ben Asher

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Abstract

The Kyoto Protocol imposed limits to industrial emission of six greenhouse gases (GHGs) the years 2008-2012. (mostly CO_2 and N_2O). Concomitantly, it recognized three mitigation actions, all associated with land-use. Within this category, crop residue, and nitrogen management with respect to carbon sequestration have been evaluated qualitatively. No attempt has been made to evaluate quantitatively the impact of plant nutrition on CO_2 sequestration. Potassium and nitrogen are of particular interest in land use category since crops are very responsive to them. Specifically important is K because its production processes requires considerably less energy than nitrogen for fertilizer manufacture and at an adequate level in plants can enhance N-use efficiency (NUE). This improving effect of potassium on NUE thus optimizes N management, while contributing to a lowering in emission of N_2O. The objective of this study was to quantify crop potential to reduce atmospheric CO_2 concentration and comparing a model with experimental results. The Global Potential Carbon sequestration (GPCS) calculations are based on a widely used soil-crop model known as DSSAT (Decision Support System for Agro-technology Transfer. Hoogenboom G et.al. https://DSSAT.net.)/ It has been modified to combine with NPK application, coupling it with the QPAIS model (Zhang et al., 2007) to obtain the actual carbon sequestration (ACS) as output. The simulated total corn dry matter (DM) weight in an arbitrary fertilization control resulted in the following: Applying 100 kg/ha K (at N=200 and P=100) increases the DM yield from 15,515 to 20,357 kg/ha and associated GPCS that increased from 7,137 to 9,364 kgC/ha. Hence the application of 100 kg/ha K resulted in an additional 2,227 kg/ha Carbon bound in the plant material (equivalent to ~8,166 kg/ha CO_2), or 22.3 kg/ha of C per 1 kg of K. that was sequestrated from the Atmosphere. This contribution of 100 kg/ha K to C sequestration is the calculated GPCS and is equivalent to 81.8 kgC/ha CO2/kg K. The Potential Carbon Sequestration (PCS) i.e. binding of carbon only in the root system under zero CO_2 efflux from soil can be also evaluated from the model. Here, root DM increased from 1,875 to 2,852 kg/ha in the K amended soil. Hence the application of 100 kg/ha K resulted in 449 kg/ha C being bound in the roots (equivalent to 1,646 kgC/ha CO_2), or 7.6 kg/ha CO_2/kg K. The model assumes that Actual Carbon Sequestration (ACS) is 30-70% of the PCS, which leads to the calculation of ACS to be 394-918 kg C/ha per 100 kg of K. Predicted soil CO_2 sequestration per kg fertilizer K exceeds considerably the CO_2 emission per kg K in industrial potash production (14–24 vs. the industry-reported 0.2–0.6 kg CO_2 [kg K]$^{-1}$).

Keywords: greenhouse gases (GHGs), CO2 sequestration, fertilizer application.

References

None

Acknowledgments: Dead sea Work israel

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Environmental Impacts Derived from A Spanish Crop Producing PGI White Bean Using Life Cycle Assessment

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Abstract

Growing population, dwindling resources, and changing climate have increased the pressure on agriculture. Pulses, which include leguminous crops such as beans, peas, chickpeas, and lentils, can play a major role in increasing production of the agricultural sector while enhancing sustainability. In this context, the availability of reliable tools to evaluate environmental aspects is crucial. Life Cycle Assessment (LCA) has proved to be a valuable methodology for researchers, growers, and policy makers. Annual global production of common bean (Phaseolus vulgaris L.), which has been reported as the most important legume for direct human alimentation, exceeds 26 million tons. Additionally, Spain is one of the principal EU-countries producing and consuming legumes. This work has evaluated the environmental impacts derived from the production of PGI “Faba Asturiana” by means of LCA methodology with the aim to widen the knowledge on the environmental behaviour of legume crops in Europe. The case study has been a small-scale organic crop sited in the North of Spain that annually produces around 1,000 kg of dry beans. The system boundaries included from the production of raw materials to the orchard gate (“cradle to gate” perspective), being 1 kg of dry beans the functional unit (FU). Impact assessment has been carried out with the LCA Simapro 9.5 software using the ReCiPe 2016 Midpoint (H) V1.08 method. In addition, the Greenhouse Gas Protocol (GHG) V1.03 method has been employed to calculate the carbon footprint (CF). Results showed that the main contribution to the environmental impacts was the electricity consumption, accounting for more than 30% in 13 of the 18 categories analysed. This subsystem was especially harmful in ionizing radiation (96%), non-carcinogenic toxicity (75%), mineral resource scarcity (68%), fine particulate matter formation (55%) and in those categories related to ecotoxicity (terrestrial, freshwater and marine) (>50%). A CF of 1.20 kgCO2eq per kg of dry beans was obtained, value within the range reported by other authors for leguminous crops (0.1-1.24 kgCO2eq per kg of seeds). Again, electricity consumption was the major responsible for CF value, followed by emissions to atmosphere derived from waste incineration and diesel use. Another key factor for CF was land productivity. It has been reported that a crop of PGI “Faba Asturiana” adequately exploited can produce annually above 1,500 kg/ha, whereas in the case study analysed here only 884 kg of dry beans were obtained per ha. One of the main reasons of this low yield might be the repetition of this specific crop on the same land, which could negatively affect productivity. According to the results obtained, the proposals to reduce the CF in the crop considered would be related with decreasing electricity consumption (or using renewable energy sources) and/or implementing good agricultural practices that allow incrementing productivity.

Keywords: LCA, Phaseolus vulgaris, leguminous, carbon footprint, environmental assessment

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Development and Sustainability Assessment of Rice Straw-based Circular Economy

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Abstract

Rice production plays an essential role in food security and the social and economic development of Asian and African countries. However, rice is currently fraught with various issues, such as vulnerabilities in climate change and low productivity. At the same time, rice production has a high environmental footprint. Rice straw burning further exacerbates the problem. Managing rice straw remains a challenge which globally produces about 500 million t of rice and the same amount of rice straw each year. Labor shortage for straw collection, the low economic value of rice straw, and lack of economically viable knowledge lead to the predominant practice of straw burning. In-field burning of rice straw leads to biodiversity loss, soil nutrient loss, and human health problems. This paper introduces a rice straw-based circular economy associated with supporting technical solutions and performance indicators. The circular economy model was developed and tested in the Mekong River Delta of Vietnam. It includes sustainable rice contract farming, straw-based bio-fertilizer, bio-plastics, urban agriculture, and business model developments. Life-cycle assessment was used in analysing the sustainable indicators. The study demonstrated the sustainable benefits of the rice straw-based circular economy through its performance indicators of profitability, nutrient use efficiency, and carbon footprint. In addition, the study also provides recommendations for developing and implementing standards or good engineering practices for sustainable rice straw management.

Keywords: circular economy, sustainability, climate change, carbon footprint, resilience, rice

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Biochar as a Priming Agent

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Abstract

Biochar is a product of carbonization, obtained through the pyrolysis of organic wastes. Biochar has received increasing attention because of its distinctive properties. Biochar can be used in various applications particularly for carbon sequestration, as a soil amendment and for bioremediation (Seyedsadr et al., 2022; Mukherje et al., 2022). Among these applications, biochar has a great potential to use for agricultural purpose. Biochar addition into soil improves soil texture and increases soil fertility by increasing the pH and cation exchange capacity and promoting aggregation of the moisture and nutrient retention ability (Kumar et al., 2022). Moreover, the porous surface of biochar which serves as a refuge for microbes from predation, enhances microbial activity and functions. Seed priming is a pre-sowing strategy for influencing seedling development by modulating pre-germination metabolic activity prior to emergence of the radicle and generally enhances germination rate and plant performance (Golezani et al., 2008). Common priming techniques include osmopriming (soaking seeds in osmotic solutions such as polyethylene glycol), halopriming (soaking seeds in salt solutions) and hydropriming (soaking seeds in water). The elimination of the use of chemicals in pre-germination applications and the use of environmentally friendly biochar instead of them is very important for sustainable agriculture. The mineral fraction of biochar comprises macro- and micro-elements which may act as a source of minerals for seeds (Saletnik et al., 2019). There is only one study in the literature on the use of biochar in priming. Saletnik et al. (2019) used the biochar in priming and reported that adding biochar to water to be used in hydroconditioning process improved the germination capacity of seeds Virginia mallow by 20%. However, the effect of biochar on germination was not investigated extensively in their study. The objective of this study is to investigate the usability of biochar in the priming to improve seedling performance of seeds. For this purpose, the biochars, which were obtained from different biomasses, were tested in priming of pepper seed. To understand the effect of biochar types and dosing on priming, the biochars obtained from six different biomasses (animal waste, lignocellulosic wastes and carbohydrate-rich wastes) at different temperatures (300, 400, and 500 °C) were used at different ratios (2.5%, 5% and 7.5%) in priming tests. Priming performance of biochars were controlled by germination and seedling emergence tests. The chemical and agronomic charecteristics, such as WHC, CEC, and water exctractable nutrients, were determined using standart analysis methods. Chemical composition of aquation phase after priming was also analyzed. It was observed that the priming using biochar increased germination capacity of seeds. But, the extent of increase varied depending on biochar type and dose. It

was found that both soluble nutrients and some organics having plant growing hormons in biochar showed effect an increase in germination performance of pepper seed.

Keywords: Biochar, Priming, Seed

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Should composting in polyethylene sleeves with forced aeration be considered a practical solution during disease outbreaks in poultry farming?

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Abstract

Mass depopulation is one of the immediate acts taken during disease outbreaks in poultry worldwide. The carcasses and the infected litter can be managed on-site or off-site, mainly through burial or composting. On-site treatment methods are preferred to minimize disease spread during transportation, although on-site composting has adverse outcomes due to potential malodor emissions. On-site open windrows operated within the poultry house appears as a preferred method in USA and Australia. However, pathogens eradication may not be complete if thermophilic temperatures are not achieved throughout the entire pile, even after several turnings. Composting in polyethylene sleeves with forced aeration was considered in the present study as an alternative for in-house composting following mass depopulation in disease outbreaks. We demonstrated that such sleeves could be constructed manually and therefore do not require special emergency machinery. Regarding sanitary considerations, the main advantage of aerated sleeves is the potential to maintain high thermophilic temperatures within the entire biomass. In a side study on carcass parts co-composted with the litter in lab reactors, we found mass losses of about 60%, 40%, 60%, and nearly 100% for rib bones, skins, breast muscles, and hearts and livers, respectively, during 30 days at 50 °C under constant aeration. Visually, most of the carcass parts were degraded, and the typical carcass odor had disappeared by the end of the 30 days. We then demonstrated in lab reactors the effect of temperature (40, 50, 60 °C) and aerobic/anaerobic conditions on the degradation of whole broiler carcasses and the successful elimination in most cases of pre-inoculated Avian flu, Newcastle, and *Salmonella Infantis* at 50 and 60 °C. The method taken for mass destruction also has practical implications for biomass management. In that case, the use of water-based foam, as compared to dry methods, totally affects the water balance in the sleeve along the process. We developed a calculator to

estimate excess water inside the sleeve based on lab-scale experimental degradation rates, mass losses, and biomass water holding capacity. This calculator can predict the water balance for different relevant scenarios, such as packing the entire biomass of the poultry house (60 m^3) in one or two sleeves and assuming a total biomass degradation of 30% during one month (1% daily). Aeration (water evaporation) was considered in a range of 100-300 m^3 h^{-1} for different time fractions. Various conditions have been analyzed for mass destruction cases by means of water-based foam or dry methods. The water balance in the sleeve during composting is a critical element that will affect the ability to achieve good aeration conditions and other operational issues. Excess water is expected in some scenarios, when wet methods are used. Some excess water can be absorbed by adding sawdust or wood chips or splitting the biomass into several sleeves assisted with increased ventilation, as long as the composting material does not cool down too early.

Keywords: Mass mortality, Mass depopulation, Mass destruction, Enclosed composting, Water balance, Pathogens

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Pilot Intensive Cultivation of the Mediterranean Native Urospermum picroides

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Abstract

The increasing inputs of chemical fertilizers and the worldwide adoption of new cultivation techniques has increased crop production and improved food security (Nerlich and Dannehl, 2021). However, the extensive application of chemical fertilizers in arable lands has long been proven to cause soil degradation, greenhouse gas emissions and water contamination (Chaney, 2012). The last decade, several alternative cultivation practices have been proposed for reducing the use of chemical fertilizers (Chew et al., 2019). On this aspect, the partial replacement of chemical fertilizers by alternative organic fertilizers has been recognized as a prominent solution to the problem (Rojas-Valencia et al., 2011). At the same time, recent research focuses on the domestication of endemic wild edible green species, due to their culinary, medicinal and gastronomic importance (Ansari et al., 2005; Petropoulos et al., 2016; Tsiftsoglou et al 2023) and also as part of the agroecosystem's conservation, in urban environments (Christoforidi et al., 2022). *Urospermum picroides* is a typical wild edible plant of the Mediterranean region, which could be considered as a promising candidate for introduction in intensive cropping systems. *U. picroides* consumed in the Cretan Mediterranean dietary pattern as boiled alone or together with other wild edible plants (Psaroudaki et al., 2012, 2015). Even though several scientific reports indicate that the plant is rich in secondary compounds with antimicrobial and antioxidant activity with health promoting properties, literature evaluating the exact cultivation practices that can increase crop yield while ensuring reduced environmental footprint, is scarce (Alper and Güneş, 2019; Balboul et al., 1997; El-Amier et al., 2016). In this context, we examine the effect of organic and mineral fertilizers in an intensive open field cultivation of *U. picroides*. The field experiment was set up in the Experimental Farm of the Hellenic Mediterranean University in Heraklion, Crete, Greece. A total number of 400 seed plants from *U. picroides* were planted and five fertilization treatments were assessed, i) a control treatment (without

any fertilization) (CO), ii) Liquid organic fertilizer (TF), iii) Organic Nitrogen (TR), iv) Conventional 20-20-20 water-soluble fertilizer (CV) and v) combination of the Conventional and Organic fertilizers (CF), arranged in a completely randomized experimental design (four replicates per treatment and 20 plants per experimental unit). Fertilization was applied at intervals of 15 days from transplant until harvest. Photosynthetic parameters of leaf relative chlorophyll fluorescence (Fv/Fm) and relative chlorophyll concentration (SPAD) were assessed at 30, 45, and 60 days after transplant (DAT) and yield characteristics of shoot fresh weight (g) and number of leaves were determined at 70 DAT. Results show that treatment TF significantly increased plant maximum quantum yield efficiency (Fv/Fm) (0.815±0.002), shoot fresh weight (73.50±13.66 g) and number of leaves (38.07±3.65) compared to TR (0.723±0.006, 46.06±5.33, and 30.07±4.56, respectively) and CO treatments (0.707±0.003, 42.79±9.46, and 26.93±3.52, respectively), 70 DAT. However, no significant effect was observed in relative chlorophyll concentration (SPAD) among the tested fertilization treatments, 70 DAT. Consequently, the results indicate that the effect of TF was more pronounced in all of the evaluated physiological and plant growth parameters compared to the control treatment without any significant differences being observed between the different kind of the tested fertilization products. The current findings are encouraging for the commercial production of *U. picroides*, with beneficial health-promoting properties, in open field cultivation systems and for the adoption of alternative fertilization methods such as the organic fertilizers for reduced environmental footprint.

Keywords: Mediterranean native plants, Cretan diet, INM bio-fertilizer, DA Meter, Fluorometer, Spad

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Unlocking the Potential of Agricultural Waste in Malaysia for Sustainable Applications as Thin Films

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Abstract

This comprehensive technical abstract provides an overview of fibre extraction from various agricultural waste sources. These abundant resources have gained significant attention as renewable sources for fibre extraction and subsequent utilization in film forming formulations, and electrospun mats. The study primarily focuses on pineapple leaf fibres (PALF), which are agricultural byproducts resulting from pineapple cultivation and are rich in cellulose. Similarly, rice straw (RS) and rice husk (RH), byproducts of rice cultivation and milling process, contain valuable fibres that can be extracted through alkaline treatments (Lai et al., 2022; Nasir et al., 2022). In Malaysia, palm oil empty fruit bunch (OPEFB) has also been identified as a plentiful and underutilized resource for extracting fibres that is rich in cellulose and lignin (Zainal Alam et al., 2020). Furthermore, herbal processing wastes, despite their potential as valuable sources of cellulose, are often overlooked in research and industrial applications (Kandemir et al., 2022). Hence, we also reported on cellulose extraction from herbal plants, specifically Tongkat Ali (TA) scientifically known as Eurycoma longifolia and Orthosiphon aristatus (OA) (Mohd Bohari et al., 2021) and compared with PALF extraction. The extraction of cellulose from PALF, RS, RH, OPEFB, TA and OA offer an environmentally friendly alternative to conventional fibres, as they contain a significant amount of cellulose. To fully exploit the potential of these lignocellulosic biomass, either the agricultural or post herbal processing wastes, our group has carried out a series of chemical treatments of these biopolymers. Through our investigation, we have recognized the importance of chemical pre-treatment as a vital step in the process. The effective removal of non-cellulosic components through chemical pre-treatment significantly enhances the suitability of cellulose for various applications, particularly in terms of its film forming properties. This process opens a wide range of possibilities, allowing cellulose to be utilized in diverse fields where film formation is crucial. Specifically, the alkaline treatment was carried out to PALF, OA and TA by using 10 % (w/v) of sodium hydroxide NaOH), followed by bleaching with 10% of sodium hypochlorite (NaClO). For RS, the extraction of cellulose was conducted by varying concentrations of NaOH ranging from 2 to 12%, in order to determine the optimal condition that would give the highest yield (Lai et al. 2022). Some fibres, like RH required for acid pre-treatment also for complete removal of the amorphous region. Meanwhile, we also further delignified OPEFB by subjecting it to hydrolysis using hydrogen peroxide. Based on the FTIR analysis, the absorption bands at 1740 cm-1, represents C=O stretching of hemicellulose were absent in the spectra of TA, OA and PALF. Meanwhile, for

the RH fibre, the absorption band of 1730 cm-1 associated with the presence of C=O carbonyl groups associated with hemicellulose and lignin was completely removed after treatment with 4, and 12 vol.% of NaOH (Nasir et al., 2023a). The FTIR spectrum also revealed that the peak assigned for C=O acetyl group of hemicellulose ester in the lignin unit, typically observed at 1735 cm-1, was not detected in the bleached OPEFB. We could further confirm that 6% of NaOH treatment was optimum for RS fibres for lignin removal base on FTIR analysis together with weight loss data (Lai et al. 2022). Moreover, the weight loss analysis demonstrated the effective removal of impurities on non-cellulosic component; whereby TA, OA and PALF exhibited a reduction of 31.52 %, 58.38%, and 42.90%, respectively after undergoing alkaline treatment and bleaching. It was also observed that the treated fibres exhibited a brighter appearance after the treatment process. This change in appearance suggests the removal of impurities and non-cellulosic components that may have contributed to a darker colour in the untreated samples. SEM analysis of the treated fibres revealed a strand-like morphology that is closely resembled commercially available cellulose. Transparent and flexible films were formed by dissolving cellulose valorised from various resources in a solvent mixture of dimethylacetamide/lithium chloride and then regenerating it via phase inversion. Despite having one of the lowest crystallinities, among other fibres, cellulose from OA still exhibits film-forming properties. This suggests that cellulose derived from herbaceous waste, such as OA, holds great potential for utilization in various applications (Mohd Bohari et al., 2021). The crystallinity analysis revealed that PALF had the highest crystallinity (76%), followed by TA (64%) and OA (57%), OPEFB (54%) and RH (51%). The film was also characterised by its gel content without and with the washing step to remove dissolvable shorter polymer chain prior to the measurement. For instance, the gel content of RS-film (98.7%) (Lai et al. 2022) obtained after washing was higher than the OPEFB-film (42.2%) obtained without the washing step. Additionally, we have successfully converted the extracted cellulose from RH into cellulose acetate and further processed it into nanofibrous mats using electrospinning techniques. We are also able to demonstrate that the RH-based nanofibrous mats possess high porosity (76-81%) and excellent water absorption capacity (maximum swelling ratio of 446) which are promising properties for potential wound dressing materials (Nasir et al., 2023b). In summary, these studies demonstrate the untapped potential of agricultural waste from pineapple leaf, rice straw, rice husk, and oil palm empty fruit bunch across different fields. The utilization of these fibres opens up new avenues for developing advanced materials with tailored properties, especially in film forming ability to form hydrogel and also nanofibrous electrospun mats for potential wound dressing application. Valorisation of agricultural waste offers sustainable solutions for waste management and contributes to a greener and more environmentally conscious future. These innovative approaches to utilize agricultural waste resources demonstrate the potential to revolutionize various fields, including biomedicine, agriculture, and environmental engineering, promoting SDG 3: Good Health and Well-Being and SDG 12: Responsible Consumption and Production.

Keywords: Pineapple leaf fibre, Thin film hydrogel, Cellulose, Wound dressing, Electrospun

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Utilizing Residues from Olive and Olive Oil Production for Environmental Protection and Soil Fertility Enhancement

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Abstract

In the Mediterranean area, olive grove soils are mainly characterized by a low carbon content (Trigo et al., 2009), while they are particularly vulnerable to erosion and subsequent desertification (Ping et al. 2015). Nowadays, it is considered necessary to increase the organic matter in olive groves to improve their quality and consequently their fertility (Fernandez-Romero et al., 2016). Shredding and incorporating olive pruning is a suggestive alternative solution, as opposed to their traditional burning method, significantly limiting CO_2 emissions and reducing the loss of organic matter from the olive grove itself (Koubouris et al., 2018). However, this approach, also increases the risk of diseases and insects spread in the fields (Benyei et al., 2018). On the other hand, composting olive pruning before incorporating it into the soil ensures the production of a high quality and stabilized organic material, free of pathogens (Ghoneim et al, 2017). Also, olive mill waste contains significant amounts of nutrients, mainly N and K, which after appropriate treatment could also be incorporated into the soil for crops nutrition (Galliou et al., 2018). Finally, studies have shown that using biochar as a soil conditioner can also be a useful tool for adapting to climate change (Stavi et al., 2003). Biochar produced from olive pruning has higher nutrient content and a higher cation exchange capacity compared to other materials (Alburquerque et al. 2016). In the preset study, the project “ELAIONAS” will be presented. It will be implemented in two regions in Greece, with a long tradition in olive cultivation, Lesvos and Crete. The olive tree pruning that will be produced from the “pilot olive groves” in these two specific areas will be crushed and incorporated into the soil after composting. The innovative process that will be implemented at “ELAIONAS” project involves the use of the olive mill waste from the olive mills after sedimentation, to regulate the humidity in the compost windrows. In addition, in the olive mill, the sludge from the sedimentation tank will be co-composted with the olive leaves to produce excellent quality compost, which will also be beneficial for crops. At the same time, biochar - the residue of the charcoal production process from the thick olive wood - will be used in the crops themselves. In addition, the production of hydrochar from the olive mill waste by the process of hydrothermal carbonization will also be examined. Afterwards, soil improvers will be applied to olive groves in Crete and Lesvos. The olive groves will be monitored for a period of approximately two years to assess the benefits and the impacts on the olive grove system. Overall, the “ELAIONAS” project aims to contribute to the development of an improved, on-site

management system for the integrated utilization of olive growing and olive production residues. By following the Circular Economy model this endeavor seeks to enhance the well-being of olive crops and the environment.

Keywords: agro-industrial waste, biochar, composting, olive mill waste, olive grove

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AWR: Alternative Water Resources and Wastewater Reuse

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Green solutions to reduce the carbon footprint of resource-intensive industries

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Abstract

The textile industry is crucial for many countries and their economies due to the social, economic, cultural, and environmental impact. The textile industry and its different sectors employ more the 60 million people and consume yearly close to 1 trillion kWh and 9 trillion liters of water. Water consumption in the textile industry depends on the type of fiber, the productive stage, the operation mode of the process, and the availability of the region. For example, during the processing of fibers like wool (100-300 L H_2O/kg) and cotton (80-200 L H_2O/kg) more water is consumed than during nylon processing (50-120 L H_2O/kg) or acrylic (30-80 L H_2O/kg) [1,2]. Although the staining stage consumes only a fraction of the water (20-30%) that goes into the process, the amount of used process auxiliaries makes the generated effluents to be considered as recalcitrant and, therefore, hard to treat by conventional biological processes [3]. In this work, we analyzed the impact of chemical and thermal intensification on the performance of Fenton and photo-Fenton processes during the treatment of a staining bath. The intensifying agents used were temperature (40, 50 °C) for the Fenton process and sodium oxalate ($Na_2C_2O_4$) for the photo-Fenton one. All processes were modelled in continuous mode in Simulink-MATLAB 2020 (MathWorks). The cost analysis considered the fixed and operational costs. The analysis of environmental performance of the process was done through a life cycle analysis using the openLCA (v1.9, database: ecoinvent v3.4) software and the ReCiPe-2016 v1.1 impact analysis method. It is feasible to attain a higher than 98% discoloration with the Fenton technologies; the consumption of electricity, due to the long treatment times, 12 h, leads the carbon footprint to reach a maximal of 6 (kg CO_2 Eqv./m^3 treated water). Thermal intensification reduces the reaction time, operational costs, and environmental footprints of the Fenton process in 58% (5 h), 28% (US$1.8/$m^3$), and 25% (4.5 kg CO_2 Eqv./m^3 treated water), respectively. On the other hand, the use of Na_2CO_3 allows operating at a neutral pH and intensifies the Fenton reaction without affecting the efficiency of the treatment, the operational cost of the process, and the environmental footprint associated to the use of reagents. A process assisted with Na_2CO_3-solar radiation reduces the treatment time (75%, 3 h) and the environmental footprint of the process (57%, 2.6 kg CO_2Eqv./m^3 treated water). The thermal and/or chemical intensification is a key element to improve the sustainability of Fenton processes because it impacts directly and significantly the reaction time. Transport of materials was not significant for the environmental footprint of the process (< 2%), whereas the consumption of reagents like NaOH, H_2SO_4, and H_2O_2 constitute less than 20% of the environmental footprint of the Fenton processes. The use of Na_2CO_3-solar radiation leads to a

more sustainable process, but its main disadvantage is the availability or not of local solar radiation. The emission of contaminants that lead to the formation of particulate matter, acidification, eutrophication, and marine and terrestrial ecotoxicity was significantly reduced (40-70%).

Keywords: Carbon footprint, intensification, life cycle assessment, textile industry,

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Zinc (Zn) alleviates copper (Cu) toxicity and rescues quality of lettuce grown in metal contaminated simulated wastewater

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Abstract

Wastewater (WW) contains heavy metals (HM) like copper (Cu) and zinc (Zn) which are beneficial at their lower concentrations but toxic at their higher concentration (Ullah et al., 2023). Shortage of freshwater compels farmers to use WW as a source of irrigation. Besides, WW has substantial amount of nutrients and organic matter necessary for plant growth. In this study it was hypothesized that Zn could ameliorate the hazardous impacts of Cu on lettuce when irrigated with highly Cu and Zn contaminated WW. Thereby, lettuce plants were grown in pots containing field soil irrigated with following treatments (i) Control or uncontaminated WW, (ii) Cu contaminated WW (Cu 20 mg L^{-1}), (iii) Zn contaminated WW (Zn 100 mg L^{-1}), and (iv) Cu+Zn contaminated WW (Cu 20 mg L^{-1}+ Zn 100 mg L^{-1}). Each treatment replicated thrice following a completely randomized design. Plants were grown in controlled condition of growth chambers and harvested at maturity. In results, irrigation with Cu contaminated WW caused a substantial reduction in growth and quality attributes of lettuce. In contrast, irrigation with Zn contaminated WW either alone or in combination with Cu left positive influence on lettuce growth and quality attributes. Addition of Zn to Cu contaminated WW retrieves the hazardous influence of Cu toxicity, hence, improved root dry matter, shoot dry matters and root length by 13.5%, 46% and 19%, respectively. Moreover, Zn addition improved lettuce quality with increased concentrations of Mg (30%), P (15%), Ca (41%), Mn (24%) and Fe (23%) as compared to control. Thereby, these findings intimate that high levels of Zn in HM contaminated WW could alleviate the hazardous influences of HM on crop growth and quality.

Keywords: Zinc · Copper · Lettuce · Minerals · Phytotoxicity · Leaf quality

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Ullah, S., A. Naeem, I. Calkaite, A. Hosney, N. Depar and K. Barcauskaite. 2023. Zinc (Zn) mitigates copper (Cu) toxicity and retrieves yield and quality of lettuce irrigated with Cu and Zn-contaminated simulated wastewater. Environmental Science and Pollution Research. https://doi.org/10.1007/s11356-023-26250-8. IF-5.19.

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GIS-Based Model to Investigate the Potential of Treated Wastewater for Irrigation

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Abstract

Nowadays, water shortages and water pollution represent two of the worldwide main challenges. In particular, the agriculture sector is the major water user, and it is expected to become more negatively influenced by water scarcity due climate change. Indeed, the reduction in freshwater availability, due to agricultural irrigation, in the context of climate change and population growth, is one of the main threats to the EU water environment. The use of reclaimed water as non-conventional alternative source of water supply (i.e., treated wastewater) could represent a sustainable and cost-efficient valid solution to face up to water scarcity-related issues. However, treated wastewater contains nutrients needed for crop growth, high percentage of this is currently discharged without being reused, implying that most of this resource is wasted without being exploited. Therefore, with the aim of overcome water scarcity issues, the assessment of potential treated wastewater in terms of quantification and localization is urgently needed. Although this topic was worldwide investigated by researchers to define the exact amount of treated wastewater, nowadays there is still a lack of data on the real quantities that are discharged from wastewater treatment plants (WWTPs). Not only the quantification but above all the spatial distribution of this WWTPs is needed since those are key factors for implementing the reuse of treated wastewater in agricultural irrigation. In this respect, Geographical Information Systems (GISs), are worldwide known as a useful tool to analyze the geographical distance and therefore could be adopted to developed tailored GIS-based model. In this regard, the aim of this research was to develop a methodology by using GIS to assess the potential of treated wastewater reuse in agricultural irrigation. The developed methodology was applied to a territorial area selected as study area in Northern Italy. GIS software was adopted for carrying out all the spatial analyses, integrating data provided by the Romagna Reclamation Consortium within the time interval 2017–2019 and thematic maps acquired by the network services provided by National Geoportal. Different criteria were taken into account to evaluate the treated wastewater capability to satisfy crop water needs by considering both the irrigated areas and potential irrigable areas, respectively. The achieved results confirmed the possibility of extending the water distribution network creating new irrigated areas (potential irrigable areas). In addition, in the selected case study, crop water needs could be largely satisfied by treated wastewater, confirming that it is a valuable and alternative water resource that can help to increase food production and thereby meet the growing food demand. Furthermore, since treated wastewater reuse is still not a widespread

practice in Italy, and as it was demonstrated, could represent a valid alternative and constant water resource quantity over time, future research should focus on the quantification of the fertilizers saved depending on the water characteristics. The developed GIS-based model could be applied to other study areas with the aim of increasing the treated wastewater reuse practices.

Keywords: treated wastewate, water reuse, agricultural irrigation, GIS

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Reclaimed Water Reuse Potential in Agricultural Irrigation for Europe

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Abstract

As in other parts of the world, in Europe water resources are increasingly coming under pressure. The agricultural sector is extremely vulnerable to climate change, and in the same time it is also the largest water user and a major polluter of water. As consequence, water stress and insufficient water quality are leading to the limited capacity to meet crop water needs, compromising also food supply and security. The use of “non-conventional” water resources is essential to overcome the irrigation water shortage as well as to prevent the pollution of available freshwater. In this context, reclaimed water has been recognized as a valuable water resource that can be used to reduce climate change’s effects and to ensure the security and sustainability of agricultural supply. In particular, the use of reclaimed water for agricultural irrigation might help to meet crop water needs and recover nutrients (e.g., nitrogen and phosphorous) from wastewater, reuse them for crop production and therefore reduce the use of fertilizers. However, wastewater needs to be properly treated before being used for agricultural irrigation. Not by chance, the new regulation EU 2020/741 sets out minimum water quality requirements to ensure safe water reuse. In detail, the regulation EU 2020/741 identifies four classes of reclaimed water quality (from A to D) in relation to the intended agricultural use and irrigation method. Despite its beneficial effects, the reuse of reclaimed water in agricultural irrigation is still not a common practice in Europe and it is deployed considerably below its actual potential. Therefore, the aim of this research was to assess the potential of reclaimed water reuse in agricultural irrigation at the European scale. A spatial analysis was performed by using Geographic Information Systems (GIS) and considering the data on available water resources (e.g., freshwater, reclaimed water) and crops distribution within the EU-27 Member States. In detail, a tailored methodology was developed by following four different phases aimed to: 1. assess the current pressure exerted by agricultural irrigation on available freshwater; 2. evaluate the amount of available reclaimed water and its capacity to satisfy crop water needs; 3. analyse the possibility of treating all the produced/collected wastewater to increase the current amount of reclaimed water; 4. classify crops in water quality classes in accordance with the new regulation EU 2020/741. The research outcomes showed that, among the EU-27 Member States, 9 are already experiencing low water stress and 1 high water stress. Therefore, reclaimed water might be used to satisfy crop water needs in different European countries and water availability increased in the case all the collected wastewater is treated and later reused in agricultural irrigation. The most spread crops in Europe can be irrigated

with water quality classes “B” and “C”, reducing the level of treatment needed and associated costs. Furthermore, the use of reclaimed water might make the EU food system more sustainable and resilient. However, the adoption of additional precautionary measures (e.g., selection of the most appropriate irrigation method) is mandatory, while protecting public health and the environment.

Keywords: reclaimed water, treated wastewater, water reuse, agricultural irrigation, EU 2020/741 regulation, GIS

Acknowledgments: This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This oral presentation reflects only the authors’ views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

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Assessment of Sewage Sludge Hygienization Methods for its Accelerated Use in Agriculture

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Abstract

Up till recently, sewage sludge has been regarded as waste with high risks and problematic re-use and due to its considerably lower quantities than solid waste it has been neglected in circular economy targets Furthermore, health and environmental risks have been identified, mandatory targets have been set by the EU Landfill Directive to reduce the biodegradable landfilled fraction, and cautious approaches have been adopted by countries towards the spreading of the material on agricultural lands for health reasons. Nevertheless, constant increase in sludge quantities has been observed globally. In EU the amount of sewage sludge produced per year was 10 million tonnes in 2008, 11.5 million tonnes in 2015 and is expected to approach 13 million tonnes of dry matter (DM) by 2020. Many countries have already set up national wastewater management strategies to aid the industry, especially in resolving issues with sludge disposal. In other countries, including Latvia, the problem is still left to the individual wastewater treatment company. At the same time the importance of sewage sludge as potential resource has already been recognized in global community. Sludge management is one of the most difficult and challenging tasks of wastewater treatment plants due to its high water content and poor dewaterability and strict regulations for sludge reuse or disposal. This also includes the methods to be applied for hygienization and stabilization for prolonged period of time that requires extensive territories of land and cause unpleasant odours. This research describes the aspect of hygienization from the agricultural plant growth angle and deals with introduction of several methods to rapidly hygienize the sludge and directly apply for plant growth without stabilization. Biological sludge from municipal sewage system was collected, treated (addition of calcium compounds, thermal treatment, and UV irradiation) and mixed with non-sludge origin soil. Further, peas were grown in the samples and their growth and biomass development recorded.

Keywords: sewage sludge, hygienization, wastewater management

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Co-treatment of Municipal Wastewater and Organic Wastes in an Up-flow Anaerobic Sludge Blanket (UASB) Reactor

Mahmoud Abdallah and Mahmoud Al-Hindi

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Abstract

The treatment of domestic wastes where they in liquid form (wastewater) or solid form (organic and inorganic) is of major environmental and public health concerns in several developing countries. Unfortunately, and due to several ongoing crises, a considerable portion of the domestic wastes generated in Lebanon are disposed of, untreated, in aquatic reservoirs and unsanitary landfills. This occurs despite the valuable resources (bioenergy, re-used water, nutrients) that can be exploited. Whilst several technologies (the vast majority of them aerobic in nature) have been utilized for the treatment of domestic wastewater, more recently anaerobic methods have gained traction: anaerobic treatment has demonstrated several preferences over conventional aerobic methods, i.e., negligible energy consumption, low sludge production, and energy recovery in terms of biogas. Although anaerobic treatment of wastewater has received a wider research interest in the past decades, there is sparse literature or research on the anaerobic simultaneous co-treatment of municipal wastewater and the organic fraction of municipal solid wastes. This proposal came into view based on several rationales. Many municipalities are promoting installation of organic wastes shredders in the sinks, which will mix it with sewage, thus both will be conveyed using the sewage infrastructure to the nearest treatment plant. It is also hypothesized that mixing the organic component of municipal solid waste with domestic wastewater will result in a higher chemical oxygen demand (COD) content of the wastewater which will produce more biogas and enhance the nutrient and mineral content of the mixture that could promote the biomass activity. In this work, the effects of organic wastes addition to a synthetic wastewater stream on biomass activity, on sludge quantity and quality, effluent quality and biogas production are investigated. The experiments were conducted in two phases using an up-flow anaerobic sludge blanket reactor (UASB) under mesophilic conditions. In phase one, the performance of the USAB reactor in treating synthetic wastewater only was investigated under different operating conditions (different hydraulic residence time (HRT) to assess the activity of biomass, quantify the accumulated sludge in the reactor and optimize the performance. While in phase two, both wastewater and organic wastes will be co-treated in the same UASB at similar conditions, and similar analyses were conducted to determine the impact of co-treatment on biogas generation and treatment efficiency. A lab scale UASB reactor has been in operation for two years. Synthetic wastewater (850 mgCOD/L) was fed at different HRTs (24,16,12,6 hours) and it showed propitious performance with COD removal efficiencies varying between 75-90%. Although only minor sludge withdrawal was made for analysis, it took almost two years for the sludge level to reach the outlet of the reactor. The produced biogas contained 62-67% methane. Currently, organic wastes will be added to the synthetic wastewater according to the ratio

that represents daily production per capita (200 Liter SWW + 700 grams OFMSW). The significance of this research lies in the potential of achieving major energy consumption reduction as compared to aerobic processes, substantial cut in organic wastes and sludge handling expenses, potential increase in biogas production and accomplish a much lower environmental impact.

Keywords: Anaerobic digestion, wastewater, organic-solid wastes, biogas

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Efficiency of Constructed Wetlands in Mitigating Antibiotic Resistance Concern: Safe Water Reuse for Agriculture and Sustainable Food Production

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Abstract

Nowadays, drugs are commonly released in wastewater and derived by human treatments and/or for livestock, or by personal products care, and included the Contaminants of Emerging Concern (CECs). Among CECs, antibiotics can promote the selection and diffusion of antibiotic resistance bacteria (ARB) and genes (ARGs). Because of their incomplete removal by conventional wastewater plants, CECs, and in particular ARBs and ARGs, are found in the effluents, posing risks to the environment and public health, mainly related to water reuse. Here, we tested Constructed Wetlands (CWs), characterized by a coupled water flow (vertical and horizontal flow in series – HCW), for civil wastewater treatment to evaluate the efficacy of ARBs/ARGs removing in the perspective of water reuse and safe food production. To this aim, a pilot-scale plant configuration HCW was designed with an innovative combination of multilayer and exploiting the plant biodiversity, that allow to reduce the CW surface of roughly five fold respect to the common literature indications. The experimentation has foreseen: i) physico-chemical (pH, COD, N, Cl, antibiotics, etc.) and biological (BOD, coliforms, enterococci) characterization of the HCW influent and effluent; ii) an UV-ray irradiation treatment of an aliquot of the effluents ; iii) evaluation of the presence of ARB/ARGs in the influents and effluents (after HCW or HCW + UV treatments) through cultural and molecular methods; iv) quantification of ARGs by real-time PCR analysis on influent and effluent ; v) use of the effluents (collected after HCW or HCW + UV treatments) for irrigation of lettuces to verify the ARB/ARGs transfer to the rhizosphere or to the leaves. The results revealed that HCW treatment was effective to obtain water of high quality for irrigation purposes, as confirmed by the physico-chemical and biological parameters assayed on the effluents deriving from HCW pilot plant. Moreover, cultural methods showed a significant decrease of ARBs (in terms of CFUs) in the effluents, after 48 hours of treatment, and their total removal after the UV irradiation. Moreover, genes quantification carried out on the effluents, collected after HCW or HCW + UV treatments, demonstrated the ARG removal up to 97% and 99%, respectively. Finally, after irrigation of lettuce with HCW effluents, the microbiological analyses on the rhizosphere highlighted the presence of few ARBs and ARGs, while they were absent in the leaves. Instead, in the case of lettuce irrigated with HCW effluent, also treated with UV, no ARBs were found both in plant organs or in their rhizosphere. In conclusion, we demonstrated that: the new HCW configuration ensure the water quality achievement for its reuse for agriculture, also reducing or completely removing the ARBs and ARGs input to soils; the limited number of ARBs and ARGs found in the rhizosphere of lettuce irrigated with HCW effluents were not translocated

to the leaves, resulting safe for consumers.

Keywords: Antibiotic resistance, water reuse, constructed wetlands, nature based solutions

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Cultivation of the Microalgae Chlorella Sorokiniana in Various Agro-industrial Wastewaters and Characterization of Biomass Extracts for Bioactive Compounds

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Abstract

Agro-industrial wastewater are characterized by high concentrations of organic matter and nutrients while important differences are noticed on their characteristics depending on the type of industry and raw material. During the last decade considerable interest has been focused on utilizing microalgae to remove pollutants from various wastewater matrices. Previous studies have shown that the microalgae Chlorella sorokiniana achieves satisfactory removal of organic load and total nitrogen from several categories of wastewater. Additionally, it has been shown that the biomass produced is characterized by high nutritional and economic value as it contains several groups of bioactive compounds. Such as chlorophylls, carotenoids and phycobilins. This research investigated the cultivation of Chlorella sorokiniana in different types of agro-industrial wastewater originated from breweries, wineries, cheese, chili sauce and natural citrus juice production units. The collected agro-industrial wastewater were initially characterized for their physicochemical characteristics (pH, electrical conductivity) and major pollutants (COD, NH_4-N). Afterwards, four experiments were performed with Chlorella sorokiniana cultured under mixotrophic conditions, with or without the addition of a nitrogen source and with or without agitation. The duration of each experiment was 21 days (3 experimental cycles of 7 days duration each). The biomass collected at the end of the experiments was centrifuged, washed and lyophilized. The dried biomass was analyzed for protein content. In addition, the dry biomass was extracted with ethanol in an icy, ultrasound-assisted water bath. The extracts were characterized using high performance liquid chromatography with diode array detector (HPLC-DAD). The results show that Chlorella sorokiniana can grow efficiently in all types of wastewater used while a satisfactory removal of COD (up to 85%) was achieved. The protein content of collected biomass was measured up to 58%. Finally, the biomass grown in different types of wastewater was enriched with bioactive substances to different degrees.

Keywords: microalgae, wastewater, nutrient recovery

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From DIANYA to HIPPOCRATES, A Story of Scaling up a Pilot Unit to a Demonstration Unit at a General Hospital in Crete, Greece

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Abstract

Hospitals are one of the main sources of pharmaceuticals pollutant emissions sent to wastewater treatment plants (WWTP) that are poorly equipped to treat efficiently these types of compounds. Hospital wastewater, in addition to conventional urban wastewater pollutants (BOD5, COD, TSS, NH4-N, TP), also contains a wide variety of micro-pollutants including widely used pharmaceutical compounds (such as analgesics, anti-inflammatory, antibiotics), specialized chemicals for the treatment of specific diseases (e.g. cytostative compounds), disinfectants as well as multi-resistant bacteria (Verlicchi, 2018). Given that the contribution of hospitals to the total amounts of pharmaceutical substances detected in urban wastewater varies between 20 and 100% depending on the type of substance, abroad during the last decade there has been a trend for on-site treatment of liquid hospital waste by adopting technologies that combine biological treatment methods and ozonation to remove specific micropollutants (Kovalova et al., 2012; Hansen et al., 2016; Tang et al., 2019). This article presents the demonstration unit HIPPOCRATES, which was recently funded by the European Programme for the Environment and Climate Action (LIFE, Project: LIFE22-ENV-EL-HIPPOCRATES-101113941). The main objective of the project is to determine if and how (optimum operating mode) the innovative combined eco-technologies (HIPPOCRATEs' system) developed and tested successfully in pilot scale (1.0 m^3/ day), for the removal of selected CEC through the on-site treatment of hospital wastewater effluent, before entering the main sewage system, are achieving similar high efficiency (removal vs cost) at large demonstration scale (40 m^3/ day or 80% of the daily produced wastewater in Venizeleio Hospital and 20% of the daily produced wastewater in the Hospital Center Emile Mayrisch), in an all year continues operation, with real hospital effluent and in different geographical areas of Europe (south vs north). There will be three locations where the main activities of the project HIPPOCRATEs will take place: a) Heraklion, Crete in Greece where both the Venizelio General Hospital and the Municipal Water and Wastewater Company will be involved (stake holders), b) Esch-sur-Alzette in Luxembourg where again the Hospital Center Emile Mayrisch and the local Wastewater Facility will be involved (stake holders), and c) Limassol Cyprus, where the local Wastewater Council will be involved (stake holder).

The background, starting point / quantified baseline of HIPPOCRATEs is the DIANYA project (https://dianya.gr/?lang=en), realised between 2019 and 2023, funded by the Greek General Secretary for Research and Technology (project code T2EDK02905), which regards the successful pilot scale, on site application, of a combination of four technologies: a) Anaerobic Moving Bed Biofilm Reactor, AnMBBR (biological), b) aerobic Membrane Biological Reactor (MBR), c) Advanced Oxidation Process unit, using UV radiation and addition of H_2O_2, and d) chlorine disinfection unit, allowing the overall reduction of CECs, in the final hospital effluents by more than 85%. The pilot unit of DIANYA project (1.0 m^3/ day) it was developed in Venizeleio General Hospital in Heraklion (GHH). The AnMBBR constructed in the DIANYA project is 400 L volume. Effluent from the inlet vessel via a screw pump feeds the Anaerobic Fluidized Bed Reactor (AnMBBR). Regarding CECs, the AnMBBR contributes to a different extent to the removal of different groups of pharmaceuticals ranging from <20% (for antihypertensive or anticonvulsant drugs) to more than 80% (for antibiotics such as metronidazole and trimethoprim). In parallel, almost 60% removal of organic loading was achieved in this bioreactor while the production of biogas exceeded 130 L per m^3 of reactor per day. This resulted to an estimated production of energy due to the valorisation of biogas higher than 0.5 kWh per m^3 of treated wastewater. The MBR constructed in the DIANYA project is 2000 L volume. As far as CECs removal, MBRs have shown varying removal efficiency for different pharmaceuticals such as metronidazole, trimethoprim, ciprofloxacin, sulfamethoxazole, paracetamol, valsartan and carbamazepine ranging between 60 and 100%. The AOPs unit included UV radiation and addition of H_2O_2. Depending on the operational conditions applied, the H_2O_2-UV process results to >95% removal of cefadroxil, amoxicillin and other pharmaceuticals.

Keywords: Hospital, wastewater, pilot unit, demonstration unit, pharmaceuticals, anaerobic, aerobic, advanced oxidation processes.

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UFP: Urban Food Production, from green roofs to micro-greens and NBS

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Design and Planning Tool for Circular Urban Food Systems

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Abstract

Urban food systems must be integrated into the concept of circular economy as their inputs and outputs are currently rarely assessed from circular perspective. The transition to circularity requires redesign of urban food systems by reusing nutrients and water generated in the city to produce food, which is in line with one of the key principles of circular economy, i.e., “keep resources in use”. In H2020 EdiCitNet project, innovative Edible City Solutions (ECS) are demonstrated. The ECS includes the whole chain of urban food production, distribution and utilization for inclusive urban regeneration and addressing societal challenges such as mass urbanization, social inequality, climate change and resources protection in cities. One of the EdiCitNet project outputs is also a design and planning tool, which was developed to facilitate implementation and monitoring of resilient and circular ECS, supported by underlaying databases which are fundamental collections of input data for further modelling of urban food systems. The design and planning tool can be used either by the individual users, to estimate the potential amount of food they can produce on their plots, and how much resources are needed, I.e.: water, nutrients and energy, or by city planners, to investigate the impact of ECS implementation on city's food production, resources management and sustainability. The database structure supports storing all data coming from the EdiCitNet project partners and beyond by creating online profiles of ECS (through survey). To structure the information stored in the database, different classifications were applied. The database includes: (1) Products data: expected yields, nutrient (i.e., nitrogen, phosphorus and potassium) demand, growth period, and energy and nutritional values of 48 products (vegetables). (2) Fertilizer data: nitrogen, phosphorous and potassium contents from different sources, i.e., compost from store, kitchen and garden waste, and three types of manure (cow, horse and chicken). Wastewater data: typical production of mixed wastewater, urine, feces, grey and black water per inhabitant and nutrient production per inhabitant. (3) Meteorological data: long-term mean monthly precipitation and reference evapotranspiration. (4) Land use data: based on the Urban Atlas for selected cities. (5) Information on ECS Profiles following the web-based survey structure. The structure of the design and planning tool will be presented along with its application for two case studies, namely one at the individual scale (used for planning a single ECS) and the other at the city scale (to plan city’s food production and resources management). The results will show (1) estimated yield, (2) Resources demand (water, nutrient and energy needs), (3) irrigation possibilities and demand and (4) needed

fertilization amount and fertilization scenario.

Keywords: Edible City Solutions, urban food systems, design and planning tool

HAR: Harvest and post-harvest management to reduce losses

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A study on the effect of conventional storage practices on the losses of onions under ambient environmental conditions

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Abstract

India suffers 40-50% post-harvest losses of onions per year due to inadequate storage techniques. Indian farmers primarily employ conventional storage methods, which are influenced by the surrounding environmental changes (Tripathi et al., 2016, Dhabi et al., 2008, Prajapati et al., 2019). Depending on the choice of storage method, losses in conventional storage may vary and therefore, there is a need to find out best from the available options. Three commonly used storage techniques were studied, i.e., bunches of onions were kept hanging under a naturally ventilated shade, bags of onions were stored beneath a shade, and loose onions were kept on the floor inside a closed room. This study focuses on the effect of storage duration and ambient environmental conditions on the losses of onions among the adopted storage methods. The physiological weight loss, microbial spoilages (neck rot, black mold, and bacterial rots), and sprouting were the parameters studied during the storage to calculate the loss percentage, along with regular monitoring of the ambient temperature and relative humidity (RH). The performance of floor storage was worse, with 67.34% of total stored products found spoiled within 15 days of storage due to microbial spoilage. Bag storage showed a total of 56.67±2.07% of losses after the completion of 77 days of storage. Out of 56.67±2.07% of total losses, 41.16±1.14% and 5.27±0.67% were due to microbial spoilage and losses due to sprouting, respectively. The fluctuation of ambient temperature and RH during the period of floor storage was 5–20 °C and 10–50%, respectively, and in the case of bag storage, 3–20 °C and 35–85%, respectively. The experiments on floor storage and bag storage were stopped after 15 days and 77 days of storage, respectively, because product losses in both cases exceeded the 50% mark within the aforementioned storage period. Hanging storage outperformed floor storage and bag storage. In hanging storage, physiological weight loss was found to be 37.6±2.1%, losses due to sprouting were 3.6±0.82%, and microbial spoilage was determined to be 14-15%. Microbial spoilage was found to be started after 35 days of storage. Cumulative losses of onions in hanging storage were found to be 55.74±1.17% after the completion of 114 days of storage. The ambient temperature and RH fluctuation in the case of hanging storage was equivalent to the conditions mentioned for bag storage. To select a better alternative, farmers need to be aware of the variations in losses between conventional storage practices. Based on their needs for storage duration, resource availability, and the quantity of the items to be stored, farmers can use the findings of this study to select a feasible storage option. However, cumulative losses of more than 50% were seen for all three conventional

storage methods between 15 and 114 days of storage, which is undesirable from an economic standpoint and will adversely influence the country's export markets and internal supply and demand ratios. Using a better storage method will therefore be a preferable choice for longer shelf life and minimal losses.

Keywords: Onion, Conventional storage practices, Storage losses

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Reducing Food Loss and Waste: Unveiling Unfair Trade Practices and Root Causes in the Brazilian Leafy Products Supply Chain

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Abstract

Food loss and waste (FLW) occurring early in the food supply chain leads to increased resource wastage, including land, water, fertilisers, pesticides, fuel, packaging, energy, and labour. Targeting FLW prevention benefits various aspects such as food security, productivity, economic growth, climate change mitigation, resource conservation, and food waste management. Additionally, understanding the causes of FLW is crucial for the design of effective solutions and their prioritisation. FLW causes can originate from various factors, such as biological, microbial, chemical, technological, and behavioural causes. This study aims to investigate the risk factors and root causes of FLW in leafy products throughout the Brazilian food supply chain, spanning from harvest to retail. To achieve this, the research methodology involves case studies conducted among small, medium, and large-scale producers and retailers in Tupã, São Paulo, Brazil. The study takes a comprehensive approach by combining a systematic literature review of FLW causes worldwide and in the Latin American context, conducting exploratory research, including interviews with various stakeholders in the food supply chain, and performing root-cause analysis. By adopting these methods, the study addresses a literature gap that primarily focuses on isolated stages of the supply chain and developed countries, providing a holistic examination of FLW as an integrated issue across the food supply chain. Findings reveal that retailers' unfair trade practices towards producers contribute to the acceleration of FLW. These practices are driven by product proximity, limited shelf life, convenience, excess supply, and the market control exerted by medium and large supermarket chains. In the retail-producer dynamic of this city, retailers lack formal agreements with local leafy vegetable producers, and the abundance of local producers further amplifies retailers' power in this dynamic. The prevalent model involves take-back agreements, where retailers only compensate producers for sold products while returning "inadequate" quality items and unsold products unpaid. Supermarkets hold significant influence over product quality, risking product removal if consumers' strict expectations are not met. However, retailers bear no responsibility for appropriate storage conditions or incentives for utilising unsold products, since FLW represents no economic loss for them. It can be concluded that small-scale primary production for local markets faces risk factors of food loss and waste (FLW) primarily rooted in behavioural and organisational causes. Although these factors are perceived as losses in the production phase, they originate in the retail phase of the food supply chain. This can be attributed to current definitions of food loss and waste, which frequently allocate responsibility for losses to specific stages in the supply chain, such as production or post-harvest handling. However, at the supplier-retailer interface, the division of responsibility

becomes unclear. This study provides valuable insights into the dynamics of FLW in the Brazilian context, focusing specifically on leafy products, and emphasises the importance of addressing behavioural and organisational issues at the retail phase to effectively reduce FLW. The implications of this research are relevant for policymakers, researchers, and stakeholders, as they provide guidance for developing strategies to mitigate FLW and promote sustainability in the Brazilian food system.

Keywords: Root-cause analysis, risk factors, take-back agreements, behavioural causes, prevention

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Farmers' Perception, Knowledge, and Control Attitudes of Rodents Infesting Cereal Growing Areas in Morocco

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Abstract

Rodent pests are significantly threatening agricultural cropping systems by affecting the food security and income of small-holder farmers in cereal-growing areas. This study aimed to investigate farmers' perception, knowledge, and attitudes toward rodents infesting cereal crops (wheat and barley) and management methods in Morocco. A KAP survey was conducted for the first time using a structured questionnaire to collect data from 100 farmers from two regions (Rabat-Salé-Kenitra, and Fes-Meknes). The results showed that more than 70% of the farmers experienced rodent infestation in their fields, and the most prevalent species were Mus musculus (28%) and Rattus rattus (26%). Other species were also reported from the survey including Meriones shawi,Rattus norvegicus, and Gerbillus campestris. The farmers' perception of rodents was mostly negative, with the majority of the respondents considering rodents as pests that cause wheat damage (e.g., spoiling, chewing, and eating) and economic losses. The study found that farmers used various control methods to reduce rodent infestation, including the use of rodenticides (77%), traps (53%), and cultural practices (up to 67%). However, it was reported that these methods are only effective if done continuously. The results also showed that age, education, and experience influenced farmers' perception, knowledge, and control attitudes toward rodents. Younger, more educated, and experienced farmers had a better understanding of rodent damage trends and were more likely to adopt suitable pest management practices. On the other hand, yielding patterns of cereal crops were significantly linked to rodent species, some farmers' characteristics, and management settings. The study revealed that farmers' negative perception of rodents led to their limited and unoriented management outputs, adopted against rodents. Thus, there is a need for educational programs to enhance farmers'

knowledge of rodent ecology and the use of Ecologically Based Rodent Management (EBRM) practices to achieve sustainable rodent control in cereal-growing areas of Morocco.

Keywords: Cereal, EBRM, Farmers, KAP, Mus musculus, Rodent

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Preliminary Evaluation of Pomegranate Peel Extracts for the Control of Postharvest Brown and Sour Rots of Nectarines

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Abstract

Significant economic losses of nectarines and other stone fruits are caused worldwide by postharvest brown and sour rots, caused respectively by the fungi Monilinia spp. and Geotrichum candidum. Synthetic chemical fungicides, such as fludioxonil and pyrimethanil, are currently applied after harvest to control these diseases. However, due to potential harmful effects of chemical residues to human health and the environment, alternative non-polluting control strategies are needed. The obtention and evaluation of natural antifungal compounds from plant sources is an increasing strategy to reduce pesticide usage. The consumption of pomegranates (*Punica granatum* L.) has arisen once their antioxidant and nutraceutical activities and consequent human health benefits have been repeatedly demonstrated. However, the pomegranate juice and aril industries generate large amounts of peel by-products, which in some cases have been reported to provide antimicrobial activity, mainly attributed to their high polyphenol content. In this work, two previously selected peel extracts from pomegranate cv. Mollar de Elche (methanolic PGE and aqueous PGE) were preliminarily evaluated for the control of brown and sour rots on nectarines (*Prunus persica* var. *nucipersica* (Suckow) Schneid), cvs. Big Bang and Ambra, wound inoculated with *M. fructicola* and *G. candidum*, respectively. About 24 h after fungal inoculation, PGE extracts at 30 g/L were applied as drops into the same fungal inoculation site on the equator of each fruit. Although the results slightly differed among nectarine cultivars, PGE extracts, and target diseases, after 4 days of incubation at 20 ºC, both aqueous PGE and methanolic PGE showed significant curative activity and reduced the incidence (percentage of infected wounds) of both brown rot and sour rot by 50-70%. These reductions, however, were lower after longer incubation periods. The severity (lesion diameter, in mm) of both diseases was also reduced by 40-50% after 4 days of incubation at 20 ºC, and the extracts also significantly reduced pathogen sporulation on infected fruit. As a conclusion, PGE extracts showed significant fungistatic activity and potential to be used as antifungal postharvest treatments for the control of nectarine decay in integrated postharvest disease management programs. Simulated commercial application modes, such as fruit spraying or dipping, commercial cold storage, and the combination of PGE extracts with other alternative non-polluting treatments of different nature should be considered in further studies.

Keywords: pomegranate by-products, stone fruits, postharvest decay, Monilinia fructicola,

Geotrichum candidum

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Understanding Rodent-Induced Losses in Turkish Agriculture: Insights from a Farmer Survey

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Abstract

Turkey is a major agricultural producer, with crops such as wheat, sugar beet, tomatoes, barley, potatoes, and maize. Agriculture is an important sector of Turkey's economy and the country is one of the world's top ten agricultural producers, with 50% of its land used for agriculture, and farming employed 16% of the workforce in 2022, provided 10% of exports, and 7% of GDP in 2020. However, rodent infestations have been causing significant losses in the agricultural industry. Specifically, mole-rats have been damaging crops by feeding on their roots during the pre-harvest period. The current practice of using synthetic chemical rodenticides has proven ineffective due to resistance development, adverse effects on non-target species, and environmental pollution. In this study, we aimed at identifying the primary pests causing damage to agricultural production and the specific diseases prevalent in the Sanliıurfa province of Turkey. To gather information, a survey was conducted among 60 experienced farmers primarily engaged the production of field crops such as wheat, barley, lentils, cotton, and corn. The survey aimed to determine the types of pests and diseases affecting agricultural production, identify the crops most affected by rodent damage, and explore the potential of Ecologically Based Rodent Management (EBRM) in reducing losses. The survey findings revealed that the most common pests affecting agricultural production in the region are fungi, bacteria, insects, rodents, and birds. Among the participants, barley, lentils, and wheat were identified as the crops most susceptible to rodent damage. Implementing rodent control measures has the potential to reduce these losses by 50% to 80%. Chemical pesticides were the preferred method of control, although participants expressed concerns about their environmental impact and sought alternative approaches. While 80.6% of respondents reported occasional rodent issues, only 63.9% implemented proactive measures before signs or damage caused by rodents appeared. In cases of infestation, 94.4% of participants resorted to chemical pesticides, while only 8.3% utilized toxic plants for rodent control. Dissatisfaction with current chemical rodenticides was expressed by 61.8% of participants, and 100% of them showed interest in purchasing organic rodent control products. However, the unavailability of organic rodenticides in the market hindered their purchase. The findings of this study provide valuable insights for the development of strategies to control rodents and manage agricultural damage. The prevalence of rodent pests and the specific crops affected by their damage were identified, the potential benefits of implementing Ecologically Based Rodent Management will be discussed. The survey also revealed a significant demand for organic rodent control products among farmers due to concerns over the harmful effects of chemical pesticides. The unavailability of such products in the market poses a challenge that needs to be addressed.

Finally, we highlight how these results can contribute to the formulation of effective rodent control and damage management strategies in Turkey's agricultural sector.

Keywords: Turkey agriculture, Rodent damage, Organic rodent control, Ecologically Based Rodent Management (EBRM)

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Unearthing Approaches to Harness the Potential of Hop Waste Biomass

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Abstract

During the hop harvesting process, the complete aboveground biomass is systematically extracted from the agricultural fields, leaving behind residual stems and leaves as a by-product, which is subsequently collected adjacent to the harvesting facilities. This surplus hop biomass can attain quantities of up to 18 metric tonnes per hectare, with an average of approximately 15 metric tonnes. Regrettably, this residual material is frequently categorized as waste, notwithstanding its significant potential as a versatile raw material with diverse applications. The potential applications for waste hop biomass encompass an array of environmentally responsible practices, including bio-gas production, composting, biomass utilization for heat generation, extraction of antioxidants for incorporation into food and pharmaceutical products, as well as fiber production for utilization as an additive in the manufacturing of biodegradable biocomposites, providing a sustainable alternative to conventional plastic materials. In this context, the principles of a circular economy can be strategically harnessed, with the judicious utilization of hop waste biomass as a valuable resource for composting standing out as a particularly prudent approach. Of note, the waste hop biomass generated from a single hectare of hop plantation is a substantial source of essential nutrients, including 21–22 kg of phosphorus pentoxide (P_2O_5), 50–71 kg of potash (K_2O), 32–41 kilograms of magnesium oxide (MgO), 5.5 kg of sulphur (S), and 88–99 kilograms of nitrogen (N). So, on-farm composting represents an efficient, cost-effective, and ecologically sound biological process for recycling residual biomass. By reintroducing this material into the soil in the form of high-quality organic fertilizer, agricultural practitioners can augment both the nutrient content and organic composition of the soil. This, in turn, leads to the cultivation of more resilient and sustainable agricultural practices. The adoption of circular economy principles, in this context, is instrumental in fostering the long-term sustainability of the hop industry, simultaneously fostering environmentally responsible and socially equitable agricultural production methods. Furthermore, noteworthy milestones were achieved by developing two distinct processes for extracting fibers from waste hop stems, each serving a specific purpose. These extracted fibers can first be incorporated into the production of biodegradable and compostable wine bottle transport packaging, offering an environmentally sustainable alternative to conventional packaging materials. Additionally, the extracted fibers can be effectively employed as a key component in the production of biocomposites, facilitating the creation of various biodegradable and compostable products. In total, LIFE project BioTHOP has successfully devised 13 such products. Upon the completion of their useful lifecycle, these products can be subjected to composting, where they degrade into water, carbon dioxide, and organic matter. The resultant compost can then be judiciously applied to reintroduce valuable nutrients and organic matter to agricultural

land, thus fostering a closed-loop, sustainable agricultural system.

Keywords: green waste, hop plant waste biomass, composting, biodegradable products, reuse, biodegradable biocomposites, biodegradable products

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AEP: Alternative Energy Production and energy use optimisation at farm level

APP: Alternative Protein Production for human consumption

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Solid-state Fermentation of Birch Sawdust by Pleurotus ostreatus for Mycelial Protein Production: Effects of Nutrient Addition and Reactor Types

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Abstract

Edible fungi offer a promising alternative to animal proteins, given their rich protein profile and ability to upgrade lignocellulosic residues. However, conventional mushroom production faces challenges in terms of significant residue generation, which consists of protein-rich mycelia but is contaminated with pesticides and antibiotics (Leong et al., 2022). To revolutionize this process, our Wood2Food project proposes to convert raw wood material via controlled, continuous, and contamination-free solid-state fermentations (SSF) into a product predominantly composed of mycelia and a minor fraction of cellulosic dietary fiber, which is presumed to be safe, wholesome, and suitable for human consumption. In this particular study, we first investigated the impact of nutrient addition, particularly nitrogen, on the mycelial expansion and oxygen consumption of a model strain, *Pleurotus ostreatus*, cultivated on birch sawdust substrate. Our findings indicate that the addition of nitrogen effectively accelerated the mycelial expansion of *P. ostreatus* in Petri dishes, but lead to a decrease in oxygen consumption rate when cultivating the fungus in SSF reactors. A potential inhibitory effect of nitrogen may have been imposed on fungal lignin degradation, which is a crucial step in their decomposition of lignocellulose. These observations suggest that a careful optimization of nutrient supplementation, particularly nitrogen, is crucial to balance the need for fungal protein synthesis and lignin-degrading activity. We also employed three different types of reactors (two static reactors with or without spacers and one rotary drum reactor) to understand the engineering aspects of this process. A marked difference was noted in the oxygen consumption pattern between the rotary drum reactor and the static reactors. Additionally, extensive drying and agglomeration of the substrate were observed in all static reactors but not in rotary drum reactors. These variations confirm the crucial role of reactor design in affecting the fungal physiology and mass transfer of nutrients and metabolites. Overall, our study sheds light on an innovative solution to produce fungal protein from woody biomass, i.e. converting wood directly into food that is rich in mycelial protein and fibers. This approach holds promise for addressing the limitations of conventional mushroom production and meeting the increasing demand for sustainable protein sources. By evaluating the impact of nutrient addition and comparing different reactor types, we have demonstrated a proof of concept and gained preliminary understandings of the process limitations. Further research is warranted to delve deeper

into the optimization of different environmental factors and reactor design, with the aim of developing a robust and environmentally friendly process with higher productivity and quality of products.

Keywords: Fungal protein, Wood, Lignocellulose, Solid-state fermentation

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Leong, Y. K., Ma, T. W., Chang, J. S., & Yang, F. C., 2022. Recent advances and future directions on the valorization of spent mushroom substrate (SMS): A review. Bioresource technology, 344, 126157. doi: 10.1016/j.biortech.2021.126157

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Flour From Drone Broods: A Viable Alternative?

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Abstract

Many insects and products derivate from them have been suggested as food or food ingredient. This work aims to enhance a natural resource, brood (pupae and larvae) drones not used by honey producers. Drones are present in the hive mainly for reproduction purposes, but beekeepers may use the technique of removing the drone frames to combat and control the Varroa destructor mite, because this parasite prefers laying its eggs in the drone larvae that is bigger than the worker larvae. However, the brood drone removed is not valued, and despite the effect on reducing varroa populations, usually beekeepers will consider its removal a loss, especially if it contributes to reducing the honey and other bee products. We aim to study and valorise the drone pupae and larvae as an alternative food source, through simple and viable extraction techniques that producers might adopt. The extraction yields of drones from the wax frames were 84.9±4.0% and 62.5±7.5%, respectively, for hot and cold surface extraction. Extraction on the cold surface proved to be more time efficient, taking 246.8±30.1 seconds to extract 100 g of broods. Larvae and pupae were subjected to two types of drying: steaming and freeze-drying. Steaming darkened the larvae and pupae too much, and the broods were too soft and not possible to transform into flour. Thus, this process did not prove to be a good drying process and was rejected. In opposition, freeze-drying (to constant weight) gave better results. Thus, both hot and cold extracted broods were submitted to this drying process to be later milled to obtain flour. Flours obtained from the hot extraction had a darker and more yellow colour (L* 60.6±1.0; a*2.5±0.2; b*29.4±0.4), while flours produced from the cold extracted samples had a lighter and less yellow colour (L*85.6±1.3; a* -1.9±0.2; b*18.3±0.6). It was found that the hot extraction method removed some protein, mineral elements, and sugars, showing a high fat content, 44.89±0.04%. The flour produced from cold extracted drone broods had a protein content of 38.67±0,07, fat 25.73±0.03, total sugars 10.80±0,55, total ash 3.18±0,03, and fibre 4.47±0.22. The use of these flours was also tested to produce some foods: biscuits, crackers, bread and pasta. In these tests, the percentage of substitution of wheat flour by drone broods varied between 10% and 30%, depending on the type of product and the type of flour that was used. Thus, this new product, in addition to bringing nutritional benefits to consumers, may also provide an increase in income for the beekeepers, proving to be a sustainable product.

Keywords: drones brood, extraction methods, dehydration, flour production, flour applications

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drone flour in the development of new foods, CERNAS and by FZ- Drone flour: innovating in the product and in the protection of the hive, with reference PROJ/IPV/ID&I/013. The authors are also grateful for the support of National Funds through FCT - Foundation for Science and Technology, I.P., under the project Refª UIDB/00681/2020. We would also like to thank the CERNAS Research Centre and the Polytechnic Institute of Coimbra and the Polytechnic Institute of Viseu for their support.

NRF: Nutrients Recovery and alternative Fertilizers

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Are biobased fertilizers an alternative to chemical fertilizers in promoting sustainable and circular economy processes?

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Abstract

To maintain or increase the agricultural production, the soil fertility level is a critical factor. Therefore, fertilizers are needed to improve soil fertility and consequently, plant nutrient uptake. These fertilizers can become from two kinds of sources: i) mineral natural resources (e.g. phosphate rocks) or ii) organic amendments provided by waste streams, such as livestock effluents, agricultural residues and urban wastes. In order to save fossil fuel reserves and natural sources of nutrients used to manufacture the mineral fertilizers, the use of nutrients from those organic amendments is considered a sustainable agricultural practice. Currently, the intensification of the livestock production causes the production of high amounts of a liquid effluent called slurry, consisting of animal excrement and washing water from the livestock facilities. Since slurry also contains organic matter, it has a high level of biodegradable organic compounds (high BOD level), which caused negative effects when discharged in waterbodies without treatment. The anaerobic digestion process, applied to valorize this slurry, has proved to be a good sustainable option. Also, the organic fraction of the municipal solid wastes (MSW) can be used to produce biogas through the anaerobic digestion process. So, the products resulted from the anaerobic digestion of these organic materials are (i) biogas (CH_4) which is a source of energy that can be used for example in the livestock facilities, for crop irrigation, etc., and (ii) digestate, a final product (effluent) containing nutrients and organic matter that can be used as soil fertilizer, if it meets each country regulations. In addition to the use of digestate directly or after composting as a soil fertilizer, it can be treated by physical-chemical processes which allow the extraction of major nutrients, namely nitrogen and phosphorus, to obtain mineral biobased fertilizers (Horta et al., 2022; Oliveira et al., 2021). These mineral biobased fertilizers have the advantage of having a known mineral composition and an easier transportation. So, the use of the circular economy processes to the valorization of the livestock and urban effluents allows to (i) increase the competitiveness of the agricultural and animal production and (ii) save natural resources as well as can contribute to develop industry to support the above-

mentioned recovered process. In this work we will present an overview of the development of biobased fertilizers, and of the agronomic results obtained with the fertilization with two different mineral biobased fertilizers. One mineral biobased fertilizer was the secondary struvite obtained from phosphorus recovered from the anaerobically digested organic fraction of municipal solid waste through the electrodialytic process and chemical precipitation. The other is a liquid ammonium sulphate fertilizer obtained from the gas-permeable membrane (GPM) technology to recover N from an anaerobic digestate from livestock production. The agronomic results showed that these biobased fertilizers, providing N and P to crops, have the same or even higher agronomic value than the traditional NP mineral fertilizer

Keywords: Agronomic effectiveness, Nitrogen fertilizers, Phosphorus fertilizers, Wastes valorization.

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Use of Acacia Pods as a Source of Vegetal Organic Matter for Soil

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Abstract

Incorporating vegetal organic matter into the soil releases nutrients and increases its contents in organic matter, which can provide higher soil productivity and lower susceptibility to compaction. Acacia is an invasive plant in Portugal, and the huge seed bank incorporated into the soil every year is problematic for their dissemination. Suppose the green pods can have a sustainable use contributing to soil fertility. In that case, it will be possible to reduce this seed bank and contribute to delaying the proliferation of this species. In this work, the value, and mineral elements contents of *Acacia pycnantha*, *A. retinodes* and *A. longifolia* green pods were evaluated concerning their potential use as soil fertilizers. The crude protein (CP), ether extract (EE), fiber (CF) and ash (Ash) content were determined according to the Association of Official Analytical Chemistry (AOAC) standardized methods. Carbohydrate content was calculated using the difference in dry weight. The mineral content (Ca, Mg, K, Na, Fe, Cu, Zn, Pb, Mn, Ni, Cd) in green pods was determined using atomic absorption spectrophotometry on an AA-7000 spectrophotometer (Shimadzu, Kyoto, Japan). Total nitrogen was quantified by the Kjeldahl method. The fresh green pods were also analyzed by Near-infrared spectroscopy (NIR)(MPA Bruker). The least significant difference (LSD) test and principal component analyses (PCA) were used to identify the differentiation between samples and their correlation with the analytical parameters. *A. pycnantha*, *A.*

retinodes and *A. longifolia* showed distinct compositions. Still, all presented appropriate mineral elements content, higher amount of N and low in Cu and Cd, with good value rich in CP and CF and low EE content. Ni, Cu, Pb and Fe do not vary significantly between species. *A. pycnantha* shows a higher content in CF and Mn; A. longifolia in Na and EE, and *A. retinodes* in Ca, Mg, K, Na, Zn, Cd, N, CP and ash content. The PCA achieved with NIR spectra produced similar findings to those obtained with analytical data and confirmed that the analyzed green pods present a distinct profile that this technique could easily distinguish. The composition of Acacia green pods, evaluated previously to the seed's viability, suggests a potential use in soil fertilization, either directly incorporated into the soil or after composting. Nevertheless, this is a preliminary study, and more research is still needed to obtain sounder results.

Keywords: Acacia, pods, soil, nutritional, mineral content, NIR

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Hydrothermal treatment of wheat bran under mild acidic or alkaline conditions to boost polyphenol recovery and produce ferulic acid-enriched extracts

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Abstract

Ferulic acid recovery from wheat bran (WB) using conventional extraction methodologies and solvents is particularly low, because a large fraction of ferulic acid is bound to chains of arabinoxylans via ether or ester linkages. Alkaline or acid catalysis may greatly improve ferulic acid extraction yield, yet there is rather a lack of systematic studies on this issue. Hydrothermal treatment is a very promising means in this context, and it involves treating of the lignocellulosic material with water at relatively high temperatures for given resident time, the maxima of which are interdependent. The addition of certain catalysts (acid/alkali) may significantly increase the efficiency of the process, which involves breaking down ether and ester bonds, such as those that bind ferulic acid onto WB arabinoxylans and lignin. On this conceptual basis, this project was undertaken to establish a hydrothermal process, aimed at maximising ferulic acid release/recovery from WB, and examining the role of acid/alkaline catalysis, under mild conditions. Aqueous solutions of either citric acid or sodium carbonate were used, and the assessment of the extracts obtained was accomplished through the determination of ferulic acid content. The most efficacious treatment was performed with 5% citric acid, at 24 h, which afforded 18.77 mg ferulic acid equivalents (FAE) g^{-1} dry mass (DM). Hydrothermal treatment with a 5% sodium carbonate solution were proven highly effective, giving a YTP of 22.33 mg FAE g^{-1} DM, at 24 h. Switching sodium carbonate concentration from 5 to 10% provoked an increase in YTP from 22.33 to 23.60 mg FAE g^{-1} DM, giving a non-significant difference of 5.4%. By contrast, raising citric acid concentration from 5 to 10% had as a result the increase of YTP from 18.77 to 23.76 mg FAE g^{-1} DM, which represented a by 21% difference. Liquid chromatography-mass spectrometry analysis revealed that, while sodium carbonate-catalysed treatments gave extracts enriched in ferulic acid, citric acid catalysis resulted in extracts dominated by a ferulate derivative. The results indicated that effective recovery of polyphenols from wheat bran may be accomplished by both citric acid- and sodium carbonate-catalysed hydrothermal treatment. There were significant differences in the polyphenolic composition of the extracts, since ferulic acid was released only under alkaline conditions. Hydrothermal treatment under mild alkaline conditions is proposed as a very effective, green means of producing high-purity ferulic acid from wheat bran.

Keywords: ferulic acid, hydrothermal treatment, polyphenols, wheat bran

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Recovering high-value P-K fertilizer from effluents by integrating adsorption and electrodialysis with bipolar membranes

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Abstract

High-efficient phosphorus (P) recovery from wastewater has recently attracted widespread attention, as worldwide food production is largely dependent on this non-renewable resource. Although some of the existing technologies (e.g., adsorption) can achieve effective phosphate removal and recovery, they require extensive use of chemicals and intensive consumption of energy to achieve substantial recovery of nutrients (Kumar et al. (2019)). Here, we developed a novel P recovery process via integrating bipolar membranes electrodialysis (BMED) with P sorption. Specifically, the integrated system incorporates P adsorption-desorption step, nanofiltration (NF) step, and BMED process in sequence. Surprisingly, a satisfactory accumulated concentration of P (3545.45 mg P/L) in the regeneration solution is obtained under the optimal operating conditions (i.e., column adsorption experiments with single-pass with the flow rate 45 mL/min; acid cleaning using HCl solution with a pH of 2.5; pH of the eluent desorption KOH solution = 13.85 ~ 14.0, concentration = 2.29 M). The desorption solution is then treated by NF to further reduce the energy consumption of the whole process. Low rejection of K^+ (20.1 %) is preferred to increase the concentration and lower the ratio of K/P of the desorption solution. The P-rich eluate after NF is used as a source for subsequent BMED steps. Therefore, the high purity of the KH_2PO_4 solution is obtained when the pH in the salt compartment reaches ~ 4.5. Finally, the bipolar membrane (BPM PCCell) and the cation exchange membrane (CEM FKS-50) are utilized within the BMED stack with two cell pairs (2cp) under the voltage of 8 V to process the salt solution after the NF step, which has the minimum specific electricity consumption (SEC). Moreover, it is estimated that the cost of PCCell-FKS-50-2cp-8V-NF is only 188.595 \$/dry ton KH_2PO_4, while the net profit is 1236.405 \$/dry ton KH_2PO_4, which offers the critical potential to translate this relatively small-scale lab example to a larger scale. Overall our results demonstrate the techno-economic viability of this new concept for sustainable P recovery from effluents, justifying further development and scaling-up efforts.

Keywords: nutrients recovery, bipolar membranes electrodialysis, nanofiltration, liquid fertilizer

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Struvite from Wastewater can Replace Conventional Phosphorous Fertilization in a Maize Crop

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Abstract

Fertilizer demand is expected to increase in the long term due to a growing world population, which will reach 9.8 billion people by 2050, according to the United Nations forecast (UNDESA, 2017). Phosphorus (P), like nitrogen (N) and potassium (K), is an essential nutrient for plants. The world's main source of P (phosphate rock) is a non-renewable resource, and reserves are becoming scarce and expensive, resulting in P-fertilizer supply problems (Reijinders, 2014). This threatens food security in the long term, especially in countries with no reserves of this mineral. Therefore, the recovery of this nutrient should be encouraged. There are currently several technologies that could cover the need for P fertilizers for global food production. In addition, it must be taken into account that the European Commission has set a goal of a 30% reduction of non-renewable resources for fertilizer production (Chojnacka et al., 2020). In this sense, municipal wastewater is a promising source of P that could replace P derived from phosphate rock. The aim of this study is to evaluate the fertilizing capacity of struvite ($MgNH_4PO_4 \cdot 6H_2O$) from wastewater treatment plant as phosphorus fertilizer for a maize crop. A field trial was carried out in 7x3 m plots. Application of struvite (STR) supplemented with a N source was compared with the application of a conventional mineral fertilizer (NPK). The combination of struvite with urea (STR+N) and thermally dried sewage sludge (STR+ST) was tested. A total of 120 kgP_2O_5/ha was applied. In relation to N, one third of the total dose (120KgN/ha) was applied as bottom fertilization and two times more as cover fertilization at two stages (30 and 75 days after sowing). Four replicates per treatment were used. After harvest, the yield of the different treatments was evaluated by measuring the plant biomass obtained (leaf and grain). Soil samples were also analyzed. The results showed a slight increase in both the total biomass (stems, leaves and cobs) and the amount of grain in the treatments with struvite supplemented with a nitrogen source, either in the form of ST or urea, compared to the NPK treatment. No significant differences in nutritional composition were found among the different treatments, although a trend towards an increase in P content was observed in STR+ST treatment. Soil fertilization with struvite supplemented with a nitrogen source, showed good results for maize crop, obtaining yield values and effects on plant and soil comparable to those obtained with conventional mineral fertilization. The use of struvite in combination with other fertilizers, in order to obtain adequate formulations for crops, would lead to a reduction in the use of conventional mineral fertilizers and consequently in greenhouse gas emissions, contributing to climate change mitigation.

Keywords: Phosphorous, leaching, soil, fertilizers, wastewater

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Design of Thermal Post-Treatment Unit for the Inactivation of Pathogens in Compost after the Composting Process for Food Production

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Abstract

The safe disposal of human waste is a basic requirement to improve sanitation and protect public health. The composting toilets system was adopted to improve sanitation and to boost food production in rural communities of Burkina Faso. In this system, the toilet produce compost from faeces which is separately collected from urine and composting matrix (sawdust). The compost still contains pathogens because there is a short retention time between the final defecation and emptying. There is low temperature (35 °C) in the composting toilet. There is a need for a post-treatment unit to ensure complete inactivation of pathogens that are found in the compost after withdrawal. This complies with the multi-barrier concept recommended by WHO (2006). The aim of this study is to design the post-treatment unit which would treat the compost removed from the composting toilet to allow a safe reuse on farmlands. The inactivation rate coefficients of indicator pathogens i.e *Escherichia coli*, *Enterococcus*, *Ascaris suum* eggs and *MS2 bacteriophage* in the compost were estimated. The kinetics of inactivating pathogens were determined at different temperatures with varying moisture content of the compost. The results of these experiments are as follows: *E. coli* requires post-treatment conditions of 50 °C and 50% MC and a contact time over 4.5 h or post-treatment conditions of 70 °C, 50% MC for 20 min. *Enterococcus* requires a post-treatment condition of 50 °C and 50% MC during 15 h or 70 °C, 50% during 2.5 h. The inactivation of *Ascaris suum* was fast with greater than 2 log reductions achieved within 2 hours at 50 °C and 50% and greater than 3 log reductions at 60 °C and 50% during 3 hours. The statistical analysis showed that the inactivation rates of *Ascaris suum* eggs significantly depends on higher temperature (i.e., 60 °C) and lower MC (i.e. 50%) of the compost. The inactivation rate coefficients of *MS2 bacteriophage* statistically depended on a higher temperature, but not moisture content.

Keywords: Pathogens, composting toilet, temperature, post-treatment, health risk assessment

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Extraction of Essential Oils and Hydrosols from three Different Citrus Peels and Evaluation of their Antimicrobial and Antioxidant Activities

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Abstract

Citrus fruits are among the most processed ones into products such as beverages, jams, canned fruits, leading to a vast amount of waste (around 50-60% of the total weight of the fruit) (Wedamulla et al., 2022). Therefore, many attempts have been made to valorize citrus waste to provide value-added, bioactive components, including essential oils, flavonoids, and pectin. Conventional methods as well as novel ones, such as ultrasound-, microwave-, or enzyme-assisted extraction have been reported, where both yield and bioactivity of the components were shown to be improved by novel methods (Rifna et al., 2023). Citrus essential oil is a complex structure with d-limonene being the dominant component, in terms of both concentration and bioactivity (Siddiqui et al., 2022). These oils are reported to have antioxidant, anti-inflammatory, analgesic, antimicrobial, and anticancer activities (Singh et al., 2021). The present study aimed (i) to extract essential oils and hydrosols from grapefruit, mandarin and lemon peels by enzyme assisted/unassisted hydrodistillation and (ii) to evaluate and compare the antimicrobial and antioxidant activities of extracted compounds. The essential oil extraction yield was increased from 0.6-0.8% to 0.9-1.2% by implication of enzymatic treatment before hydrodistillation, in line with previous attempts (Chávez-González et al., 2016; Ramos-Ibarra et al., 2021; Waheed et al., 2020). As a result of well diffusion assay, the antimicrobial activities of hydrosols against Escherichia coli ATCC 25922 and Staphylococcus aureus ATCC 25923 were found to be lower than essential oils. While lemon essential oil obtained by unassisted method showed strong antimicrobial activity with minimum inhibitory concentration and minimum bactericidal concentration values of 4-16 mg/mL and 8-16 mg/mL, respectively, Staphylococcus aureus ATCC 25923 was found to be the resistant culture for most of the essential oils. Furthermore, both essential oils and hydrosols were screened for antioxidant activity with DPPH (2,2- diphenylpicrylhydrazyl) free radical-scavenging and CUPRAC (Cupric Reducing Antioxidant Capacity) methods, and their total phenolic contents were determined by the Folin-Ciocalteu method. The highest total phenolic component concentration was found in mandarin hydrosols obtained by enzyme assisted extraction (73,9 mg GAE/L hydrosol), whereas grapefruit oil and hydrosol, both obtained by enzyme assisted method, had the highest antioxidant activity with respect to CUPRAC and DPPH methods, respectively (36,05 mg TE/g oil and 3,84 mg TE/L hydrosol). In conclusion, the extracted essential oils and hydrosols having antimicrobial and antioxidant activities are considered as interesting candidates for utilization in several industries while contributing to sustainability.

Keywords: Citrus waste, Essential oil, Enzyme-assisted extraction, Antimicrobial activity, Antioxidant

activity

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Recycling Wastewater as Fertiliser for Basil Growth in Indoor Farming

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Abstract

Water scarcity has emerged as a serious issue worldwide due to the growth of the global population. At the same time, generated wastewater volume has increased with the development of population, economy, and urbanization. To combat water shortage, one potential solution is the reclamation and utilization of wastewater in agriculture. Notably, wastewater contains valuable nutrients such as nitrogen, phosphorus, potassium, and essential metals. Thus, wastewater may be used as a substitute for synthetic fertilizer in agriculture, simultaneously conserving water resources and mitigating environmental concerns associated with synthetic fertilizer production. Therefore, to investigate the potential of using wastewater as a fertiliser, a pot experiment was conducted with basil (*Ocimum basilicum L.*) growing to recover nutrients from various wastewater streams. Ten basil seeds were sown in each round pot (D: 15 x H13.9 cm) containing zeolite-based substrate. Nutrient-free composition of the substrate allows for precise management of nutrient levels and simulates conditions found in hydroponic systems. The special characteristics of the zeolite-based substrate can also provide valuable insights into the potential utilization of wastewater as a fertilizer in both traditional and hydroponic farming approaches. A total of 16 pots was set up with four replicates of four different water streams including tap water as control, optimal liquid fertilizer, treated wastewater that was discharged from the wastewater treatment facility, and partially treated wastewater (after mechanical treatment). The pots were placed in a controlled indoor environment with temperature (18-20 °C) and humidity (40-50%) regulation. Irrigation occurred every two days over an eight-week period. Parameters such as plant height, number of leaves per plant, fresh weight, chlorophyll content, nutrient content in substrate, roots and the shoots of the plants, and metal concentrations are measured post-harvest. Collected data are analysed using the statistical software R. Differences in growth parameters and nutrient concentrations among treatments are analysed by performing the analysis of variance (ANOVA) and Duncan’s post-hoc test. This study aims to provide insights into the potential of wastewater reuse as an alternative to synthetic fertilizer for growing herbs in indoor farming. By exploring the use of wastewater as a nutrient source, this research addresses the pressing need for alternative fertilization methods that simultaneously promote resource efficiency and environmental sustainability in the field of agriculture and indoor farming. The findings will contribute to developing sustainable agricultural practices, conserving water resources, optimizing fertilizer usage, and mitigating environmental pollution uniquely in parallel.

Keywords: wastewater reuse, indoor farming, nutrient recycling, alternative fertiliser, sustainable agriculture

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Green Covers as a Soil Recovery Measurement in Agricultural Policies

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Abstract

In recent decades, agriculture has been evolving in two directions: on the one hand, the accelerated growth in the use of new technology, and on the other hand, the transition towards sustainable agriculture. The first has led to an excessive consumption of fertilizers and plant protection products, including herbicides, and thus to a loss of biodiversity, organic matter, and nutrients in the soil. The second is a new ecological revolution that aims to reduce these inputs through the implementation of different measures proposed by the new European Agricultural Policy (CAP), in the Farm to Fork and Biodiversity Strategy for 2030, to mitigate climate change, avoid desertification and erosion, improve the structure and biodiversity of soils, and achieve a more sustainable agricultural system. Within this context, in Spain and specifically around Valencia, in the region of Ribera Alta del Xúquer, a study is being carried out on plant cover in persimmon plots with mixtures of Festuca, Medicago, Onobrychis, Trifolium, and Vicia species, among others, comparing them for their contribution to the soil in terms of organic matter content, biomass and biodiversity that improves the properties of the soil and the crop. For this purpose, two replicated plots are sown with different cover crops. In addition, some plots with spontaneous plant cover are monitored. In all cases, soil samples are obtained for physico-chemical and biological analysis, as well as hyperspectral images for processing and study. The experimental work begins in 2022 and will be completed in 2024. By this date, the plant covers have been planted, several soil samples have been taken and soil respiration has been measured, one before planting and every three months thereafter. The soils have been analyzed in the University laboratory, obtaining data on organic carbon, nitrogen, among other elements, electrical conductivity, and pH, and the Berlesse funnel has been used to obtain a sample with soil microfauna. Satellite images have also been used to obtain relevant information for the study. The initial results are favorable, as an increase in the amount of organic matter, the C/N ratio and soil biodiversity has been observed, with useful fauna such as Oribatid mites, which are predators of crop pests, being found. It is therefore a question of improving soil fertility and auxiliary fauna and finding a method that allows its management through geoprocessing tools, which facilitates the work of the farmer in making decisions on pest control, the reduction of inputs such as fertilizers, water, or dependence on herbicides to avoid the competitiveness of the crop and the use of herbicides.

Keywords: Green covers, soil improvement, geoprocessing tools, agricultural policies

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Calcium-rich Biochars Synthesis and Valorization for Phosphorus Recovery from Effluents: Dynamic Investigations

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Abstract

Phosphorus (P) is a vital element for humans, animals and crops growth. P natural reserves are non-renewable, heterogeneously distributed in the world. Due to the important increase in the worldwide population and its food needs, these reserves would be seriously depleted before the end of the current century (Cordell et al., 2009). At the same time, large amounts of P are annually discharged in wastewaters with an important risk of surface water bodies quality deterioration (van Puijenbroek et al., 2019). In parallel to that huge quantities of organic and mineral wastes are produced and not appropriately managed. Finding a sustainable solution for P and other nutrients recovery from wastewaters by using solid wastes is considered as an innovative and promising approach that contribute to the achievement of international initiatives regarding sustainability and circular economy concepts promotion (Jellali et al., 2022; Parasana et al., 2022). The objective of this work is to study the efficiency of using calcium-rich biochars for P recovery from aqueous solutions for a reuse in agriculture as slow release fertilizer. In the current wok, we synthesized three biochars from abundant agricultural activities' wastes (poultry manure and date palm fronds) mixed with calcium rich material: waste marble powder at different temperatures (700, 800, and 900 °C). Then, these biochars were deeply characterized by using various sophisticated analytical equipment. P recovery from both synthetic solutions and urban wastewater was studied under dynamic conditions by using laboratory columns and continuous stirring tank reactors (CSTR). The effect of the P initial concentration, the mass of the biochar (or bed height), and the flow rate (contact time) on P recovery performance was assessed. Moreover, the involved mechanisms were explored. Results indicated that increasing the pyrolysis temperature has resulted in the production of biochars with interesting structural, textural and surface chemistry properties. For instance, the highest surface area, pH of zero-point charge, and calcium content were observed for the biochar produced at 900 °C (B-900) with respective values of 52.3 m2/g, 13.5, and 324 mg/g. The application of B-900 for P recovery from synthetic solutions in column mode showed that this process is jointly affected by the three studied parameters. The highest recovery capacity (79.7 mg/g) was observed for a P initial concentration, a flow rate, and a biochar mass of 25 mg/L, 5 mL/min, and 10 g, respectively. This biochar also shows a high P recovery efficiency even from P-doped urban wastewater (55.8 mg/g). In CSTR mode, B-900 exhibits excellent P recovery for both synthetic solution and wastewater effluent. Indeed, the P recovered amount in this mode was 43% higher than that observed in column assays. Based on specific analyses, the P recovery process was found to include electrostatic interactions,

complexation and mainly precipitation as hydroxyapatite ($Ca_5(PO_4)_3OH$). In real cases, we suggest to recover P from existing wastewater treatment plants through the implementation of a CSTR followed by a decantation device after the secondary treatment step. The P-loaded biochar, collected at the decantation device, could be valorized in agriculture as slow release fertilizer instead of the commercial synthetic ones. Valorization of this P-loaded biochar for the growth of local plants in pot mode is currently under progress.

Keywords: Phosphorus, biochars, recovery, column, CSTR

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Phosphorous Recovery from Tomato Waste Digestate

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Abstract

The current sustainability wave is pushing the market towards making more products from renewable and sustainable sources. Each year the agriculture industry has high amounts of waste production during post-harvesting period especially for annual crops. Tomato plants are one of these annual crops in Europe which produces approximately 3 million metric tons waste per annum (Løvdal et al., 2019). Anaerobic digestion (AD) for producing energy is an alternate method of managing and valorising these materials. Apart from Biogas, another by product of the AD process is a nutrient-rich digestate. For e.g.; the solid fraction (SF) from digestate produced after mechanical separation contains high levels of phosphorus (P), which can be recovered by acid leaching followed by re-precipitation. Tomato plants are rich in phosphorous and so is the resulting digestate at the end of anaerobic digestion. This study aims to recover phosphorous from tomato waste digestate. The efficiency of four inorganic acids (sulphuric acid (H2SO4), hydrochloric acid (HCl), nitric acid (HNO3), phosphoric acid (H3PO4)) and one organic acid, citric acid ($C_6H_8O_7$) in extracting P from the solid fraction of digestate to soluble P (PO4-) was investigated. The SF was mixed in L:S of 2:1, 3:1 and 4:1 at varied concentrations (0.1-1M) on a lab scale to obtain a wide pH range. It is observed that lower the pH, higher is the phosphorous recovery, but a pH range of 3-6 is chosen as optimum pH for further treatment of supernatant. The acidic supernatants produced by this study will be used to re-precipitate the dissolved K and P as potassium struvite using bases, and the effect of recovered phosphorus as a potential fertilizer will be studied later. Hence, this study will compare various strategies with different acids, such as cheap inorganic acids, strong acids with mineral nutritional values, and organic acids, to determine which is the most techno-economically and environmentally interesting so that a well-founded choice can be made to recover two of the three macronutrients.

Keywords: phosphorous recovery, acid leaching, nutrient recovery, tomato plant, digestate processing

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Study on the Transformation of Pruning Residues in Citrus Fields Dedicated to Organic Farming

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Abstract

La importancia agronómica y ambiental de la incorporación de materia orgánica al suelo es un tema conocido y actualmente estudiado por muchos autores en el contexto del uso sustentable de la tierra, pero existe poca información sobre los cambios que sufre en el proceso de humificación y cómo estos. Los cambios influyen en las propiedades del suelo. Se caracterizan los residuos foliares orgánicos de los cítricos, solos o mezclados con otro tipo de residuos orgánicos como lombricompost o lodos (estos últimos no permitidos en agricultura ecológica), que se añaden a suelos orgánicos de diferentes texturas y características conocidas, principalmente en cuanto a su contenido orgánico. contenido. es una fracción. Se estudian los efectos de las enmiendas orgánicas, evaluando determinadas propiedades físicas y químicas, como la estabilidad de los áridos, Al aumentar el contenido de materia orgánica del suelo, se modifica su composición mediante análisis de fraccionamiento químico de sustancias húmicas y realizando un reconocimiento de estos residuos mediante técnicas de espectroscopía infrarroja y microscopía electrónica. Los resultados están relacionados con evaluar la influencia de estas enmiendas en estos suelos. Evaluar cómo la cantidad y calidad de la materia orgánica incorporada al suelo depende del tipo de enmienda, las dosis aplicadas y el tipo de suelo. La importancia agronómica y ambiental de la incorporación de materia orgánica al suelo es un tema actualmente conocido y estudiado por muchos autores en el contexto de la sostenibilidad del suelo. pero se dispone de poca información sobre los cambios que sufre en el proceso de humificación y cómo estos cambios influyen en las propiedades del suelo. Se caracterizan los residuos orgánicos de hojas de cítricos, solos o mezclados con otro tipo de residuos orgánicos como lombricompost o lodos (estos últimos no permitidos en agricultura ecológica), que se añaden a suelos orgánicos de diferentes texturas y características conocidas, principalmente en cuanto a su contenido orgánico. fracción se refiere. Se estudian los efectos de las enmiendas orgánicas, evaluando determinadas propiedades físicas y químicas, como la estabilidad de los áridos, el aumento del contenido de materia orgánica del suelo, se modifica su composición mediante análisis de fraccionamiento químico de sustancias húmicas y realizando un reconocimiento de estos residuos mediante técnicas de espectroscopía infrarroja y microscopía electrónica. Los resultados están relacionados con evaluar la influencia de estas enmiendas en estos suelos.

Keywords: soil, organic matter transformation

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Circular Economy in Agricultural Production: the Cycle of Nutrition Between Plants, Fish and Insects as a New System of Food Production with Low Environmental Footprint

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Abstract

Circular economy is a multi-level concept and in this presentation we focus it on primary production. We present a pioneering circular tri-trophic model that includes three types of organisms (plants, fish and insects) that feed each other. The aim of the project is to apply the principles of the circular economy to the agricultural production, through the reuse of nutrient-rich materials that have so far been considered waste. By joining the cycle of nutrition, the residues or by-products of the metabolism of one organism will become food for the next, turning them from waste into a resource. Insects will be reared as a source of protein/vitamins/minerals and feed the fish through the production of insect meal which is a significant substitute for commercial feed. Fish will be linked to plants through a water recirculation system where they excrete metabolic products rich in nitrogen and other elements necessary for plant nutrition (this system is called aquaponics). Plant residues resulting from the high-wire farming system (e.g., pruning residues, cut fruits) will provide food for insects. The objectives of the project are two-fold: a) to create new knowledge through research on the implementation of the circular production system, the completeness of which will provide the roadmap for its introduction in the primary sector and b) to transfer knowledge/technology, to inform and raise awareness among producers, primary sector enterprises and citizens about the new model which is contrary to the current linear model of development.

Keywords: nutrient recovery, greenhouse crops, wastewater re-use

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Rice Straw Pyrolysis for Nutrient Recovery: Investigating Silicon and Phosphorus Co-Release as Alternative Fertilizer Components

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Abstract

Research on nutrient recovery and alternative fertilizers has received more attention in recent years. For growth and development, rice plants have ingested several nutrients from the soil, including nitrogen (N), phosphorus (P), potassium (K), silicon (Si), and many other mineral elements. Each nutrient has a different role in the development of roots, stems, flowers, and seeds. Si is believed to be the primary component of phytoliths, which make up the skeletal structure for many components of the rice plant. During the formation of phytoliths, there can be many nutrients assimilated from the soil, such as P, K, etc., that can be trapped inside this structure. In many agricultural countries, rice straw is freely burned to sanitize fields following each harvest. However, this approach is controversial because it does not warrant the amount of nutrients returned to the field and has a risk of increasing air pollution due to the generation of CO2 emissions during the combustion process. In this study, we focus on the optimal conditions for the release of Si and P from the burning of rice straw to increase the nutrient content, especially P, returned to the soil and minimize the negative impacts on the environment. According to results from batch heating investigations, P that had been obligated in the phytolith structure might be released when the phytolith is dissolved. The highest values of dissolved Si and P were found in the temperature range of 500 – 700 °C. Chemical composition, X-ray diffraction, infrared spectral data, and specific surface area (SSA) suggest that the presence of organic carbon is masked at temperatures smaller than 500 °C, and the crystallization of silica at temperatures larger than 700 °C is the main reason for the decrease in phytolith dissolution rate and P release. For the practice of burning rice straw, it is possible to recommend optimal treatment conditions to return the maximum amount of P contained in rice straw back to the soil or create alternative fertilizer components for crops.

Keywords: Rice straw, Nutrient recovery, Silicon, Phosphorous, Alternative fertilizer

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Cascade Hydroponic Systems as Means of Nutrient Re-use in Melon Cultivation

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Abstract

Cascade hydroponic systems represent a novel approach in fertilization management, aiming at nutrient recovery and waste minimization. In this system, the used nutrient solution drained from a primary crop is directed to a secondary one enhancing resource-use efficiency through nutrient re-use. Therefore, cascade systems represent the alternative of the current practice of discharging the drainage solution to the environment with the well-known negative environmental impacts. In a pilot-scale cascade hydroponic system unit we have implemented a comparative study of melon performance and yield under two treatments; a control one, where fresh nutrient solution is applied and the cascade one, where the crops are watered with the drainage solution of cucumber (primary crop), without any other nutrient amendments. The experiment lasted for 3 months, during which crop functional parameters (photosynthetic pigments and light use efficiency of the photosynthetic apparatus) and growth parameters (aerial biomass, fruit number and weight) were measured at regular intervals. Although the evaluation of crop performance is currently ongoing, the results are encouraging. Our findings suggest that the recycling of drainage water and the subsequent nutrient re-use is an efficient cultivation technique succeeding both high productivity and low environmental footprint.

Keywords: nutrient recovery, greenhouse crops, drainage management, salinity management

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Effectiveness of Composting with Different Soil Types: A Modal Experimental Study

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Abstract

Countries can adopt sustainable soil management policies using resources like the World Soil Charter and International Code on Sustainable Fertilizer Use. The FAO stresses investing in sustainable soil management for soil dehumidification and land use security. Soil fertility can decrease due to unsustainable farming practices, but composting can help conserve soil organic matter. A study aimed to improve plant hydrolysates for sustainable soil fertility. The present study details the outcomes of a modal experiment involving four types of soil: Vertisol (VR), Chernozem (CH), Luvisol (LV), and Fluvisol (FL) (WRBSR, 2014). These soil types were treated with a proportional amount of compost and two types of microbiological preparations, namely the Klebsiella strain and microbial preparation MicroVeda. Soil-compost mixtures were treated with 50-, 100-, and 200-ml gradients. After composting, changes in pH, content, and composition of soil organic matter, nitrogen, phosphorus, and potassium were measured. The data were processed using Microsoft Office's Excel, descriptive statistics, and correlation. The changes were compared to the control variant, limit values, and average soil statistics. The levels of organic carbon and pH in different soil types significantly vary. CH and VR soils are of a medium humic class, while LV and FL are low to very low in the humus class (Filcheva, 2015). Adding compost increases bioavailable nitrogen, phosphorus, and potassium. However, the mineral nitrogen supply needs to be enhanced. Organic fertilisation improves nitrogen bioavailability in CH and VR but not LV and FL. Generally, phosphorus and potassium levels are satisfactory, but VR has a phosphorus deficiency. Compost and microbiological strains can mitigate this deficiency. Humic acids dominate humus systems, with CH having fewer colloids and more unstable organic acids. Plant hydrolysates can maintain soil fertility, but CH and FL soils are more susceptible to degradation. LV and FL have higher aggressive fulvic acid levels, leading to more degradation. Analysing changes in soil composition can provide a deeper understanding of the process. Growing plants is necessary for definitive diagnoses, and the effectiveness of compost and micro strains can be evaluated by growing beans in soil-compost variants. The primary factor affecting macroelement composition is imported compost.

Keywords: sustainable soil management, composting, microbiological preparations, soil fertility, humification

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Monitoring the Carbon-Nitrogen Ratio in Soil for Sustainable Agriculture

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Abstract

In Europe, sustainable agriculture is a top priority, and the responsible use of natural resources is crucial. To preserve "healthy soils," it is essential to minimise soil organic matter degradation, which is a significant threat to farmland in the face of global climate change. To achieve balance in agroecosystems, it is highly recommended to incorporate safe and natural waste products, such as compost. Composts provide plants with the necessary nutrients and maintain the balance of elements in the soil. Our study aims to assess soil diversity in terms of current and exchangeable acidity, carbon, nitrogen, and their ratios and evaluate the effectiveness of compost materials in achieving system sustainability. To examine the ecological status of soils in Bulgaria, we utilised a national monitoring network with a grid of 16 to 16 km whole area. Periodic surveys of the monitoring network points provide valuable information on element balance. Cluster analysis of the macroelements has identified three clusters: the first comprises solely phosphorus, the second combines the C/N ratio, total carbon, and nitrogen, and the third includes both pH variants. We also developed maps of element content and C/N ratio using TOC and total nitrogen data. The C/N ratio in the surface layer (0-20 cm) ranges from 4.4 to 31.6; in the 20-40 cm layer, it varies from 4.4 to 32.7. Based on this data, the country's area can be divided into three zones according to C/N, directly related to land use practices. In the area with predominant grain production, the ratio is 4.4 to 14.4. The variation in areas with developed animal husbandry is 19.6-31.6, closer to the optimum. This information allows us to recommend differentiated applications of compost. It is crucial to test soil and compost for nutrients before application, and applying compost is highly dependent on land use practices. Excessive use of one type of compost can lead to an imbalance of macronutrients due to the accelerated assimilation of nitrogen and a relatively lower degree of accumulation of phosphorus and potassium. Applying compost with a calibrated spreader ensures crop yield goals will be achieved and reduces the chance of pollution. Additionally, the volume reduction of composting manure can save producers money.

Keywords: Agroecosystems, Compost, Element balance, Macronutrients, Soil diversity

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Sustainable (De)centralised Recovery of Macro- and Micro-nutrients From Human Excreta Without Pharmaceuticals/PFAS: a Proposal for the "Green Architecture" of the Brisbane 2032 Olympics

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Abstract

Establishing the circular economy of the future requires the development of innovative solutions that allow for the continuous recovery and reuse of resources – including the nutrients currently excreted by humans around the world. Since 2017, researchers at The University of Queensland and Tampere University have collaborated to develop the 'UGOLD' concept, a hybrid between electrodialysis and microbial electrolysis cells, that allows for the recovery of macro- and micronutrients from various wastewater sources as a liquid fertiliser in one of the most energy-efficient ways demonstrated to date (Ledezma, et al., 2017). One of the most promising nutrient sources for the UGOLD system is source-separated human urine – which contains 79% of the nitrogen (N), 71% of the potassium (K) and 47% of the phosphorous (P) and many essential micro-nutrients, yet constitutes ≤ 1% of the total volume of wastewater generated in sewered urban environments (Ledezma et al., 2015). As a result, the energy consumption for N recovery as NH4+ is among the lowest ever demonstrated in the laboratory: 2.4 kWh kgN 1 and pilot scale: 4.3 kWh kgN 1 at a removal rate of 23.1 kgN m^{-3} d^{-1}, while simultaneously producing a liquid fertiliser that contains 27 gNH_4-N L^{-1}, 9 gK L^{-1}, 0.7 gPO_4-P L^{-1} and ~20 g L^{-1} of organic acids (+ all micro-nutrients e.g. S, Ca, Mg, Mn, Fe, Zn) (Ledezma et al., 2019). More recently, the UGOLD concept has also been tested on digested sewage sludge reject water, with results similarly promising (Koskue et al., 2021). Of equal importance is the fact that, since the process is driven by large biofilms of heavily active bacteria plus electrochemical oxidation and reduction processes, the absolute majority of the micropollutants found in either human urine of reject water are either degraded during the recovery process and/or excluded by the electrodialysis membranes, therefore yielding a liquid fertiliser product that is rich in nutrients but devoid of both micropollutants (21 compounds measured incl. caffeine, nicotine, ethyl-glucuronide, acesulfame, common medications such as antidepressants/anticonvulsants and antibiotics/antimycotics) and per- and polyfluoroalkyl substances (PFAS; 10 most common compounds measured) (Monetti et al., 2021; Koskue et al., 2022). Despite such encouraging results however, the up-scaling and commercialisation of UGOLD has been hampered by the fact that transport costs (from 'production sites' in urban centres to 'usage sites' in agricultural fields outside the city) for liquid fertilisers produced in relatively small-scale (when compared to megaton y-1 synthetic production facilities) are simply prohibitive in Australia. In other words, the proposed concept can only be financially viable if the nutrients removed and recovered from human excreta can be

reused in close proximity. In 2021, Brisbane was elected as the host city for the 2032 Olympics. While the city's bid proposes a more austere celebration of global sport that its predecessors, there will still be significant infrastructural developments in the city, as part of the 'Brisbane 2032 masterplan'. One key feature of this masterplan is the development of large 'green corridors' that will allow for the spectators to easily move between the different competition and social venues around the city by walking and/or zero-emission vehicles (e-bikes/scooters). These corridors will be completely surrounded/covered by green architecture i.e. green canopies, horizontal gardens and other types of vegetation arrangements that will showcase the exceptional native flora and fauna of Australia, while providing numerous environmental benefits such as urban cooling, air purification, etc. These corridors will therefore necessitate large amounts of water but also nutrients, which is an excellent opportunity for the UGOLD technology to contribute to one of the first intra-urban fully-circular nutrient loops, where both inhabitants and visitors to Brisbane will contribute to the long-term sustainability of the city's green architecture by 'donating' their nutrients and simultaneously benefitting from their local and sustainable implementation.

Keywords: nutrient removal & recovery, source-separated urine, anaerobic sludge reject water, alternative fertilisers, green architecture.

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Testing the Effectiveness of Natural Zeolite on Polymetallic-Contaminated Soils in Bulgaria

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Abstract

Soil contamination is a serious issue that poses a threat to both the environment and human health. This research focuses on the soils between Plovdiv and Asenovgrad in Bulgaria, contaminated with lead, zinc, and cadmium from a zinc-lead processing plant operated in the last century. The area is currently home to the largest lead-zinc production facility in Southeastern Europe, which takes a new approach to nature conservation. However, the damage caused by past pollution persists. This study aimed to test the effectiveness of natural zeolite on polymetallic-contaminated soils with a neutral or slightly alkaline pH and its impact on lettuce cultivation. The goal is to reduce the effects of contaminants in the food chain.

The experiment involved three soil variants with varying levels of heavy metal loading: soil 1, soil 2, and soil 3. The Pb contents in soil 1, 2, and 3 were 6, 9, and 18 times higher than 120 mg/kg. For zinc, the contents in soil 1, 2, and 3 were 2, 3, and 6 times higher than 400 mg/kg, while for cadmium, they were 5, 6, and 16 times higher than 3 mg/kg. Natural zeolite was added at 1%, 5%, and 10% levels to each soil while maintaining a humidity level of 60%. The experiment was conducted for 45 days under vegetation house conditions. After conducting a multifactorial analysis, it was found that soil is the most influential factor affecting lettuce yields, followed by the interaction between soil and zeolite. The amount of zeolite used has little effect on lettuce growth in heavily contaminated soil. Nevertheless, the slow release of nutrients like potassium, ammonium, or phosphates from zeolite can make it an excellent carrier for potassium fertilisers. It has been found that decreased levels of heavy metals in soil can lead to improved photosynthetic activity and plant transpiration rates, indicating a better physiological state. Additionally, adding zeolite to heavily contaminated soil significantly impacts the plants' photosynthetic activity and gas exchange parameters. The study has also confirmed that lead and cadmium are the primary toxic elements, and applying zeolite at 5% and 10% levels can reduce plant contamination. However, even if safe levels are achieved, growing leafy vegetables in the area still pose risks.

Keywords: Remediation, Adsorption, Soil quality, Heavy metals, Environmental impact

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NOV: Novel materials from food resources

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Conversion of food waste to energy storage materials

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Abstract

Food waste and loss have been recognized as major issues facing humanity because of their environmental, economic, and social implications with global consequences. Waste is generated throughout the food life cycle, starting from agricultural production up to industrial manufacturing, processing, retail and household consumption, resulting in loss of valuable resources and causing management problems. However, many of the waste streams generated during food production, processing, marketing and consumption have the potential for valorization within biorefineries. This presentation focuses development of composite materials from food industry byproducts, specifically shells of edible tree nuts, edible oil wax and animal fat that can be used in energy storage systems and many other applications. The goal of this study is to develop composite materials for solar energy storage. Although solar energy is an abundant resource, its intermittency is a major constraint for continuous supply of energy for domestic and industrial use. Hence, development of efficient energy storage systems is vital for augmenting reliability of energy supply from renewable sources. Thermal energy storage (TES) materials are used to mitigate the intermittence of solar energy directly from the source. Concentrated Solar Power (CSP) systems utilize TES to store solar energy in thermal energy form. This study focuses on the latent heat thermal energy storage, also referred to as Phase Change Materials (PCM) which have an intrinsic capability of absorbing (charging) and releasing (discharging) heat during phase transition cycles. Hazel nut shells are evaluated as a potential feedstock for producing high porosity carbon materials that can be used to encapsulate and shape stabilize PCM to eliminate leakage during operation of CSP systems. Thermal properties of sunflower oil wax, and beef, pork and lamb fat are examined to evaluate their suitability as PCM to be loaded into porous carbon produced from hazel nut shells for shape stabilization. Zinc chloride and potassium hydroxide were separately tested as catalysts to increase pore volume of the carbon produced from nut shells via pyrolysis. Evaluation of the surface area and pore distribution of the produced biochar samples indicated that $ZnCl_2$ was a better catalyst than KOH to generate high surface area and pore volume. A carbon material with over 1200 m^2/g of specific surface area, as measured via Brunauer-Emmett-Teller (BET) analyses, and pore volume of 0.627 cm^3/g was produced from hazel nut shells via pyrolysis at 600 ^oC. Acid treatment of the samples prior to water washing enhanced pore volume and surface area of the material. Pore size distribution analysis showed that average pore diameter and width for the latter sample was 20.462 Angstrom (2.1 nm) and 21.795 Angstrom (2.2 nm), respectively. XRD analyses of the biochar samples indicate high carbon content and a disordered structure. Thermal analyses of the animal fat and sunflower wax confirmed their suitability as PCM.

Keywords: nut shell, lipids, food processing byproducts, energy storage, porous carbon

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Agrifood Waste Valorisation for Bioplastic Composites and High-value Chemicals

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Abstract

Linear production is no longer possible in a logic of sustainability and circular economy. An important and emerging alternative is based on Circular Economy and the 4R principles (reduce, reuse, recover and recycle) that should be applied during the entire cycle of production, consumption and return of resources, involving the entire supply chain from production to disposal. In this context we will report recent results achieved within various successful case studies reporting the recovery, recycling, and valorization of biomass to produce high value chemicals (Visco et al., 2022). In particular:

1. From Brewery to Bioplastics: The EU Brewing Industry produces over 39.5 MioL of beer yearly, generating over 6.4 Miot/year of Beer spent grain (BSG), main side-stream of the brewing process. In EU, 20% of BSG is landfilled (1.28 Miot/year). LIFE RESTART is a close to market project which will reuse BSG to substitute Fossil based Plastics for food and non-food packaging, giving adequate answer to some of the most pressing environmental issues related to BSG disposal and non-biodegradable, persistent FbP packaging, tackling relevant social issues (Visco et al. 2022).

2. Production of green biopolymers for leather tanning: a novel class of bio-based polymers is being developed within the recently financed LIFE I'M-TAN project with low chemical hazard, sustainable costs, reduced waste and improved circularity (recycle/re-use of waste) compared to conventional processes. An innovative ultrafiltration/nanofiltration purification process (UF/NF) will be scaled up to separate concentrate purified natural tannins (CPNT) from non-tanning LMWS. The CPNT will then be chemically modified according to green chemistry principles to produce tanning agents while LMWS will be used as animal feed.

Keywords: Agriffod waste valorization, biopolymer composites, fine chemicals, circular economy, green chemistry

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Biosorption of diesel oil using hydrochar derived from low temperature hydrothermal carbonization of Aloe vera leaf bark

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Abstract

In this study, Aloe vera leaf bark was used to produce hydrochar by hydrothermal carbonization process. Hydrothermal carbonization is the process of pyrolysis of solid wastes at temperatures from 180 - 350oC and is suitable for solid wastes with high moisture content (80 - 90%). In recent years, in southern Vietnam, the area of land for growing Aloe vera has significantly increased to meet the needs of domestic production and export with hundreds of thousands of tons of products per year. In addition, in Greece during the last decade, Aloe vera is also grown in many regions, bringing sustainable economic value to replace some traditional crops. However, the processing of Aloe vera to collect juice and gel discharged a lot of solid waste. Currently, it is mainly collected and buried as green manure. Aloe vera leaf bark has high moisture and cellulose content, which is very suitable for hydrothermal carbonization technology. Utilizing the by-products from Aloe vera processing to produce hydrochar as bio-adsorbent in general and waste oil adsorbent, in particular, can be considered a new research direction and has potential for application in Vietnam as well as in Greece. In this study, the hydrothermal carbonization process was carried out at low temperatures of 180 - 220°C for a time of 2 hours – 8 hours. All experiments were carried out in batch tests. Aloe vera hydrochar produced at low pyrolysis temperatures of 180oC at a short time (2 hours) without any activation process showed the ability to absorb Diesel oil (DO) was relatively high (maximum 4.8 g oil/g hydrochar) with an exposure time of 15 minutes. Results confirmed that the sorption process of Aloe vera hydrochar depended on adsorption phase exposure time between hydrochar and diesel oil in the solution; the size of hydrochar; the initial concentration of Diesel oil; and the solid/liquid ratio (hydrochar dose). Batch experiments also indicated that hydrochar made from Aloe vera leaf bark had an average capacity to adsorb and partially removed a certain amount of Diesel oil in water contaminated with waste oil. Therefore, hydrochar made from Aloe vera leaf bark has the potential to be used as an oil adsorbent in oil-contaminated water sources.

Keywords: Bio- Adsorbent , Diesel oil , Hydrochar , Aloe Vera leaf bark

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Molecular features and disease suppressive activity of organic fractions extracted by green composts

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Abstract

Composting is a viable technology to process bio-wastes and organic biomasses through a controlled aerobic microbial process that promotes an effective sanitization and biochemical stabilization of organic matter (Ballardo et al., 2020). Horticultural crops and agro-industrial productions provide significant amounts of residues and by-products that are important sources of carbon, nutrients and potential bioactive components (Spaccini et al., 2019). Besides the conventional use of compost as soil amendment and fertilizer, the bulk compost and the extractable fractions are reckoned to act as either plant biostimulants or disease suppressive compounds (Pane et al., 2016). The main objective of this study was the evaluation of potential plant disease suppressive properties of two green compost obtained from olive residues and coffee processing wastes, determining a possible relationship between their molecular features and bioactivity. Various organic fractions as humic substances HS, Compost tea, CT, aqueous fraction DOM, and lipid compounds have been isolated by different extraction methodologies. The molecular composition of bulk composts and derived fractions have been analyzed by 13C CPMAS NMR, thermochemolysis GC- MS and Folin Ciocalteau assay (Verrillo et al., 2022). The suppressive activity was tested with an in vivo assay on the pathosystem Fusarium oxysporum f.sp. raphani/wild rocket (Diplotaxis tenuifolia) (Navarro et al., 2022) by evaluating the potential to induce systemic resistance (ISR) in the plants. Moreover, antioxidant features and antibacterial properties on human microbial strains have been carried out to propose a possible additional applications of compost extracts in pharmacology and nutraceuticals fields. The in planta assays have shown for both biomasses a greater suppressive activity against wild rocket tracheofusariosis for the bulk Composts, followed by and HS fractions. Conversely, the evaluation of antioxidant properties and antimicrobial assays have shown that HS and CT extracts from olive compost induce a suppressive effect on pathogens related to human health. The combination of molecular characterization and biological data suggest the occurrence of a structural-activity relationship between structure through different modalities of mechanisms of inhibition or resistance induction. In particular, for plant

pathogens the bioactivity seems related to the interaction of plant roots with either the polar fractions such as oligosaccharides and peptides or to the complex amphiphilic fractions, while the lignin and phenolic derivatives were correlated with antioxidant activity and inhibition growth of multi drug resistance human pathogens.

Keywords: compost, recycling biomasses, agricultural wastes, suppressive disease, molecular characterization

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A Modified Crustacean Biorefinery Approach: Carotenoids Extraction and Porous Magnesian Calcite Powder

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Abstract

Crustacean shells are a type of food waste with widely recognized valorisation potential within the circular economy. The usual shell biorefinery approach comprises carotenoids extraction, then obtaining proteins, and finally demineralisation to dissolve the calcium carbonate and obtain chitin, as described, for instance, in references [1] and [2]. In the current study, we propose another valorisation approach which avoids the destruction of natural shell nanoporous composite, and rather uses it as a novel adsorbent material for water pollutants removal. Although there are not many reports specifically targeting the porosity of biogenic calcites, our recent project laid down the foundation of native crab shells porosity investigation and their applications potential [3]. Indeed, the literature reports the effectiveness of powdered shells in water purification, Moving further, here we present simple processing methods, such as thermal, acidic and alkaline treatments to obtain different composition and improved porosity of the material. To demonstrate this view, carotenoids were firstly extracted for a batches of 300 g of the blue crab (*Callinectes sapidus*) shell fragments using acetone immersion method. This results in a solution containing 6.5 to 7.2 mg carotenoids, which were submitted to purification, while the residual shells were grinded to micrometric powder using a vibratory disc mill. TGA measurements of resulting powder, in argon gas, show distinct temperature ranges where organic matter and chitin degrade (250 – 370 °C, finally followed by decarboxylation of $CaCO_3$ (620 – 740 °C). These temperature steps have been used to effectively conduct purpose-oriented thermal treatment of the shell powder. Our porosity measurements by the BET method show that the pore surface area firstly increased from 8.21 $m^2\ g^{-1}$ in shells powdered in native state to 32.94 $m^2\ g^{-1}$ in those powdered after extraction. The porosity can be further improved to over 90 $m^1\ g^{-1}$ by alkaline treatment, followed by acidic treatment with intermediate calcination at 500 and 700 °C using a proprietary method in preparation patent submission. Hence our findings allow the improvement of adsorbents from crab shell waste with tailored structural properties.

Keywords: crustacean shells, porosity, adsorbent material, carotenoids, chemical composition

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Circular Recycling of 2,5-furandicarboxylic Acid from Designed Biobased Polymers

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Abstract

2,5-furandicarboxylic acid (FDCA) is a fascinating example of new monomer, successfully derived from renewable resource, suitable for the realization of novel biobased polyesters settling as competitive alternatives to terephthalic acid-based polymers. Among furan-based polyesters, poly(pentamethylene 2,5-furandicarboxylate) (PPeF) is one of the most interesting, showing outstanding gas barrier properties and high flexibility (Guidotti et al. 2019). PPeF has been successfully combined with another well-known biobased polymer, poly(lactic acid) (PLA), expanding its suitability for flexible food packaging applications, thus, overcoming PLA intrinsic limitations, such as brittleness and poor thermal stability. By playing with composition and chemical architecture, the design of new biomaterials was accomplished (Bianchi et al. 2023, Rigotti et al. 2021). Although presenting numerous advantages, polymer blends and copolymers entail a big challenge when they come to recycling. In this view, enzymatic hydrolysis constitutes an outstandingly valuable solution, due to its substrate specificity, allowing separation and recovering of the single components and monomers. On the basis of previous studies (Gigli et al. 2019), Thermobifida cellulositilytica cutinase was selected to preferentially hydrolyse PPeF from PLA/PPeF blends and PLA-PPeF copolymer. The polymer films were incubated in the presence of the cutinase

for different times (3, 6 and 7 days). The recovered samples were subjected to weight loss determination, SEM and FTIR analyses, while the hydrolysis products were quantified by HPLC and NMR analyses. The results revealed the selective attack of the enzyme towards the furanic component both in the blends and in the copolymer. The FDCA monomer was successfully recovered from the hydrolysate as white powder, with a high purity level (as confirmed by NMR and TGA analyses), and reused for PPeF re-synthesis (yield 95%). The polymer synthesized from the recovered monomer has been reprocessed in form of film presenting the same functional properties of PPeF obtained from commercial FDCA. The results confirmed the fully circularity of bioplastics, from production to after-life recycling and finally re-synthesis (Siracusa et al. 2023).

Keywords: furandicarboxylic acid, biopolyesters, chemical design, enzymatic degradation, green recycling

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Waste Management in the Sugar Industry: Study of Pectin Extraction from Sugar Beet Flakes by Conventional and Non-conventional Techniques

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Abstract

Sugar industry generates large amounts of by-products that can be used in various applications. Through the production of refined sugar from sugar beets, two main by-products are obtained – beet pulp in the form of fibrous flakes that result from the extraction of sugar, and molasses, which is a dark-colored, viscous, and liquid by-product of the production process. In general, sugar beet flakes are used in animal feed, while molasses is used for alcohol production, in animal feed or as a medium for obtaining yeast biomass. Sugar beet flakes composition is mainly made up by three major polysaccharides – cellulose, hemicellulose and pectin, together with small amounts of fat, protein, ash and lignin. As a result, the flakes generated from sugar beet processing in the sugar industry were considered as raw material for pectin production. Pectin extracted from sugar beet is one of the main types of pectin available on the market, mostly due to its properties and the availability of source material. Pectin represents a group of polysaccharides naturally found in the plant cell walls; pectin recovered from plant materials, mainly citrus peel, apple pomace and sugar beet flakes, has industrial and commercial value as thickening, stabilizing and gelling agent. The general process of pectin production, irrespective of the plant material used as pectin source, comprises the following main steps: pretreatment of plant material, extraction, and a post-extraction stage (precipitation and purification of pectin). By focusing on the extraction stage of pectin production, the aim of this research was to compare different conventional and non-conventional extraction techniques applied to sugar beet flakes, and to investigate the influence of the extraction conditions on the yield of the process and the purity of the extracted pectin. This represents the first study on use of sugar beet flakes resulted from sugar processing in the north-east region of Romania, by one of largest sugar producers in Europe, as pectin source. For conventional extraction with citric acid, the parameters that were varied were temperature, pH, solid-to-liquid ratio (SLR), and time. In the case of the non-conventional extraction techniques, the following parameters were varied: for microwave-assisted extraction – microwave power, pH, SLR and time, and for ultrasound-assisted extraction – ultrasonic amplitude, pH, SLR and time. Overall, better results in terms of yield were achieved by conventional citric acid extraction, which resulted in a pectin yield of about 20%. The highest purity of pectin, expressed as galacturonic acid content, was obtained for pectin extracted by ultrasound-assisted extraction and exceeded 90 g galacturonic acid/100 g pectin. Following the optimization of the extraction conditions of each technique, pectin extracted from sugar beet flakes will be used to develop new food products through its incorporation into the composition of gluten-free pasta.

Keywords: sugar beet flakes, pectin, extraction

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Development of Biodegradable Films Based on Cellulose Derivatives and Pectin for Food Packaging

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Abstract

Nowadays, solid wastes generated from various industrial, domestic or agricultural activities have created serious environmental problems. The impact of different types of packaging (paper, plastic, metal i.e.) on the environment has reached a critical stage all over the world. Currently, it is a high interest in the use of biodegradable polymers over non-biodegradable synthetic polymers obtained from petroleum and which create major environmental problems. Biodegradable polymers such as cellulose, cellulose derivatives, pectin, starch, lignin, and polyester have lower mechanical, barrier and thermal properties compared to synthetic polymers. Thus, in order to replace non-biodegradable polymers with biodegradable polymers, the characteristics of biodegradable polymers must be improved by various methods, such as mixing with synthetic polymers or natural polymers. The aim of this study was to develop biodegradable films for food packaging. A biodegradable films were obtained by casting method using three cellulose derivatives, pectin and glycerol as plasticizer. The thickness and mechanical properties (tensile strength, elongation at break and elastic modulus) of biodegradable films are basic characteristics that have been investigated to ensure the integrity of food packaging under the influence of external factors. The films obtained with hydroxypropyl methyl cellulose (HPMC) had the highest thickness (93.1±5.56 mm) compared to those obtained with hydroxyethyl cellulose (HEC) (58.7±3.48 mm). The HEC films had the highest elongation value of 13.27% and the lowest tensile strength of 28.18 MPa. The highest value for tensile strength was recorded for HPMC films 60.04 MPa. Close values for elongation at break were reported for the films obtained from carboxymethyl cellulose (CMC) and HPMC, 8.71% and 9.12%, respectively. The hardness of the biodegradable films was also determined, this characteristic being important during the handling, transport and storage of food products. The lowest value for hardness was 245.90±15.53 HL for HEC film and the highest value was 526.9±10.50 HL (CMC film). The moisture content of the biodegradable films was 8.25 – 11.72%, while the water activity (a_w) was 0.29 – 0.35 which ensured information about their microbial stability. The barrier properties of films, such as water vapor transmission rate (WVTr) of the biodegradable films were determined between 1.14 and 1.87 $g*m^{-2}*day^{-1}*atm^{-1}$. The light transmission, transparency and modifications in the structure of the biodegradable films were investigated using spectroscopy.

Keywords: carboxymethyl cellulose, hydroxyethyl cellulose, hydroxypropyl methyl cellulose, pectin, ATR-FT-IR

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Characterization of Biodegradable Films Based on Cellulose Derivatives, Pectin and Essential Oil

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Abstract

Synthetic polymers have caused ecological problems because they are not fully biodegradable, generating huge quantity of waste which can be noxious to humans and the environment. Environmentally conscious people are therefore looking for better properties and availability in packaging materials which do not pose health or other environmental concerns and provide alternatives to conventional non-biodegradable materials. Films are composed of starch, cellulose, chitosan and gums which are commonly studied by means of their good mechanical and barrier characteristics against different gases (e.g., oxygen). Pectin, an inexhaustible polysaccharide (utilised in the food production as a gelling, stabilizing, thickening and encapsulating agent), is a polymer with major potential for future development. The aim of the current work was to produce films from citrus pectin, cellulose derivatives (carboxymethyl cellulose – CMC, hydroxypropyl methyl cellulose – HPMC, and 2-hydroxyethyl cellulose – 2-HEC) and essential oil extracted from bee bread using glycerol as plasticizer, to determine the mechanical properties (tensile strength and elongation at break), thickness, and physicochemical properties (FT-IR characterization, opacity and colour parameters) of obtained films. The elongation at break and thickness of the films depended on the type of cellulose derivative used for each film formulation, the HPMC film had the highest value of thickness (86.1 mm), while the CMC and 2-HEC films had approximatively the same thickness (62.1 and 65.1 mm, respectively). The highest elongation at break (12.57%) was identified for HPMC film, while the lowest value (8.89%) for CMC. The FT-IR spectrum of the HPMC film exhibited two characteristic absorption bands at 3457 and 1048 cm^{-1}, which were attributed to the hydrogen bonding and bending vibration of C–O, respectively. On the other hand, FT-IR spectra for CMC film indicated peaks at 3301 cm^{-1} due to O–H stretching and inter/intramolecular hydrogen bonds, and at 2905 cm^{-1} caused by C–H stretching, while FT-IR spectrum for 2-HEC presented peaks at 2922 and 1639 cm^{-1} which were attributed to C–H and C=O stretching, respectively.

Keywords: biodegradable films, cellulose derivatives, pectin, essential oil

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“Waste a second!” Novel Use of Food Waste for the Development of Advanced Nanomaterials

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Abstract

Since ancient times, humankind has exploited the diversity of plant life for a wide range of applications, including food, textile manufacturing, and the treatment of various diseases. However, among millions of tons of generated biomass, nowadays agriculture and health food industries face waste management and disposal issues worldwide (Santana-Méridas et al., 2012). In this context, the potential recirculation of wasted biomass is one of the major challenges for the scientific community exploiting their potential to be transformed into added-value products with biological and industrial significance (Tuck et al., 2012). Among wasted biomass, polymeric materials derived from natural and sustainable resources, have garnered particular attention due to their inherent biocompatibility, strong stabilizing activity, and abundance. The use of polymers obtained from natural sources offers an ideal platform for the fabrication of advanced materials for medical purposes. For example, protein-based nanostructures have found numerous applications in tissue engineering and drug delivery owing to their excellent biocompatibility and biodegradability. The presence of functional groups (such as amine, carboxyl, hydroxyl, and phenolics) within the protein structure provides inherent advantages over polysaccharides, which often require chemical modifications to form stable nanostructures (Abakumov et al., 2018). In our research, different food waste sources were employed to explore novel possibilities for the fabrication of nanomaterials with potential biomedical and industrial applications. Specifically, Cucurbita pepo L. (pumpkin) seeds waste and Serenoa repens (saw palmetto) fruits waste were utilized as sources of polysaccharides, proteins, and long-chain fatty acids. Purple corn cobs and unripe tomato fruits and leaves have been used as a source of bioactive molecules such as anthocyanins and tomatine, respectively. Nanoformulations were produced through simple, mild, scalable, and cost-effective procedures capable of generating advanced materials with strong activity, thanks to the combination of bioactive molecules stabilized and delivered by biogenic macromolecules. The obtained nanomaterials morphologies and dimensions were investigated through Transmission and Scanning Electron Microscopy (TEM, SEM) and Dynamic Light Scattering (DLS), confirming their nanometric size and spherical shape. Finally, biological investigations have revealed enhanced activity facilitated by the presence of the nanocarrier, which enhances the bioavailability of the active agents protecting them from degradation and hence improving the lifespan of the formulations.

Keywords: Nanomaterial, Delivery system, Proteins, Polysaccharides

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From Food Waste to Metal Protecting Agents: the Case of Green Inhibitors and of Bio-based Polymer Coatings

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Abstract

The ever-growing demand for raw materials necessary to satisfy the hunger of modern society is one of the biggest issues that global policies have to face and solve in the near future. The corrosion protection is one of the areas in which the new paradigm of the circular economy can be applied. Among the available technological solutions, corrosion inhibitors and polymeric coatings represent two interesting springboards for the applied research, not only for the huge market potentialities, but also for their need of very high amount of raw materials, mostly derived from petrochemical industry and/or connected to environmental issues. Thus, it is expected the related market to be restricted in the next future by environmental regulations, asking for novel sustainable alternatives. The imminent request of a green turn in the corrosion protection market can be satisfied by exploiting biomass from the significant amount of food waste produced worldwide. Here we present the rationale and the main results of two research lines designed to satisfy this need, with a focus on green inhibitors and bio-based polymer coatings.

i) Green inhibitors from waste of processed fruits and vegetables

Waste from edible fruits and vegetables usually still contain macromolecules and redox active compounds of low nutritional impact but having characteristics, like the presence of heteroatoms and instaurations, well desired for adsorption onto metal surfaces. These features can induce a corrosion protection effect resulting from a combination of active and passive mechanisms of action. In this work, extracts from waste of pomegranate (Magni et al., 2020) and cynara derived from industrial processing were obtained using different extraction protocols. Leafs of Moringa oleifera were also considered in the comparative study. The resulting complex mixtures were firstly analysed through chromatographic (GC-MS and HPLC-UV) and spectroscopic (FTIR) techniques. Through dedicated libraries, the main families of compounds were identified by the chromatograms: carbohydrate, short-chain acids and saturated/unsaturated fatty acids, the relative amount being modulated by the extraction medium, too. Additionally, starting from available literature, a quantification of some specific target molecule(s) for each extract was also performed (flavonoids, chlorogenic acids, etc.). Finally, the corrosion inhibition efficiency of the natural extracts towards metal specimens (Armco® iron, Fe >99.8 wt.%) was assessed by mass-loss

measurements (dipped sample in a stationary solution) and through electrochemical investigation (open circuit potential, dynamic electrochemical impedance spectroscopy and anodic potentiodynamic polarization). The aggressive media was 1 M HCl aqueous solution, mimicking the conditions of the pickling treatment for carbon steel handworks. Comparable performance for the three natural extracts were detected, independently by the quite different nature of the vegetable matrix. In all cases, a maximum in the inhibition efficiency up to 86-97% was detected after 10-24 h of exposure of the metal specimens to the corrosive environment spiked with a comparable amount of extract. For longer exposure, a decrease in the inhibition efficiency was invariably detected for all the extracts and for the control sample (hexamethylenetetramine solution, a synthetic organic corrosion inhibitor). After 72h, the inhibition efficiency was reduced levelling between 76-80%. A more detailed time-resolved investigation of the decreased protective features of the inhibitors over time has been possible through electrochemistry, and the related results will be discussed. Degradation (and hence modification) of the chemical composition of the extract has been deduced. Lastly, but not less important, we will discuss how our data provide evidences that the main anticorrosive component in such extracts is not a single molecule (as stated in many related articles) but derives from a synergism between a plethora of compounds belonging to the above-cited main families of compounds.

ii) Polymer coatings from tomato peel waste

The project aims at the valorization of tomato peels, an abundant agricultural waste in Italy that is currently exploited only in few low added-value chains (animal feed, waste-to-energy). In this work, the attention will be focused on the utilization of the cutin monomer, derived from the depolymerization of tomato peels, as curing agent of some naturally-derived epoxydized prepolymers for the preparation of corrosion protection coatings for carbon steel (Figure 1, left). First, the innovative approach will be discussed evidencing improvements and advantages with respect to the few analogous examples in literature, in term of both extraction of pure cutin monomer (purity >93 wt.%, with a total yield of 35 wt.%) and formulation of bio-based coatings. Then, the focus will be shifted on the electrochemical assessment of the protective features of the coatings under natural and accelerated aging conditions, and on the correlation with their thermal, physical and mechanical properties. The performance of the fully naturally derived coatings has been compared with that i) of control coatings (partially natural ones), with either the pre-polymer or the hardener being petrol-based, and ii) of a benchmark coating, made of bisphenol A diglycidyl ether and phthalic anhydride (fully petrol-derived). With the optimized formulations, the protective performance of cutin-derived fully bio-based coatings outperform both reference coatings, with value of $|Z|_{0.01Hz} > 109\ \Omega\ cm^2$ even after accelerated cyclic electrochemical tests lasting 7 days.

Keywords: biowaste, corrosion, inhibitors, polymer coatings, electrochemistry

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Sea Urchins Waste Valorization: Functional Collagen-based Biomaterials for Skin Regeneration

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Abstract

In the framework of the modern societal challenges, the principles of circular economy concern designing out waste, regenerating ecosystems and keeping items in use. In relation to these waste recycling and valorization pillars, our projects aim at developing innovative and eco-friendly collagen-based composite biomaterials to be used for skin regeneration from a food by-product, sea urchins wastes. In particular, collagen - in its native form - was obtained from part of the sea urchins waste, named peristomial membrane (surrounding the mouth of the animal). The remaining carbonatic matrix, constituted by tests and spines, was then employed to extract and isolate polyhydroxynaphtoquinones, a class of small polyphenols characterized by potent antioxidant activities (Di Benedetto et al., 2014, Marzorati et al., 2021). Collagen and antioxidants were then combined to obtain functional biocomposite materials, in which the structural properties of collagen fibrils are integrated with antioxidant additional features in order to promote skin regeneration. Composite biomaterials were characterized in terms of morphology, mechanical properties, degradation kinetics, polyphenols kinetics of release and antioxidant activity. Scanning Electron Microscopy indicated that composite biomaterials were morphologically similar to the simple collagen-based counterpart, with homogeneous fibrils organization pattern in the absence of undesired aggregates. Porosity was confirmed to be ideal for cells infiltration, settlement and growth. Surprisingly, polyphenols kinetics of release pointed out that polyhydroxynaphtoquinones antioxidants remained adsorbed onto the matrix of biomaterial, without any significant release. This aspect was investigated also *in silico* by using Tight Binding Molecular Dynamics. Some of the representative constituents of such systems, in particular a couple of glycine-arginine-aspartic acid tripeptides and the most abundant polyhydroxynaphtoquinone present in the extract, were simulated in presence of water as a solvent and a quite strong bond was found, explaining the stability of these compounds. Subsequently, the antioxidant activity of composite biomaterials was evaluated using ABTS assay directly on the solid composite materials. Results confirmed that a strong antioxidant activity was maintained on the collagen-based scaffold, after freeze-drying even without any antioxidants release in solution. Overall these data indicate that sea urchin wastes can be profitably exploited to obtain valuable molecules and develop innovative biomimetic and bioactive biomaterials, potentially effective in the promotion of tissue regeneration. As a future perspective, 3D bioprinting will be selected as modern technology to produce collagen-based biomaterials with enhanced mechanical properties, tunable morphologies

and personalized scaffold shapes.

Keywords: Sea Urchins Waste, Collagen, Antioxidant, Regenerative Medicine

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Tomato Peel Waste: a Powerful Source of Bio-based Polymer for Innovative Biomedical Devices

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Abstract

Italy is one of the world-leading processed tomato producers, the third one worldwide after California and China. In 2019 the National Association of the Canned Vegetable Industry (ANICAV) estimated that the tomato transformation campaign in Italy closed with a production of 4.8 Mtons of processed tomatoes and 91 thousand tons of waste composed of skin, seeds, and fiber (WTPC 2015). In the last decade, several routes have been covered for tomato waste valorization. Some of them involve the use of these waste in agriculture, as fertilizers or animal feeding (Abbeddou ,S. et al. 2015) or in second-generation biorefineries as biofuel (Hijosa-Valsero, M. et al. 2019). On the other hand, the biomedical sector is lacking of innovative bio-based and biodegradable polymers to involve in medical devices design. Tomato peel is composed by a tridimensional polymer named cutin, a repeated sequence of 10,16-dihydroxy hexadecanoic acid (10,16-diiHHDA) monomers (90% by weight). This unit has peculiar chemical features useful for the development of bio-based functional materials. The project CuToPro aims at recovering this secondary raw material for design new biomedical devices as nano-filtering face masks (nFFF) and Advanced Wound Dressings (AWD), but not limited to these. The tomato peel was purified through super critical carbon dioxide (sc-CO2), isolating an oleoresin rich in carotenoids. The latter constituting secondary high added-value impurities of the tomato peel to destinate to other markets. The depolymeritazion reaction, followed by a tailor-made purification, allowed to isolate 10,16-diHHDA in good amount (35%) and purity (>92%). The monomer was opportunely mixed/formulated with another bio-based polymer (PLA-PCL) and turned into micro and nano-ranged fibrous tissue by electrospinning. The fibers showed a smooth surface, they were free of defects and fibers were uniform in size and well interconnected. The hydrophobic nature of the monomer provides optimal water resistance maintaining high-water contact angle (112°). Furthermore: i) the antimicrobial tests showed an intrinsic antibacterial activity of the monomer alone and formulated, against E. Coli and S. Aureus; ii) the cytotoxicity tests confirmed the biocompatibility of cutin based formulations. These experimental data reveal the high potential of cutin form tomato peel waste as innovative secondary raw material for biomedical devices.

Keywords: tomato peel, biomedical devices, supercritical fluid, circular economy

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Synthesis of Magnetic Carbon from Pomace: It's Adsorption Performance

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Abstract

One of the most important sources of food waste is the food industry. Most of the waste in food industry is by-products of fruit processing industries such as the juice industry. Proper management of these wastes can provide economic benefits and preserves the environment from pollution caused by their excessive accumulation. As an example, during the industrial production of pomegranate juice, important amounts of pomace (approximately 50% in fresh weight) are generated (Cano-Lamadrid, M. et al., 2018). As alternative to landfilling, these wastes can be used to produce additives in foods and materials. In this study, the production of magnetic carbon from pomegranate pomace and its Cr(VI) adsorption performance has been investigated. Magnetic carbons (MCs) is gaining attention for the adsorption of contaminants from aqueous solutions due to their easy separation (Singh, P. et al.,2019). More importantly Red mud (RM) and chemical sludge has been used an iron source. Both pose serious environmental problem (Kazak, O., 2021). In this way, this study aimed to show that multi-faceted benefits can be achieved to ensure waste elimination and to obtain a potential alternative adsorbent for the removal of Cr (VI) from aqueous solution. In this work, raw pomace, torrefied pomace and hydrochar derived from pomace were used as carboneous precursors. The mixing of iron containing wastes with carbon precursers were carried out by two ways: mechanical mixing and empregnation with their acid leachate. Then iron loaded carboneous precursors were thermally treated with N_2, CO_2 and H_2O. Firstly, the magnetic properties of carbons were determined by a hand-held external magnet to provide knowledge whether the carbons show magnetism or not. Further experiments were carried out by selecting 4 magnetic carbons (raw pomace derived carbons) according to the magnetic property, magnetic carbon yield and iodine number. The XRD patterns of all carbons exhibited characteristic peaks correspond to Fe_3O_4 and the zero-valent iron. The magnetic carbons showed S_{BET} values between 219 and 357 $m^2 g^{-1}$. It is noteworthy that the different iron compounds formed during the activation-pyrolysis process were proven to have potential catalytic activity due to the well-developed porosity. The hysteresis loops indicate that all carbons exhibit typical superparamagnetic with saturation magnetization (Ms) values of between 5.41 and 9.61 d emu g^{-1}. Since the Ms of all magnetic carbons are greater than 1 emu g^{-1}, they can be magnetically separated after adsorption process. It is worth mentioning that the Ms of magnetic carbons prepared using biomass and iron-rich solid wastes in this study are comparable to previously reported in the literature for magnetic carbon prepared from different biomasses using ferric chloride. The Cr(VI) adsorption was studied as a function of pH, adsorbent dosage and contact time by batch method. The adsorption isotherms were fitted to Langmuir isotherm. The determined adsorption capacities of magnetic carbons were ranged between 41.67 – 86.21 mg g^{-1}, which

is comparable to that of other magnetic carbons.

Keywords: Pomegranate pomace, Magnetic carbon, Red Mud, Cr(VI), Adsorption

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Study on the Extraction of Bioactive Compounds from Beetroot Peels

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Abstract

Beetroot (*Beta vulgaris*) has been cultivated for hundreds of years and is used as a vegetable in daily food, but also in the form of juice and extract, later being used in traditional medicine, as a food colouring and additive for cosmetic products. After processing the beetroot, a considerable amount of peels results which can be valorised due to the high content of bioactive compounds that can be used in the food industry. Polyphenols represent a group of secondary metabolites in the cell walls of plants, beetroot being included in the list of the main vegetables with an important antioxidant capacity. The presence of the betalain pigments determines the classification of beetroot powder in the category of food colouring. Betanin (E162) is used to restore the original colour of some food products and to colour some food products. The aim of this study was to optimize the extraction process of polyphenols and betalains from beetroot peels, in order to use the extracts as food colouring or in food supplements with antioxidant properties and in the pharmaceutical industry. Thus, the content of polyphenols and betalain pigments (betaxanthins and indicaxanthins) present in the peels of beetroot was analysed and which, under certain favorable conditions, can be extracted and used in different fields, such as food industry, pharmaceutical industry i.e. In the experimental study, the influence of temperature, time, solvent concentration, type of solvent and ultrasonic frequency on the polyphenols and betalains (indicaxanthin and betaxanthin) extraction from beetroot peels was studied. The extraction of polyphenols and betalains was carried out according to different parameters, as following: ultrasonic frequency (12.5, 25 and 45 kHz), temperature (50, 60 and 70 ℃), time (15, 30 and 60 min), and solvent (methanol, ethanol and 2-propanol in different concentrations: 50, 70 and 90%). As a general conclusion regarding obtaining an optimal extraction of polyphenols from the beetroot peels extract, it was found that the most favorable conditions were achieved by using methanol 50% as an extraction solvent, at an ultrasonic frequency of 12.5 kHz, temperature of 70 ℃ and a time of 30 min. Moreover, the optimal parameters for extraction of betaxanthin and indicaxanthin from the beetroot peels were methanol 90% used as an extraction solvent, an ultrasonic frequency of 12.5 kHz, temperature of 70 ℃ for 60 min.

Keywords: beetroot peels, polyphenols, betalains, ultrasonic extraction

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Optimizing Lactic Acid Production from Potato Fermentation: Effects of Inoculum-to-Substrate Ratio and Organic Acid By-products.

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Abstract

Potatoes have formed the foundation of diet in Central Europe and are one of the main components of food waste in the region. This study investigated the influence of different inoculum-to-substrate ratios (ISRs) on lactic acid fermentation utilizing potatoes as the sole (pure) substrate. The objective was to evaluate how varying inoculum levels could affect the synthesis of both lactic acid and other organic acids. A mixed culture of anaerobic digester from a municipal wastewater treatment plant was employed as process biomass, and five ISRs (1:1, 1:2, 1:4, 1:6, 1:8) were tested with different substrate loading rate. The fermentation process was conducted under controlled conditions, including agitation at 100 rpm, a pH ranged from 5 to 6, and a temperature of 35 °C. Periodic sampling was performed to measure the concentrations of organic acids. The findings demonstrated that the ISR significantly influenced lactic acid production. Higher ISRs (1:6, 1:8) resulted in increased lactic acid synthesis compared to lower ratios (1:1, 1:2, and 1:4). Notably, the study revealed a positive correlation between the ISR and lactic acid concentration, with the highest concentration observed at an ISR of 1:6, reaching 87 g/L. However, at the ISR of 1:8, the concentration of L-lactic acid decreased to 75 g/L, primarily due to an elevated concentration of D-lactic acid, whereas, the highest L-Lactic acid concentration recorded at ISR 1:1, 1:2, 1:4 are 6 g/L, 9 g/L and 23 g/L. The higher concentration of D-lactic acid at an ISR of 1:8 suggests that this ratio may have a distinct effect on the microbial composition and metabolic pathways. This shift towards D-lactic acid production may be attributed to the presence of specific microorganisms or metabolic pathways that promote its synthesis. Additionally, a higher substrate quantity relative to the inoculum biomass created a less favourable growth environment for lactic acid bacteria, contributing to the decrease in lactic acid concentration at the ISR of 1:8. In addition to lactic acid, the fermentation process yielded various other organic acids, whose concentrations were also influenced by the ISR. These results underscored the impact of initial levels of the inoculum biomass on the microbial composition and metabolic pathways involved in fermentation. Overall, this study emphasized the importance of optimizing the ISR for lactic acid fermentation using potatoes as a substrate. Higher ratios were found to enhance lactic acid production, although the ISR of 1:8 led to a decrease in lactic acid concentration and an increase in D-lactic acid concentration. These findings highlight the significance of considering an appropriate ratio to maximize lactic acid production, regulate fermentation processes, and modulate the

concentration and isomeric composition of the resulting products. Industrial applications can benefit from these findings by optimizing lactic acid production and effectively managing the fermentation process.

Keywords: Food waste, Lactic acid, Inoculum-to-substrate ratio, Organic acid, Valuable product recovery

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Effect of pH on Volatile Fatty Acids Production During Anaerobic Fermentation of Dairy Wastewater

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Abstract

The sustainable bioeconomy supports and promotes the conversion of biomass not only into renewable energy but also into high-value bio-products, thus contributing to the goals of the circular economy. Among the various bio-products that can be produced from biomass, volatile fatty acids (VFAs) are of significant interest. VFAs (acetic, propionic, butyric, isobutyric, valeric, and isovaleric acids) and their derivatives are widely used in the food, textile, pharmaceutical, leather, and plastics industries (den Boer et al., 2016). The value of the VFA mixture can range from $50 to $130 per ton (Fei et al., 2015), while for pure substances, the value is much higher, especially for volatile fatty acids with a higher carbon number (butyric acid $2163/ton > propionic acid $2000/ton > acetic acid $600/ton) (Calt, 2015). So far, VFAs have been produced chemically from petroleum by-products, requiring significant energy consumption and having a significant negative impact on the environment. On the other hand, it is known that VFAs are key intermediate products in the anaerobic digestion of biomass. These compounds are produced by acidogenic bacteria and are subsequently degraded by acidogenic bacteria. Therefore, with appropriate techniques, we can direct the process towards VFA production. The techniques used to increase the concentration of VFAs include a) increasing the hydrolysis rate to produce more soluble compounds for fermentation, b) promoting acidogenesis, and c) removing inhibitory factors. Promoting acidogenesis is the critical step in VFA production. The rate of acidogenesis depends on various parameters such as the composition of the substrate, characteristics of the microbial consortium, pH, temperature, hydraulic retention time, and organic loading rate (Zhou et al., 2018). In this context, the main aim of this work, was to examine the effect of pH on the production of VFA from raw dairy wastewater. Batch experiments were conducted in an automated lab-scale reactor (Minifors 2, Infors, Switzerland) at three different pH values (4.0, 5.0 and 6.0). The inoculum used for the experiments originated from a full-scale upflow anaerobic sludge blanket reactor treating domestic wastewater. The temperature was set at 35 ^{o}C and the agitation at 200 rpm. Samples were collected daily from the reactor and analyzed for VFA using a gas chromatography (6890N, Agilent) equipped with an FID detector. The results showed that the maximum VFAs concentration (2.223 mg/L) was achieved at pH 5, while pH 6 resulted in lower VFAs production (994 mg/L). Regarding the composition of VFAs, it was found that pH 4 mainly promoted the production of propionic acid (61%) and acetic acid (31%). In contrast, experiments conducted at pH 5 promoted the formation of valeric acid (26%), butyric acid (24%) and acetic acid (24%). In conclusion, pH 5 appears to be an interesting option for VFA production from dairy wastewater, offering optimum results in terms of both quantity and quality.

Keywords: acetic acid, propionic acids, anaerobic digestion, acidification, wastewater

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Whey valorization from cheese manufacturing in Switzerland

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Abstract

Around 45% of the whey produced in Switzerland is used for pig fattening, which could be replaced by plant-based feed. Despite its current use, whey is a valuable source of protein for direct human nutrition. Direct human consumption would bring not only economic (through the valorization of by-products), but also ecological (localized food systems, reduction of food waste) and social (societal commitment) benefits. The following reasons prevent whey from being processed primarily for direct human consumption: Firstly, cheese production in Switzerland is dominated by decentralized small and medium-sized production units, which means that small quantities of whey have to be transported over long distances for industrial processing. Secondly, the quality of the whey is very heterogeneous, which makes processing a process engineering challenge. Finally, even if the taste of whey products is widely accepted by consumers, in reality whey is still perceived as a waste product. In this project, we analyze local market structures in the context of dairies in Switzerland. In a participatory process, we develop the basis for setting up food hubs for the aggregation, distribution and marketing of whey products locall

Keywords: Bioeconomy, circular economy, whey valorization

AAF: Alternative Animal Feed production

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Animal Proteins from Human Food to Animal Feed

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Abstract

Food, Animal by-product (ABP), Feed, Food-waste, are concepts with important health, economic and environmental dimensions governed by a specific European and national legislative framework. Food of animal origin (meat, milk, eggs, fish) businesses, from animal farms, slaughterhouses and processing industries, as well as retail businesses that provide food to the final consumer (catering, supermarkets, wholesale stations) are production areas of significant quantities of animal by-products and waste. The use of ABPs in animal feed production achieves their best added value. Processed animal protein (PAP) is animal protein derived exclusively from low risk ABPs (category 3) by processing method (combination of high temperature and pressure). The broad variety of PAPs from ruminants, non-ruminants and insects, including meat meal, fish meal, insect meal, blood meal and feather meal is used as high protein animal feed for aquaculture, poultry and swine feeding, pet-food, supporting animal growth and development. In the context of the circular economy, the nutrients of food of animal origin could, under certain conditions and restrictions (feed ban regulation), be fed to animals, exploiting their high nutritional and energy value and reducing the amount of waste.

Keywords: animal by-product, food of animal origin, animal feed, processed animal protein

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European Regulations 1069/2009, 142/2011, 999/2001

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SMARTWASTE: Reusing wastes and by-products of agricultural industry to develop bioactive livestock feeds'

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Abstract

Infectious diseases of the gut, caused by various pathogens such as gastrointestinal parasites, are one of the most serious problems in livestock, causing reduced productivity, ailing health and necessitating heavy chemical drug use. Controlling residues of these medicines in food is highly important for consumer safety, while there has been a continuous trend towards the production and consumption of "clean" food. This concept involves limited use of drugs while reducing the impact of food production on the environment and considering animal welfare. The potential for natural dietary components from recycled biowastes against pathogens is an attractive alternative to the use of synthetic drugs. A range of plants and crops are considered bioactive due to their content of chemical compounds, especially the so-called plant secondary metabolites (PSMs). Secondary metabolites, such as tannins, are thought to protect plants against herbivory or predation by insects and have long been studied for their putative medicinal properties. The exploitation of plant secondary metabolites containing natural resources can be considered as an ecologically friendly option because, they reduce synthetic chemical use. For this, our research is focused on exploiting the bioactivity of by-products derived from olive processing, wineries, pomegranate industry against gastrointestinal nematodes and coccidia of small ruminants and rabbits. The above agricultural industries have been selected because they represent an important economic sector in Greece and Mediterranean region and a major source of industrial wastes/by-products. The final goal is the development of functional livestock feeds to i) improve the efficiency of feed utilization, ii) increase animal productivity by protecting gut health iii) reduce the environmental footprint of livestock farming and iv) support circular economy.

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Keywords: bioactive feed antiparasitic activity tannins

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From Composting to Solar Drying: One Machine - Two Uses

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Abstract

TM Solutions LTD (TMS), has been involved in a number of projects regarding the onsite treatment of waste, supporting a new perspective for innovative and flexible composting technology solutions. The conversion of a solar autonomous mechanical composters into a hybrid solar dryer, utilizing both thermal and solar energy and the alternative use of it, is presented in this work. This modified drying system was utilized for drying of non-marketable vegetable products, as well as non-marketable (damaged packaging) flour, pasta, etc. A series of experimental processes were carried out, from which it emerged that the optimal mixture of the above-mentioned materials is 8 parts of plant products and 2 parts of flours. The vegetable products, after hand-sorting, in order to remove any foreign materials, were shredded, so that the maximum diameter of the shredded product not to exceed 2cm. This material was then mixed with flour and the mixture fed to the dryer. The initial mixture moisture was about 75% and the drying time in order to reduce the moisture up to 35-40% was about 6 days (during summer, where the outside average temperature was around 32oC and the air temperature inside the solar drying system exceeded 50oC). The thermal resistors' temperature varied at 45 ^{o}C. Afterwards, this material was transferred into a solar drying greenhouse, until the final moisture content to be reduced below of 12%. The above process resulted in the production of a significant nutritional value product, with crude protein, crude fiber and fats content at 12-14%, 4-6% and 2-2.5% respectively, without any presence of pathogens, aflatoxins, etc. It is noted that the specific product was incorporated in pigs feeding trials at 15% with very encouraging results. Further investigation will take place in order to both evaluate the production process and the produced feed component.

Keywords: solar drying, feed components, non-marketable fruits and vegetables, non-marketable flour and pasta

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FWU: Food Waste management in the Urban environment, from collection to on-site treatment

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When is it Really Dead? Ethnographic Reflections on Animals as Food and (Food) Waste

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Abstract

In this paper I present some ethnographic observations on the cultural processes by which an ingredient can be food or waste. More specifically, I wonder how the senses, values and cultural perceptions of edibility transmute food into waste and waste into food. I ask: how do people perceive food waste? What renders foods inedible? Is it just the expiration dates or is it a more complex process? What is the role of the senses, values and culture in the shaping of behaviours and attitudes around food waste, especially when it comes to animal foods? How are food waste practices and attitudes shaped? But also, how do they become tropes for the negotiation of grander ideas around planetary sustainability? My regional focus is Athens, Greece. Methodologically, I will be conducting digital ethnography, following conversations related to food waste on social media platforms such as Facebook and Instagram, as well as specialised food waste forums. I will also be conducting ethnographic research (participant observation) in selected Athenian middle-class households, engaging with the dynamics, behaviours and motivations around food waste. Theoretically, I approach food waste as an assemblage of organic, social and symbolic elements which result in interesting multi-species entanglements with significant impact on human lives, and reflect on how waste and humans cultivate one another in the wake of climate change and biodiversity loss. These enquiries and reflections seek to illuminate several cultural aspects around food waste attitudes which may be useful in generating future-oriented solutions when it comes to managing food waste.
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Keywords: food waste, multispecies ethnography, anthropology, sustainability

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Design of a Sustainable Supply Chain for Fruit Puree Production through Organic Waste Valorization.

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Abstract

In recent years, climate change and its effects have gained significant global attention due to the implications for the environment and people. Presently, its consequences, such as water scarcity, glacier melting, and biodiversity loss, among others, have become global concerns. Drought directly impacts food production by decreasing soil productivity, while the global population continues to increase, implying a higher demand for food. According to the Food and Agriculture Organization of the United Nations (FAO), around one-third of all food produced annually is wasted. Consequently, reducing food waste and reusing food has been set as a significant objective to decrease its carbon footprint.
In Chile, there are various businesses dedicated to marketing fruits and vegetables, such as street markets, the Central Vega, and Lo Valledor. At the end of each sales day, organic waste is generated, collected by the municipal service, and eventually taken to a landfill. Various authors propose reusing this waste in several ways, such as generating biofuels or compost, among others. However, the use of this food for social purposes is not mentioned in the literature.
Given this scenario, the purpose of this project is to support the valorization and management of the food organic waste generated in various city markets. For this, a sustainable supply chain for fruit puree production is developed, implementing a multi-objective optimization model considering different sustainability criteria. We present the production of fruit puree and its subsequent distribution in municipal educational centers of the Metropolitan Region of Chile as a case study, aiming to demonstrate the utility of this research. At first, when implementing the functions in a single-objective manner, favorable results are obtained, always considering the satisfaction of demand, capacity constraints, material balances, among others. For the economic model, benefits are maximized, achieving a net annual profit of $1,899,334,067.09. Regarding the environmental model, CO_2 emissions during the production process are minimized, obtaining 439675.2 kg of CO_2 eq generated taking into account the fabrication and transport of the product. Finally, from a social standpoint, the final product is distributed, prioritizing the educational establishments from communes with a higher percentage of people in poverty risk, and the demand of all the schools is met. Subsequently, when implementing the weighted sum for multi-objective optimization, with equal weights for each objective function, the following results are obtained: the benefits decreased to 47.48%, the CO_2 emissions increased by 0.822% and the social function decreased to 59.17%.
In conclusion, the study showcases how a multi-objective approach can address food waste management, climate change, and social equity simultaneously. Despite trade-offs, the sustainable supply chain model for fruit puree production and distribution in Chile proves

that it is possible to balance economic, environmental, and social sustainability. It underlines the importance of an integrated approach, serving as a valuable example for future sustainability efforts.

Keywords: Food Waste Management, Supply Chain Design, Sustainability, Multi-Objective Optimization, Organic Waste Valorization.

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Development of a Blockchain Ecosystem Based on the Tokenization of Food Waste

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Abstract

The coexistence of food waste and food insecurity is a paradox of modern times, especially in the urban environment. In this context, the core objective of the project presented in this paper is to develop a decentralized application (dApp) running on mobile devices, for reducing food waste by providing safe and nutritious meals, mainly to food insecure citizens. There are two basic user profiles of the BLOCKFOODWASTE system, the Food Service Establishments (FSEs) and the citizens. FSEs are the suppliers of the system's core product i.e., food surplus, and the citizens are the consumers that purchase these meals using the project's tokens. Tokenization is the process of converting assets into digital tokens on a blockchain and in the context of the presented project is used to track and incentivize the reduction of food waste. The asset represented by the digital token is the food surplus available to the ecosystem by the FSEs. Each citizen, upon registration, is granted an initial number of tokens to spend and acquiring more tokens is possible by collecting meals from the suppliers. The project's token is created using a smart contract that outlines the terms and conditions of the token, such as its value, ownership, and transferability. The smart contract automatically executes the terms of an agreement between both parties and is used to manage the allocation, transfer, and redemption of tokens issued to FSEs and citizens, based on their food waste reduction participation. The contract will be monitored by all parties on a public blockchain, providing a secure and transparent way to manage the process, allowing for widespread adoption and participation in reducing food waste. Every participating establishment receives a certain number of tokens in exchange for every portion of food saved from going to waste. FSEs can redeem their tokens for access to data analytics and other incentives from the community, or donate the tokens to food insecure citizens. On the other hand, citizens use the tokens as a currency to purchase food surplus or other products from participating business entities. This incentivizes users to participate in food waste reduction and aligns their interests with the goals of the project. The tokens are managed using a blockchain wallet, integrated into the mobile app to provide customers and restaurants with a secure and convenient way to manage their tokens and track food waste reduction. The blockchain can also enforce rules and conditions for token transfer, such as minimum food waste reduction goals, to ensure that the tokens are used effectively. The logic of the proposed blockchain ecosystem, considers parameters such as, supply, distribution, utility and economics of the token, along with network effects and market demand. Based on these parameters and with the utilization of financial modeling and market analysis tools, the authors will estimate the potential value of the token and the overall tokenomics of the BLOCKFOODWASTE application.

Keywords: Food waste, Food insecurity Blockchain, Tokenization, Smart contracts

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Use of Adaptation Pathways for Urban Food Waste Management

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Abstract

Food waste is a growing problem of the 21st century. In recent time, food waste has received considerable attention in literature due to its environmental, economic, and social impact. Rapid urbanization and increased amount of food waste generation are uncertain conditions that require a new model for management planning. The model helps decision makers develop strategic short term committed plans over a period to direct future actions. To this end, this study developed series of short-term actions aimed at proper food waste management and increasing the life span of new landfills in India. To achieve this goal, the landfill threshold was determined by estimating future food waste generation per capita using the country's population and uncertain income growth. Furthermore, varied time frames were considered while choosing a sequence of actions meant to prevent food waste from ending up in landfills. An adaptive strategy for the projection of food waste management for a dynamic and uncertain future was developed using the chosen actions. The different actions were sorted from experts and studied in the literature. It was further determined what each chosen action was capable of. Actions with the most significant impacts on landfills were selected. Food banks, source segregation of food waste, increased awareness, municipal composting, upgrade of existing vermicomposting and biomethanation facilities are some of the actions considered. Selected actions were hence used to create an adaptation pathway for the proper management of food waste and that which reaches the landfill. The pathways developed can serve as a guideline for decision makers for an effective and encompassing food waste management plan. The results show that the actions proposed in the Adaptation Pathways, whilst implemented progressively have a significant impact on food waste reduction in India and increasing the tolerance of the landfills by a reduced amount of food waste that reaches the landfills. This study shows that proper food waste management can be executed through the use of an effective waste management strategy that adapts to an ever changing future circumstance. Adaptation pathways as a concept can help planners and decision makers in India significantly to significantly reduce food waste and improve the ability of food waste managers to deal with both existing and incoming food waste in India.

Keywords: food waste, management, adaptation pathways, food waste reduction, landfills, India

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The Influence of Acidic Demineralization on the Characteristics of Chitosan Extracted from Shrimp Waste

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Abstract

In recent years, there has been a significant increase in the shrimp production industry, reaching a milestone of 8 million tons annually. However, around 30-50 percent of shrimp aquaculture is generated as waste, posing a significant environmental and climate threat. Extraction of chitosan from shrimp shell waste has emerged as a preferred industrial option to address this issue and promote circular economy principles and EU Green Deal targets. Shrimp shells contain valuable minerals such as magnesium, calcium, and phosphorus, which can be crucial in chitosan extraction. The initial step in this process is the demineralization of shrimp shells, where the current research aimed to evaluate the impact of different acidic demineralization concentrations on chitosan characteristics. This evaluation was conducted under stabilized deproteinization and deacetylation stages at 50℃. Shrimp shell waste was collected from an indoor shrimp farm in Lithuania, and mineral content analysis was performed using inductively coupled plasma mass spectrometry (ICP-MS). Furthermore, FT-IR spectroscopic analysis was carried out to confirm the formation of chitosan using various acidic concentrations (1%, 2%, 3%, 4%, and 10%) of HCl for demineralization, followed by 4% and 50% alkaline deproteinization and deacetylation, respectively. The study determined the extracted chitosan's moisture content, ash content, yield, deacetylation degree, and morphological structure. The results indicated that calcium was the most abundant mineral in shrimp shells, with a content of 6.85%. The formation of chitosan was verified through FT-IR analysis, comparing it with commercial chitosan as a reference. The moisture content ranged from 1.3% to 5%, while the ash content ranged from 1.1% to 2.1%. Interestingly, the degree of deacetylation under 2% acidic demineralization was higher than that of commercial chitosan. Additionally, the research suggested that lower concentrations of acidic demineralization are more likely to yield higher amounts of chitosan. Overall, the outcomes of this research are intended to be applied in optimizing the chemical extraction of chitosan from shrimp waste by manipulating the extraction stages.

Keywords: Shrimp waste, Chitosan, Acidic Demineralization

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Municipal Solid Waste Management: In the Case of Itaya Town, Arsi Zone, Oromia Regional State, Ethiopia

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Abstract

Solid waste is anything that is neither liquid nor gas and discarded as useless or unwanted material. Most cities or towns in the world experience challenges in managing waste due to ineffective waste management systems that drive to stress on infrastructures and resources with threats to the environment, health and economy. Thus, this study aimed to assess municipal solid waste generation, composition, collection, transportation, treatment and disposal in Itaya Town, Arsi Zone, Oromia Regional State, Ethiopia. Multistage sampling procedures including both probability and non-probability sampling techniques were employed to select respondents, whereas, a total of 220 respondents were involved in the household survey. The collected data was analyzed with the statistical Package for Social Science (IBM SPSS version 26.0) and STATA/MP version 17.0 statistical software. It was described using descriptive statistics and binary choice probity model analysis. The rate of solid waste generation in the study area was 0.30 kg/day/person, which has not been accompanied by current adequate sanitation facilities and management programs. The results of the study indicated that out of the aggregated waste collected from all sampling units, organic waste accounted for over 80%. In addition there were notable problems in municipal solid waste collection, transportation, recycling, reusing and disposal processes. The findings of the study revealed that 75% of the respondents reported that recycling is not being practiced in the town. Household awareness, willingness to pay for solid waste management, and availability of waste collectors were significant and positively correlated with effective solid waste management (t-test, $p<0.05$). The study concluded that the most commonly employed waste disposal methods were illegal dumping and open burning, which are associated with environmental and health risks. Finally, the study indicated that all actors have to cooperate and participate in awareness creation, sanitation and integrated waste management by improving their scientific understanding through exchanges of scientific and technological knowledge.

Keywords: Generation rate, Municipal, sanitation, organic waste, waste recycle

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Finally, I wish to express my deepest gratitude to my family for their love and support during the study. They are the greatest treasure in my life and I want to dedicate this effort to them. I wish to express my appreciation and sincere thanks to my wife Aisha Barsho for her patience and for taking responsibility for my family issues while I am on my study.

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The Relationship of Citizens with Source Separation in Municipalities of Thessaloniki Regional Unit

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Abstract

The objectives set by the new Greek National Waste Management Plan (NWMP) are based on the development of strategies and policies aimed at protecting the environment and human health. To achieve these goals, special emphasis is placed on waste prevention and reduction, limiting the use of natural resources by improving their efficiency, with the ultimate aim of transitioning to a circular and sustainable economy. Furthermore, Law 4819/2021 (Government Gazette A΄129/23.07.2021) establishes a new framework that further promotes recycling and circular economy as key policy tools for the rational management of waste. Key provisions of Law 4819/2021 address the extended producer responsibility, the introduction of the Pay as you Throw system, the establishment of Green Points, Recycling Corners, and Creative Materials Reuse Centers, as well as the preparation of waste for reuse and recycling. In order to achieve these goals, active citizen participation is needed, since they are the ultimate contributors to these actions. Within this framework, this study examines the relationship of citizens in the municipalities of Thermi, Kalamaria, Kordelio-Evosmos, Pavlos Melas, and Pylaia-Chortiatis in the Regional Unit of Thessaloniki with source separation and its implementation. According to the research results, there is a lack of information among citizens regarding source separation actions. Therefore, our study proposes ways to enhance source separation in order to minimize waste directed to landfills and to aid the transition to a circular economy.

Keywords: Municipal Solid Waste, Source Separation, Green Points, Pay as you Throw System

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An Industrial-Urban Symbiosis (I-US) concept for the production of gaseous biofuels

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Abstract

The production of biofuels has increased in order to reduce the dependence on fossil fuels and mitigate climate change. However, current production practices are heavily criticized for their lack of environmental sustainability. In the coming years, biofuel production practices should improve in order to meet strict environmental sustainability policies. The Industrial and Urban Symbiosis concept focuses on long-term collaboration between local municipal and industrial actors that enables more efficient use of materials, energy, and other resources. Such collaboration and networks can increase the value of businesses, stimulate innovation, improve environmental and sustainability performance, and foster local and industrial development.
The aim of the research is to characterize waste from industry and municipality aiming at Industrial-Urban Symbiosis (I-US), to identify possible material and energy exchanges between municipalities and industries and improve the efficiency and environmental performance of biofuel production within the Horizon Europe project SYMSITES.
The main objective of SYMSITES is to implement regional industrial urban symbiosis in four European regions different in social economic, and environment aspects, from the north Denmark, through the mid Austria to the south Spain and Greece. The four EcoSites will use the same technologies for wastewater and waste treatment and energy production and integration, enabling a clean comparison of the EcoSite impacts. The four EcoSites will generate virtuous circles of energy, treated waste and wastewater streams between urban and industrial entities.
This study concerns the production of methane from three different waste streams: Olive Industry Wastewater (OIWW), Liquid Fraction of Food Waste and Municipal Wastewater (MWW). These streams are collected from the area of West Achaia in Greece.
Methane production from the three above waste streams through anaerobic fermentation under mesophilic conditions was carried out using a 40L CSTR, operated at different 40d, 30d and 20d with an organic loading of 0.5 gCOD/(Lreactor*d) and feedstock rates (91.7% MWW, 3.3% LFFW, 5% OIWW). Also TSS, VSS, tCOD, sCOD, pH, VFAs and methane were measured. The methanogenic reactor was operated for 50 days. The mean biogas production rate was 11.6 L/d with a mean methane content of 78%.

Keywords: EcoSItes, biofuels, Industrial-Urban Symbiosis (I-US)

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COM: Compost production, quality and utilization

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Experimental Analysis on the Aerobic and Anaerobic Degradation of Paper-Based Boxes for Food Delivery

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Abstract

The organic fraction is generally the most relevant among the source-separated materials collected with municipal solid waste. In addition to food waste and garden waste, the amount of other material such as bioplastics and cellulosic fractions are not negligible, and on the rise. This study aims at evaluating the behaviour of compostable paper-based packaging when subjected to aerobic and anaerobic degradation conditions. Differently from the technical standard for compostability (EN 13432:2002), the tests were performed under conditions more similar to those found in industrial plants. In particular, four paper-based boxes for food delivery were tested: two corrugated cardboard boxes, one cartonboard box coupled with a film in polylactic acid (PLA) and a cartonboard box (with a lid) subjected to a barrier treatment. With regards to aerobic conditions, the European standard EN 14045:2003 was taken as reference. The anaerobic degradability of two out of the four boxes (one made exclusively of paper and the one with the PLA film) was firstly investigated through biochemical methane potential (BMP) tests. Then, semi-continuous co-digestion tests with food waste were also carried out on the box with the PLA film to verify the BMP test results under conditions more similar to the full-scale treatment plants. When subjected to composting, the four boxes exhibited different behaviours. After four weeks, the two boxes made exclusively of paper were completely disintegrated and indistinguishable from the compost. Analysing the box with the PLA film, limited variations in the structure of the inserted pieces were observed at the end of the first four weeks of testing. On the contrary, after eight weeks the average weight loss of the inserted pieces increased up to 75%. Finally, the box subjected to the barrier treatment showed an intact structure after four weeks, which was still distinguishable after eight weeks. Only after twelve weeks the level of degradation resulted comparable to that of the other boxes. The BMP test showed a good anaerobic degradability (>72%) of all the packaging, with no undigested residues after the tests. In particular, the box made exclusively of paper showed higher degradability and methane production compared to the one with the PLA film (+24%). These results are confirmed by the semi-continuous tests, in which the anaerobic degradability of the box with PLA (75%) resulted slightly higher than the one observed in the BMP tests (72%). Despite the good degradability, due to the changed operating conditions, undigested PLA residues were observed in the extracted digestate. The outcomes of the study are in agreement with the characteristics of the tested boxes. The best results were obtained for the paper-only boxes, a material highly compatible with biological processes. As regards the box coated with PLA, the slower disintegration in the composting process and its lower anaerobic degradability in BMP tests are reasonably related to the presence of the bioplastic film.

Similarly, the barrier treatment is potentially the cause of the slower disintegration in the composting process of the box characterised by this feature.

Keywords: composting, anaerobic degradation, packaging

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Assessment of operational and design issues in a municipal solid waste treatment facility in Lebanon with the Project Cycle Management tool

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Abstract

Solid waste management is still an issue, especially in low and middle-income countries. The case of Lebanon is particularly interesting: in the past two decades, many investments have been done by the European Union and other international actors to target this problem, without reaching a satisfying solution, as highlighted by the waste crisis of 2015. Besides the described issue with solid waste management, given its geographical and climatic characteristics, Lebanon is also suffering from land degradation, which makes every effort towards organic waste valorisation extremely important. The present research is focused on the improvement of an existing solid waste treatment plant, providing a method for the identification of problems and the prioritisation of interventions, with special attention to compost production. The field research was performed in 2018 within a development cooperation project funded by the Italian Cooperation Agency (AICS). The Ain Baal Solid Waste Treatment Facility (SWTF) was built in 2009 to serve 63 municipalities within the Governorate of Sour by treating 150 t/d of MSW. The facility is composed of a mechanical treatment area, where the mixed waste is divided into several streams: the organic waste is biologically stabilized, while the non-organic waste is separated manually to extract the recyclables. Since its construction, the facility has never been able to cope with the expected amount of waste and was consequently revamped in 2018. Moreover, the stabilized organic waste did not have the minimum quality characteristics requested to be used as compost, since it originates from mixed MSW. The development cooperation project had the purpose of improving the overall waste management situation, by introducing segregation-at-source and proposing strategies to optimize the SWTF. The purpose of this paper is to explain how these strategies were elaborated by applying the methodology of Project Cycle Management (PCM). The problem tree for Ain Baal SWTF Operation and management was created to highlight cause-effect relationships and share them in an effective way with the key local stakeholders. The identification of problems was carried out during a three months' period of on-site investigation. Five major problems were selected, therefore, a solution tree was created and general objectives were identified: 1) reduction of odours; 2) improvement of the quality of the compost; 3) implementation of a proper system for leachate treatment; 4) clear description of the operation and management for the SWMF; 5) increase of the market for the output materials. Specific objectives were identified, together with expected results, actions, investment and priority. The application of PCM allowed a clear understanding of cause-effect chains, identifying the source of each problem and not its most evident consequences. As an example, the low quality of compost was addressed in the past through

technical expensive interventions, while the main reason was its origin from MSW and not from food waste segregated at the source. This approach allowed the prioritization of interventions and can be fundamental, especially in contexts where the lack of resources poses a limit to possible actions and every effort should be done to avoid pointless investments.

Keywords: organic waste, compost, optimization, waste treatment, low-income countries

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Decentralized urban composting as an initial step to a circular agricultural nutrient economy

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Abstract

Urban sanitation has evolved into a linear flow of farm nutrients to cities as food, which are then lost to the atmosphere as reactive nitrogen, and to water bodies as soluble nitrogen, phosphorus, and potassium. Decentralized composting of food waste in southern Brazil has demonstrated how a small fraction of these nutrients can be recovered and used in urban agriculture. The methods used can be useful in projecting decentralized treatment of the larger fraction of agricultural nutrients pooled in urban sewage, forming a more circular economy while strengthening intensive urban agriculture. Source separation of organic wastes, collection services with small sealed containers, decentralized treatment with variable scales of thermophilic composting using the UFSC method of static piles with passive aeration, and weekly loading of food waste, as described by Miller and Inácio (2022), spread slowly in the municipality of Florianópolis, Santa Catarina, Brazil. Community composting patios and institutional mechanized compost yards, have spread through the municipality due to lower transportation and treatment cost, allied with small footprints, and payments for services equivalent to tipping fees in landfills. Tests were routinely made for heavy metals and pathogens (Trivella, 2022), and alternative treatments of many other types of residues were tested. Food waste, yard trimmings, sewage sludge, and slaughterhouse waste were all used in small composting patios. Different products from the composting process were tested in different urban crops for ideal efficiencies (Winker et al., 2009). Careful source separation and aerobic, thermophilic conditions in composting yards resulted in pathogen and heavy metal levels at undetected levels or consistently below existing levels in legislation for organic fertilizers (Trivella, 2022), and resulted in changes of legislation on state and national level. Santa Catarina state regulations established parameters for decentralized urban composting patios in 2019, permitting outdoor composting with reduced buffer distances in urban areas. Federal regulations were changed to permit compost from source-separated urban wastes to have unrestricted use as organic fertilizers in 2020, and use of urban compost in certified organic farming was widened in 2021 (Trivella, 2022). Leachate from static piles, rich in potassium, proved to have the exact nutrient composition required for banana production, in which 5 m^3 of leachate contained 3.9 kg N, 1.0 kg P_2O_5, and 12.0 kg K_2O, the amount of nutrients recommended to produce one thousand kg of bananas (CQFS–RS/SC, 2016). A compost yard of 1000 m^2 size therefore can fertilize a grove twice the size, producing four thousand kg of bananas per year. The technical success of these experiences, and the low cost per unit treated, can be applied to urban black water. Instead of end-of-pipe solutions, where sewage sludge is composted, secure decentralized

treatment is possible. Changes in legislation will allow the application of these nutrients to the soil of high value orchards, such as açaí palm groves, which can occupy urban hillsides. These orchards have extremely high nutrient demands, with high-value, high nutrient output (Zambonim et al., 2017), leading to a more circular economy for agricultural nutrients.

Keywords: UFSC method, leachate, source separation

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Nutrient utilization efficiency and soil carbon management index (CMI) following the use of compost in open field on cereals crops

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Abstract

The European Union (EU) is currently promoting the recycling of organic waste for agricultural purposes to restore soil organic matter (SOM), thus preserving soil fertility and supplying nutrients to plants as an alternative to chemical fertilization. However, there is still limited information on the agronomic benefits of using these products in medium- and long-term field trials. In this light the aims of this study were: (ì) the investigation of the plant nutrients (N; P) uptake following the distribution of different types of compost; (ìì) the study of the SOM variation; and (ìì) the investigation of the soil functions via the assessment of the Carbon Management Index (CMI), over 3 year in a field plot test. In this framework two agronomical pathways were compared: continuous and pulsed compost application (every year / every 3 years), the latter followed by solely chemical nitrogen (N) fertilization. Three types of compost: from bio-waste (BWC), from anaerobically digested bio-waste (DC) and from urban/agro-industrial sludges (SC), were compared in this study along with a chemical N-P-K fertilizer (Chem) and a unamended control (Ctrl). The study revealed Path 1 performed high relative agronomic efficiency (N-EAR% vs. Chem): SC (118)> DC (114)> BWC (109), indicating a general benefit in the use of the chemical N fertilizer following basal compost application. In Path 2, the N-EAR (%) was highest in BWC (112)> DC (105)> SC (74). Indicating SC performed lower N-use efficiency, consistent with its high C:N ratio and biological stability (OUR). The N-EAR obtained following the application of N fertiliser, always >100%, proved to be an effective strategy to maximise plant N use, valorizing also the residual P applied with organic fertilisers, in almost all cases. The P balance was consistent with the inputs and removals, revealing an important accumulation of total and inorganic P following the continuous application of compost. This aspect deserves further investigation in light of the EU guidelines on P efficiency maximizing. The two paths highlighted the different SOM kinetics. The single application of compost ensured a significant initial SOC increase, between 10 and 25% (SC and DC) at the end of the first year, returning to the background at the third year. On the contrary, following continuous applications of compost, a constant accumulation of SOM was observed, from 10 up to 40% from the first to the third year on average. Besides the quantitative changes in the SOM, its 'functionality' appears increasingly. To this end, an index has been successfully adopted in research in this area, the CMI: Carbon Management Index (Lou et al., 2011). This parameter, from the combination of total organic C and the labile fraction (oxidizable with KMnO4), is very sensitive to changes that may occur as a result of different fertilization management. The tested composts were optimal substitutes for chemical fertilizers and fertility restorers with a general increase in SOM soil functionality. Overall the treatments

showed higher N efficiency used in combination with the chemical fertilizer, also presenting a good ability to supply P over the three-year period.

Keywords: Compost, Soil Organic Carbon, Nutrients

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Kitchen Plant Waste as Source for Organic Composting Serving Circular Economy. Effects of Vermicompost on the Growth of Greenhouse Vegetables (I)

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Abstract

Since we live in a context in which waste production is continually increasing and the economic activity linked to them is becoming increasingly important, reusing, recycling or recovering waste is to be prioritized wherever feasible. Kitchen waste from homes, restaurants, catering services, nursing institutions, and from food processing plants are classified as domestic biodegradable waste (Demirbas, 2011). Direct composting of kitchen plant waste is rather recalcitrant due to its physicochemical characteristics (Peng et al., 2022). Vermicomposting is a green technique that produces vermicompost from different types of organic wastes using specific earthworm species, while it plays a vital role in organic and sustainable agriculture, due to its ability to increase soil fertility and crop nutrition (El Jawaher A. Bin Dohaish, 2020). This study investigated co-composting of kitchen plant waste of a psychiatric hospital with vermi-composted cow manure and evaluated its exploitation as soil amendment to produce organic early crops vegetables, in the light of sustainable development and circular economy. Specifically, the effects of the co-compost application on the chemical and microbial properties of greenhouse soil of the Green Unit of the Psychiatric Hospital of Thessaloniki were investigated and then related to growth responses and crop production of eruca vecisaria, parsley, celery, and dill, cultivated in the greenhouse. Foliar and root analysis was also performed for every crop. The results indicated that the growth height and the plant mass for all crops increased, while nutrients analysis proved that plant waste vermi-compost could effectively be used as organic soil amendment, enhancing green house vegetables without added fertilizer.

Keywords: vermicompost, kitchen plant waste, greenhouse vegetables, cow manure, circular economy

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Safety of Decentralized Composting of Human Waste for Improved Nutrient Cycling in Urban Agriculture

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Abstract

There are important synergies between recovery of perishable food for food banks, source separation of organic waste, decentralized composting, and co-composting of human waste, all of which contribute to a more circular economy of agricultural nutrients in urban centers. These synergies are present in the environmental programs of the Social Service of Commerce (SESC), which operates Mesa Brasil, a food bank that recovered and distributed 44 million kg of food in 2022, much of it from source-separated perishable foods from retailers and wholesalers (Tenuta et al. 2021). SESC also promotes and practices decentralized composting from its kitchen and hotel sites (BRASIL 2017), and has experimented with dry toilets and co-composting of human waste (Andrade 2020). Composting of human waste is an unreliable method for pathogen reduction if there is poor control of temperature, as in turned windrow systems (Wichuk and McCartney, 2007). However, static piles can provide much more temperature uniformity and co-composting with other organic wastes can provide the high temperatures necessary for pathogen inactivation. Two forms of human waste, sewage sludge from a WWTP (wastewater treatment plant), and a urine and feces mixture from a public dry toilet station, were separately co-composted with source-separated OFMSW (organic fraction of municipal solid waste) along with selected yard trimmings in the form of straw and chipped brush in naturally aerated static piles using the UFSC method (Miller and Inácio 2022). External, porous, straw walls insulate the interior for uniformly high temperatures of applied wastes. Temperatures were evaluated in the composting piles throughout the process. Pathogens were evaluated before, during, and after composting (Andrade 2020, Teixeira 2012). The composted dry toilet waste was then inoculated with *Escherichia coli*, and applied to soil 24 hours before transplanting lettuce. Residual microbial activity was measured up to harvest (Ferreira et al. 2022). Macronutrient levels of the compost were 38 g N, 53 g P_2O_5, and 34 g K_2O per kg dry matter, analyzed for proper application rates. Co-composting with static piles provided uniformly high temperatures and met all legislation for time and temperature required for pathogen inactivation. All helminth eggs in sewage sludge were inactivated, and thermotolerant *E. coli* were reduced 99%, from 10^5 to less than 10^3/g sludge after composting. *Enterococcus faecalis* in dry toilet waste decreased by 99% during the thermophilic phase of composting. These bacteria increased in abundance during the

maturation phase, because of humid warm conditions, poor aeration and external sources of inoculum, but disappeared entirely during dry storage. Once applied to the soil for lettuce cultivation, calibrated quantities of reintroduced *E. coli* dwindled rapidly, due to fully aerobic conditions in soil, and intense microbial competition. Risk analysis indicates that from planting to harvest and consumption of lettuce, there was higher risk to farm workers during the application of the material to the soil, through inhalation or skin contact, and negligible risk of *E. coli* contamination to harvesters and consumers.

Keywords: UFSC method, co-composting, pathogen reduction

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Enhancing Composts Added-value Through the Addition of Spent Mushroom Substrate from Pleurotus and Lentinula Mushroom Cultivation During the Mesophilic Phase

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Abstract

Composting is the thermophilic aerobic-microbial process of breaking down the organic matter of various organic materials (such as agro-industrial residues and by-products) into humus-like material, which can be beneficial for both the environment and the society (e.g., management of organic residues/wastes, sanitation, end products useful as soil amendments). The constantly increasing demand for mushroom production has resulted in huge amounts of spent mushroom substrate, an agro-industrial by-product originating from the mushroom cultivation industry, which is usually disposed of on land. Commonly cultivated mushroom species, like Pleurotus ostreatus and Lentinula edodes, belong to white-rot fungi, that can produce a variety of oxidizing and hydrolytic enzymes capable of degrading lignocellulose. Based on this, their addition to the composting process can potentially affect the duration of the maturity period as well as the humification (quality) of the produced compost. The aim of the present study was to determine how the addition of spent mushroom substrate could affect the composting process and the quality of the end product. Wheat straw, tree pruning, cotton gin, and poultry manure were mixed in order to achieve a C/N ratio of 30/1. Three identical compost piles were set up in composting boxes, with an initial moisture content of 52%. At the end of the first thermophilic phase/ beginning of the first mesophilic phase, agitation of the composts occurred which triggered a second milder and shorter duration thermophilic phase. Afterward, in the middle of the second mesophilic phase, compost piles were agitated, and spent mushroom substrate from the cultivation of the mushrooms *Pleurotus ostreatus* and *Lentinula edodes* was applied to each box separately at 10% w/w. The third box was used as the control, without the addition of spent mushroom substrate. Sampling took place at every composting phase, as a way of monitoring the process. Fourier transform infrared (FTIR) spectroscopy was also applied for the monitoring of the composting process through the detection of peak indexes related to lignocellulosic, phenolic, aromatic, and other easily degradable compounds. Spent mushroom substrate, as a carrier of fungal strains that produce ligninolytic enzymes, accelerated the decomposition of the agricultural wastes and resulted in the production of a rich in humic acid (HA) compost. HA is an important and stable component of organic matter, as well as a significant parameter for determining compost quality. Therefore, the addition of spent mushroom substrate not only resulted in shortening and improving the

composting procedures but also led to an end product of better maturity and physicochemical properties.

Keywords: spent mushroom substrate, composting, Pleurotus, Lentinula, humic acid

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Development of an Innovative Compost Maturity Evaluation Method Using the CIELAB Colour Model

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Abstract

An applied and promising method for treating various biowaste for the production of organic fertilizers and soil amendments is composting (Epstein, 1997). Compost maturity is essential due to the fact that immature and poorly stabilized composts can lead to a series of problems regarding storage, use and marketing (CCQC, 2001). Most of the typical maturity indices require expensive and time-consuming analyses that have also been questioned about their reliability thus making compost maturity evaluation impractical (Thompson, 2001). As a result, in order to reduce operating expenses, composting evaluation is often compromised which results in the production of immature composts that may inhibit seed germination and reduce plant growth. Four Green Waste (GW) industrial scale composting processes, in two experimental cycles with different GW collections periods and added materials, were monitored using CIELAB colour variables in order to correlate them with composting time and critical physicochemical compost variables as a means to evaluate GW compost maturity. Colour variables a*, b*, C* and ΔE* were found to exhibit a constant variation trend until the point of maturity, presenting a strong correlation with composting time (R^2>0.80) during all composting processes. Moreover, in each composting cycle color values and progress were similar regardless of the different added materials that were implemented. However, CIELAB colour variables, and especially the initial values, were found to be dependent of the inherent characteristics of the main composting material. In each composting cycle different fitting equations described colour progress via time in accordance with each general composting progression, as results showed strong correlations (R2 > 0.80) for almost all measured compost variables with several CIELAB colour variables. Colour variable Δb appeared to bypass the influence of the inherent characteristics of the materials, as all composting experiments reached maturity when Δb values were greater than 2.81±0.21. As a conclusion, colour variable Δb can be used to evaluate the maturity of a composting process that utilizes the same main substrate, regardless of variations in composting parameters such as extra added materials, windrow size, initial conditions, properties and collection period. Δb maturity values are not similar for all substrates (Tsivas et al., 2021) (Khan et al., 2009) and cannot be used as a universal maturity index for all composting procedures. Different maturity colour charts using the variable Δb should be developed for each composting substrate. Therefore, two different colour protocols are presented for the evaluation of compost maturity using a rapid and low-cost analysis that can reduce composting operating costs up to 57.64% and 79.07%, respectively. These novel compost monitoring and evaluation protocols could encourage composting facilities to evaluate compost maturity more accurately without increasing costs in order to produce better organic fertilizers that will ultimately enhance soil remediation and crop yields.

Keywords: CIELAB model, compost colour protocols, compost maturity, Green Waste composting

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Coconut Waste: Composting and Vermicomposting for Reuse

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Abstract

La reutilización de residuos es una investigación dirigida a la gestión, tratamiento y aprovechamiento de residuos agroindustriales para la producción de productos útiles como insumos para otros procesos industriales, ha sido y sigue siendo uno de los temas prioritarios en los ámbitos del medio ambiente. Los residuos de coco son difíciles de eliminar a pesar de ser útiles como sustrato en jardinería, su larga vida los hace útiles para otras actividades. Algunas partes del coco que son difíciles de reutilizar después de su uso agroindustrial pueden procesarse mediante compostaje y vermicompostaje, transformándolo en un recurso útil como fertilizante, dada su alta proporción de nutrientes. Los residuos compostados se prepararon mediante la adición de estiércol de conejo y agua, y se analizaron en las diferentes etapas de los procesos de compostaje y vermicompostaje. Durante el proceso de transformación de residuos se controlaron parámetros como temperatura y humedad, se requiere una temperatura alta para desinfectar el producto final y mantener la humedad en torno al 60% para facilitar el proceso. Actualmente, solo el 17% de la cubierta y parte media de los cocos se utiliza a partir de residuos agroindustriales de coco, el 83% restante se considera residuo. Para su transformación, se seleccionan los residuos de coco de la parte externa de la corteza, media e interior. Se molieron utilizando un molino de cuchillas (VIKING 4000 Bio-shredder), hasta que alcanzaron un tamaño aproximado de 1 cm de longitud. Los residuos del suelo se mezclaron con estiércol de conejo parcialmente transformado. Las proporciones de las mezclas fueron 1:1:1 (residuo, estiércol, agua). 25 kg de las mezclas homogeneizadas se introducen en envases de PVC de 25 litros y 32 kg. Posteriormente, se añadió agua a las muestras preparadas en cantidad suficiente para alcanzar una humedad del 70-85%. En las mezclas preparadas para compostaje y vermicompostaje, la humedad siempre se mantuvo por encima del 50%, y nunca por debajo del valor crítico a partir del cual la actividad biológica podía detenerse, como indican autores como Moreno y Moral (2008). Finalmente, se cubrieron los contenedores, dejándolos en condiciones de oscuridad y con una temperatura inicial entre 25 y 29 ºC. La humedad y la temperatura se controlaron durante 4 meses. Las pilas se giraban semanalmente para garantizar una correcta aireación de estas y mantener la humedad. El producto terminado tiene un contenido de humedad del 45% y una capacidad de retención de agua del 85%, con un contenido de carbono del 23,5% y una conductividad eléctrica de 1,9 dS/m. Los resultados muestran la riqueza nutritiva de los productos finales (Ca2+, K+, N) aptos para su uso como fertilizante, y tras su transformación en pellets, habiendo comenzado las pruebas para poder ser utilizados también como sustrato y para el desarrollo de plantas. La obtención de materia orgánica a partir de residuos minimiza el daño ambiental, apuntando hacia una agricultura más sostenible. El compostaje es una alternativa interesante que facilita el reciclaje y la reutilización de residuos. Por todo lo anterior, el presente trabajo

pretende dar una visión de su reutilización como fertilizante de este residuo debido a su utilidad en ambos campos. Los resultados muestran la riqueza nutritiva de los productos finales, aptos para su uso como fertilizante, y tras su transformación, habiendo comenzado las pruebas para poder ser utilizados también como sustrato y para el desarrollo de la planta.

Keywords: coconut waste, recovery, composting and vermicomposting

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A Systematic Study on the Greenhouse Emissions from a Community Composting System Implemented in a Primary School at Universitat Autònoma de Barcelona, Spain

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Abstract

As stated by European regulations, biowaste must be source-separated and collected for its proper treatment and valorisation for resource recovery. In Spain, new legislation requires municipalities to totally separate in origin domestic biowaste by the end of 2023, highlighting the fact that domestic or community composting will be one of the best ways to fulfil these requirements. In this context, different communities are being engaged to perform composting as a way to valorise their own biowastes and contribute to the implementation of circular economy strategies. In this sense, the "Citizen Arenas for improved Resource management and Environmental quality (CARE)" project aims to bring the composting science to children at primary schools to raise their awareness on the different environmental impacts that their own organic waste are responsible for, when not properly managed. To achieve the goals of the CARE project, different formation and information sessions have been imparted to professors and students at a selected school in Bellaterra (Cerdanyola del Vallès, Spain) prior to the installation of a community composting system composed by four different 1 m^3 composting modules. The selected school has a daily average generation of domestic-like biowaste of 50 kg, which is daily introduced in the first composting module together with shredded pruning waste locally supplied. At this moment, 450 kg of biowaste has been treated in a single batch, where typical process parameters such as material temperature, interstitial oxygen, humidity and volatile solids content, as well as material biodegradability and greenhouse gases (GHG) emissions, have been monitored continuously. Temperature and interstitial oxygen were measured 2-3 times per week by means of PT-100 probes and an oxygen probe (Sensotran, Spain). Standard methods for compost materials were applied for material characterization. Gaseous emissions were sampled once a week before and after mixing the material inside the corresponding composting module by means of a dynamic flux chamber, obtaining two 1 L gas samples in two Tedlar bags (before and after mixing) for each sampling event. Then, methane and nitrous oxide were measured by means of gas chromatography (Agilent Technologies, USA). GHG emission factor in terms of g of CO_2 equivalent was calculated using the IPCC Global Warming Potential (GWP) for methane and nitrous oxide, which are 27 and 273 times the CO_2 GWP, respectively. Thermophilic conditions were reached to ensure sanitization during the first active phase, which also coincided with the maximum gaseous emission rates of

methane and nitrous oxide, the most significant GHG from composting. Regarding GHG, an emission factor of 25 g of CO_2 equivalent/kg of dry matter was determined, which accounted for a total of 4.7 kg of CO_2 equivalent emitted throughout the composting process operation. To our knowledge, this is the first study on the GHG emissions from an actual community composting system, and it can be of help for further studies.

Keywords: Community composting, biowaste, compost, greenhouse gases emissions

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Efficacy of an Onsite Rotary and Fixed Bin Composting System for Food Waste Management

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Abstract

Food waste management is one of the most significant challenges worldwide, contributing to the unsustainable management of food waste resulting in the loss of food resources and environmental degradation. A decentralized composting facility with onsite food waste treatment is one of the solutions to improving food waste management. Composting is an aerobic process during which organic waste is biologically degraded by micro-organisms to humus-like material suitable for use as a soil amendment (Partanen et al., 2010). This study designed and evaluated the performance of a small-scale rotary drum composting vessel for onsite food waste management and compared it with the traditional fixed bin composting process within university premises. A rotary drum composting vessel of 50 kg capacity was designed and fabricated to evaluate food waste recycling and management. The composting recipe of 25 kg volume was made from a food waste layer consisting of eggshells, cucumber, carrot, potato, and bread and mixed with brown and green materials. The key compositing parameters, such as dry organic matter content, temperature, pH, electrical conductivity, moisture content, pathogen indicators, and heavy metals, were monitored over seven weeks to evaluate the composting process's effectiveness and compared with the fixed bin compositing system to assess good quality compost. Oxford nanopore-based 16S rRNA gene sequencing method was used to monitor bacterial community changes in the fixed bin and rotary composting system. The physicochemical parameters of the compost were found within the recommended range of good-quality compost. Metals such as Cu, Cd, Cr, Pb, Ni, As, Zn, and K were found within the maximum permissible levels in the rotary drum and a fixed compost bin. The last few stages (weeks 5-7) of the composting process indicated a significant reduction of *E. coli* and total coliform. Higher reads and diversity of bacterial classes were observed in the fixed bin compared to the rotary drum system throughout the composting process. However, good quality and ready-to-use compost was detected on day 17th in the rotary drum composting system. In conclusion, the newly designed rotatory composting vessel was more efficient for onsite treatment and food waste disposal than the fixed bin composting system in terms of quality and time of compost production.

Keywords: Rotary drum and fixed bin composting, food waste, Bacterial community, physicochemical parameters, heavy metals, pathogen indicators

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Distribution of Residence Times in Rotary Drum Composting and Implications for Sanitary Regulations

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Abstract

Rotary drum systems enable more efficient composting processing of organic wastes compared to static systems. Typical residence times (RT) in these systems range between 3-5 days on average. This short composting time expects to fulfill sanitary requirements as well as initial organic matter stabilization, reduction of phytotoxicity and destruction of weed seeds viability. However, a portion of the feed passes through a well-mixed drum in less than the theoretical RT which may not be sufficient to guarantee safety application of the end product. This study explores the distribution of residence times (RTD) along with the dynamics of other properties in a commercial rotary drum (EcodrumTM) during composting of calves manure and green waste. Two different 'tracers' were used, including short pieces of plastic tubing and lumps of raw organic mixture packed in nylon socks in which several species of weed seeds were incorporated. We distinguished between a transient stage, during which the drum is only partly occupied, and a steady state stage, when the drum is operated at optimal loading. We assumed 'approaching' steady state conditions based on temperature dynamics and the discharged volume per drum rotation. Starting temperatures inside the drum were close to ambient when the drum was fairly empty and then increased gradually up to 60-65°C when the occupied drum volume approached 50%. The distribution of all types of markers were close to normal. Under steady state conditions, the observed distribution suggests that the RT of 10% of the particles is about two-third of the mean residence time (MRT) whereas the RT of 1% of the particles will be only half of the MRT. Even shorter RT can be expected under transient conditions. These shorter RT coupled with non-thermophilic temperatures under transient conditions likely increase the risk of inadequate pathogens reduction. The viability of plant seeds that were incorporated with markers indeed showed some dependence on their specific RT. This study is the first to explore the issue of RTD in rotary composting drums. The findings are valuable for risk assessments and the formulation of guidelines for safe utilization of rotary drum composting.

Keywords: Residence time distribution (RTD), Retention time (RT), Markers, Rotary drum, Rotation, Solid flow, Pathogen elimination, Weed seed viability

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Compost Effects on Soil Health and Yields of Organic Winter Wheat in Semi-Arid Environments

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Abstract

Organic dryland wheat (*Triticum aestivum* L.) is an important crop in Utah and the Intermountain Western United States. Yields are often severely constrained by lack of rainfall and, to mitigate crop failure, a wheat-fallow system is typically used. Organic dryland wheat-fallow systems risk major soil loss due to dependency on tillage and a lack of economically viable organic inputs to improve yield and return residue to the soil. The objective of this study was to assess the effects of a one-time compost application on soil health and organic carbon (OC) content of soil fractions in surface- and sub-soils. Three compost rates (0, 25, and 50 Mg dry weight ha^{-1}) were applied once at three organic dryland sites, Snowville (SN), Blue Creek (BC), and Historical (HT) after 3 yr (SN and BC) and 24 yr (HT). Soil samples were collected at four depths, 0-10, 10-30, 30-60, and 60-90 cm and OC in bulk soils, particulate organic matter (POM), sand associated organic matter (SMA), silt + clay mineral associated organic matter (MAOM) and dissolved organic carbon (DOC) were measured. Active carbon, microbial biomass and enzyme activities were measured on the 0-10 cm depths and grain yield was collected across all treatments. Water infiltration was measured in 2022 and 2023. After 3 yr, OC content of POM and MAOM fractions was greater in surface- and sub-soils at all sites. Additionally, POM and MAOM were positively correlated with bulk soil OC. Compost increased soil water infiltration and reduced runoff. Yields of winter wheat increased by 30 to 250 percent depending on site and have persisted consistently at least sixteen years. Our findings indicate that a one-time compost application (25-50 dry weight ha^{-1}) resulted in gains in wheat yield, OC in SOM fractions and bulk soil, and should be considered for OC restoration and the long-term sustainable management of organic dryland agroecosystems. A lack of yield response to conventional fertilizer at the BC site suggests that non-nutritive benefits of improved soil health were responsible for improved yields at the high compost rate.

Keywords: Compost carryover, soil health, organic wheat

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ANA: Anaerobic digestion, biogas valorisation and digestate utilization

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Digestion Enhancement of Recalcitrant Food Organics using a Low Temperature Thermo-alkaline Hydrolysis Process

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Abstract

Lystek thermo-alkaline hydrolysis process is a well-known commercial low temperature hydrolysis technology, which significantly increases the solubility of organics, enhances anaerobic digestion processes, and facilitates the application of dewatered biosolids as a concentrated liquid fertilizer. The technology has been deployed at wastewater treatment plants in Canada, USA, and the United Arab Emirates, primarily for production of Class A liquid biosolid based fertilizers and enhancement of biosolids anaerobic digestion (Elbeshbishy et al., 2014; Singh et al., 2016). The objective of this project was to assess its impact on the non-biodegradable food wastes fractions, which are typically in the range of 15%-25% of organics (Nguyen et al., 2017; Zhou et al., 2022). Anaerobic digestion of food waste (FW) was investigated in a 9-L continuous stirred tank reactor (CSTR) for 103 days (7 phases including a recovery phase) under mesophilic conditions, at organic loading rates (OLRs) ranging from 3.2 to 9.2 g COD/L/d, and SRTs ranging from 14.2d to 20.6d. FW was collected from the Waste Resource Innovation Center, in Guelph, Ontario, Canada. After collection, the FW was immediately grinded and diluted to a range of 2.8% - 9.4% solids content, homogenized using a blender (Cuisinart SBC-1000 4-Speeds Blender Cook Soup Maker) and stored at 4◦C. Biogas production, and FW biodegradability were evaluated. The results indicated that the methane production rate and methane yields ranged from 8 L/d to 20.3 L/d, and 0.4 L CH4/ gVS added to 0.64 L CH4/ gVS added, respectively, with increasing OLR. The biodegradability of FW fluctuated between 53.2% and 85%. During and at the end of phase 7 (days 81-103), digestate samples were collected and kept in a cold room (4˚C) for further investigation. Two Biochemical Methane Potential Tests (BMPs) were conducted at 37˚C±1 and pH 7±1, using anaerobic digester sludge (ADS) as inoculum. BMP1 was conducted with the digestate collected from the CSTR during phase 7 between day 81 and day 103 when the FW biodegradability in the CSTR was 73%, and BMP2 with the digestate solids collected at the end when the FW biodegradability was 77%. In BMP1, Lystek process (pH 9.5, 75˚C, 12 min shearing) was applied to the digestate before inoculation and the BMP test was conducted with untreated and Lystek treated digestate. In BMP2, the digestate was centrifuged first and Lystek process was then applied to the solid fraction. In this case BMP2 was conducted to both untreated and Lystek-treated digestate solids. The results showed that Lystek improved post digestion of FW by 35.5% in BMP1 (0.131 L CH4/ g COD Lystek-treated digestate added vs 0.097 L CH4/ g COD of untreated digestate added), and 22% in BMP2 (0.116 L CH4/ g COD Lystek-treated digestate solids added vs 0.095 L CH4/ g COD of untreated digestate solid added). These results provide strong evidence that Lystek not only enhances the solubility of organic matter, but also improves the biodegradability of

recalcitrant FW organics. This opens the door for the treatment of other refractory agricultural wastes such as animal manures

Keywords: Food waste, nonbiodegradable organics, anaerobic digestion, Lystek thermo-alkaline technology

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Valorization of Kitchen Waste for Gas Production Using Anaerobic Digestion

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Abstract

Over the years, the world population increases, and the quantity of kitchen residue over the years. With the diversity in dieting habits and culinary cultures around the world, kitchen waste can be complex in composition, and may not be treated properly by conventional methods such as landfill and incineration. Although kitchen waste has been used as the feeding forage for pigs due to its organic-rich characteristic, the concern for the spread of pig diseases by kitchen waste often limits such an application. A proper mechanism for kitchen waste treatment seems urgently required. In this study, the anaerobic digestion of synthetic kitchen waste was evaluated for its gas generation under various scenarios. The sludge from a domestic wastewater treatment plant was used as the inoculum to mix with synthetic kitchen waste, and the gas (i.e., methane and carbon dioxide) production by anaerobic degradation was evaluated. The synthetic kitchen waste used in the study included Chinese cabbage, beef, and fish which were used as the feed individually, subject to the culinary treatment of cooking with salt, oil, or both. The mixtures of three individual raw kitchen wastes were also digested anaerobically as well and the observed results were compared. In addition, the experiments using sludges with different ages (i.e., 0, 6, and 18 months after collection) were conducted for comparison. For the individual raw feeds investigated, fish showed the least gas production both for methane and carbon dioxide. Cooking helps to increase the production of both gases from fish anaerobic digestion. Among all the tests of individual feeds (i.e., Chinese cabbage, fish, and beef), cooking with oil showed an apparent inhibition of gas production. This is because the tested kitchen waste was coated with oil, which makes it difficult for bacteria to facilitate the digestion process. For the experiments of mixed kitchen waste, the mixture of vegetables and beef demonstrated the highest efficiencies in producing methane and carbon dioxide. Generally, the anaerobic treatment for well-cooked or uncooked residues also exhibited different gas production efficiency. The gas quantity generated 16% more by the mixture of sludge and well-cooked residue, while methane generated 24% more. The elder sludge and well-cooked kitchen residue could produce more methane. The total gas production using the younger sludge produced 33% less than the elder one, with 46% less methane and 66% less carbon dioxide. The results from the present study can be a useful reference for the design of anaerobic digestion for kitchen waste.

Keywords: Waste Valorization, Kitchen waste, Methanogens, Anaerobic fermentation

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Biohydrogen Production Using Fermented Acidic Cheese Whey

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Abstract

Hydrogen production through dark fermentation (DF) is an environmental process with the dual advantages of energy production and waste treatment (Kim et al., 2022). DF is still challenging, requiring further research to make the process more stable regarding productivity. In recent years, redirecting DF towards using lactate-acetate as a new hydrogen-producing pathway has been proposed, which addresses the proliferation of lactic acid bacteria and stability, both of which are bottlenecks in DF (García-Depraect et al., 2021). Besides, the performance of the reactor is influenced by operational parameters such as the organic loading rate (OLR), pH, hydraulic retention time (HRT), and temperature. The range of OLR applied to the process is operationally relevant to obtain suitable microbial growth and hydrogen production rate (HPR). Nevertheless, higher OLR does not necessarily lead to higher hydrogen production. Thus, optimization of OLR is essential to obtain higher productivity (Mohammadi et al., 2012). On the other hand, Fe^{2+} could improve HPR by promoting cell growth because it is a fundamental component of the hydrogenases and could serve as an electron carrier (Ren et al., 2022). This study evaluated the influence of OLR and iron supplementation on the biohydrogen production rate from the lactate-acetate pathway using fermented acidic cheese whey (FCW) in an expanded granular sludge bed reactor. The FCW was collected from a cheese factory in Mexico. Hydrogenogenic granular sludge adapted to FCW was used as inoculum (Ordoñez-Frías et al., 2023). Biohydrogen production was evaluated using three different OLR of 82 g/L·d, 165 g/L·d, and 213 g/L·d corresponding to lactate concentrations of 15.5 g/L, 31 g/L, and 40 g/L, respectively, and at a constant HRT of 4.5 h. The lactate-acetate fermentative pathway was evaluated using an FCW and acetic acid (HAc) with an optimal ratio (8.25) previously found (Ordoñez-Frías et al., 2023). FCW with Fe^{2+} (50 mg Fe^{2+}/L) was added to the optimal OLR condition. The increase in the OLR from 82 to 165 g lactate/L·d positively affected HPR. The highest HPR was observed at 165 g lactate/L·d, and the maximum HPR obtained was 5.8 L H_2/L·d. However, a further increase in OLR to 213 g lactate/L·d decreased the HPR value at 3 LH_2/L·d, 48% lower than the HPR showed at 165 g lactate/L·d. Butyrate (3.7 g/L) was the primary metabolite in the reactor (at an OLR of 82 g lactate/L·d). Conversely, lactate (9.9 g/L) and caproate (1.6 g/L) were the primary metabolites using an OLR of 165 g lactate/L·d. For the OLR of 213 g lactate/L·d, lactate (25.5 g/L), caproate (1.3 g/L), and propionate (1.1 g/L) were the primary metabolites. So far, no significant improvement in HPR (2.4 L H_2/L·d) was achieved with iron dosing. The results showed that high OLR favored high HPR under the lactate-acetate pathway.

Keywords: Biohydrogen, iron supply, lactate-acetate pathway, organic loading rate

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The Effects of Hydraulic Retention Time, Applied Potential and Pretreatment Process During the Electrofermentation of Cheese Whey

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Abstract

Cheese whey (CW) is the most potent waste generated by dairy industries, as it is characterized by high Chemical Oxygen Demand (COD) and dissolved solids, posing a risk to the environment, the aquatic life and human health, if not properly disposed (Dereli et al., 2019). The conventional CW treatment methods mainly include biological and physico-chemical processes, which result in inefficient valorization or significant capital and operating costs, respectively (Asunis et al., 2020). Anaerobic Digestion (AD) is a well-established and widely-applicable process. However, it can be inhibited from factors such as Volatile Fatty Acids (VFAs) accumulation or high Organic Loading Rates (OLRs) (Stamatelatou et al. 2011). Recently, scientists introduced electrodes in the conventional AD, in order to form an electrofermentation (EF) process (Vassilev et al., 2021). The integrated technology is a promising solution for the efficient treatment of high-strength wastewaters and the enhancement of biogas production, overcoming the limiting factors of the AD reactors (Vassilev et al., 2021). The aim of this study was to examine the EF process, comparatively with the typical AD, utilizing CW as the feed (pH 3.8; sCOD 60 gO2/L; tCOD 66 gO2/L). For this scope two identical 2 L bioreactors were constructed, a typical AD bioreactor and an EF bioreactor. The EF bioreactor was equipped with two submerged carbon felt electrodes (2.5 cm x 10 cm x 2.5 cm each). Both bioreactors were kept in a temperature-controlled box (35 ^{0}C) and were constantly stirred magnetically and operated in a draw-fill mode. The parameters examined were the Hydraulic Retention Time (HRT) (35 and 55 d), CW pretreatment and the applied potential on the EF bioreactor (1 and 2 V). The raw CW was fed with no pretreatment, while the pretreated CW was filtered and the pH was adjusted to 6.2 using a 2% v / v NaOH 2 M solution. The results showed that the AD process failed within the first 20 and 35 d of the draw-fill operation, with the raw and the pretreated CW, respectively. On the other hand, the EF bioreactor operated for 180 d. Initially, the EF bioreactor treated successfully the raw CW (HRT 55 d), at an applied potential of 1 V (94% sCOD removal and 78% tCOD removal); however it failed at a lower HRT (35 d). The optimal performance of the EF process, in terms of waste treatment, was achieved during the operation with the pretreated CW (HRT of 35 d), at an applied potential of 1 V (98% sCOD

removal, 79% tCOD removal and a production of 2.1 Lbiogas / (d * Lreactor) with 62% v / v CH4), while in terms of biogas upgrading, the optimal performance was obtained during the treatment of pretreated CW (HRT 35 d), at an applied potential of 2 V (95% sCOD removal, 84% tCOD removal and a production of 1.8 Lbiogas / (d * Lreactor) with 75% v / v CH4). All in all, the EF process can effectively treat the CW, while producing a good effluent quality and achieving high biogas production, rich in CH4 content, whereas the AD process fails.

Keywords: electrofermentation, cheese whey, applied potential, anaerobic digestion, biogas upgrade, carbon electrodes

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Effect of GAC Addition and Application of Voltage on the Performance of Anaerobic Digestion and the Removal of Persistent and Mobile Substances

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Abstract

Benzotriazoles (BTRs) as well as per- and polyfluoroalkyl substances (PFAS) are partially removed during conventional wastewater treatment (Stasinakis et al., 2013) while they are often accumulated in sewage sludge (Arvaniti et al., 2012; Arvaniti and Stasinakis, 2015; Zhang et al., 2022). These substances are two different groups of manufactured chemicals that are widely used in several application and they are considered as environmental contaminants of emerging concern (Menger et al., 2022). Few studies are, so far, available on their fate during conventional sludge anaerobic digestion, AD (Thompson et al., 2023) while there is no information for the role of the addition of conductive materials in the anaerobic digesters or/and the application of voltage on their removal. The main objective of this study was to examine PFAS and BTRs fate during sludge thermophilic anaerobic digestion and to study the application of granulated active carbon (GAC) and voltage in this process. For this reason, four lab-scale reactors were used in parallel. They were fed on a mixture of primary and secondary sludge and operated at thermophilic range. From the group of BTRs, the studied micropollutants were 1H-BTR, 5TTR, CBTR, XTR, while from the group of PFAS analyses were conducted for PFOA, PFDA, PFPeA, PFNA, PFUdA, and PFOS. The reactors were monitored for 100 days for major pollutants removal, biogas production, methane content and micropollutants elimination. Four lab-scale reactors (1 L) operated in parallel under thermophilic conditions (55 ℃). Anaerobic sludge was used as inoculum and a mixture of primary and secondary (30:70) sludge was used as feed. The investigated compounds were spiked every day at a concentration of 100 μg/L. Reactor 1 was a typical AD reactor, in Reactor 2 voltage was also applied at 0.8V, Reactor 3 contained GAC, while in Reactor 4 GAC + voltage (0.8V) were applied. The studied AD reactors operated for a period of 100 days with an HRT of 20 days. The temperature and pH were monitored on a daily basis, while biogas volume and methane content were measured twice a week. Samples were taken twice a week from the influents and effluents for COD, TS,VS and once a week for the target microcontaminants. PFAS were analyzed using a LC-MS/MS. The solid phase extraction for PFAS was based on a previously developed method by Arvaniti et al. (2012). BTRs analysis were based on the method reported by Asimakopoulos et al. (2013). The operation of all reactors was stable during the experimental period, the pH values in the reactors ranged between 7.2-7.3 while the average VS removal for all four reactor was 49.7%. The average production of biogas was 155-262 mL/Lreactor/day, and the average methane content was 45-59%. Regarding the target compounds, AD reactor containing only GAC achieved high removal of BTRs (91%), in the AD reactor GAC+voltage the removal was

87%, while the conventional AD reactor achieved removal of 65% and the AD reactor using only voltage had the lowest removal of BTRs (55%). PFAS did not show any removal during the experiment. The results of this study show that most of BTRs are significantly removed during thermophilic sludge anaerobic digestion. The addition of GAC enhances BTRs removal, while there is no clear effect of voltage addition. From the current results we conclude that the conditions in which the experiments were performed are not suitable for PFAS removal.

Keywords: anaerobic digestion, methane, electron transfer, PFAs, benzotriazoles

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Dry Anaerobic Bioreactors at the All4Waste Circular Economy Park

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Abstract

The major objective of All4Waste Circular Economy Park is to enable primarily private organizations to carry out their innovative research activities connected to wastewater management, usage, and treatment within the context of the Circular Economy. The All4Waste park has the needed environmental licensing for waste and wastewater treatment, according to the current EU legislation (3982/2011). Energy and food production must have minimal environmental impact in order to meet the demands of the growing world population. In order to manage organic wastes, anaerobic digestion uses biological processes to break down proteins, lipids, and carbohydrates without the use of oxygen in order to produce biogas. Dry anaerobic digestion has a variety of advantages to wet anaerobic digestion, including less fresh water use and a more favorable energy balance. Agricultural waste, like lignocellulosic biomass, has a high TS content. This article describes the two types A and B pilot anaerobic bioreactors that are situated in the All4Waste park and operate solidly under intermittent conditions with a useful volume of 3 m3. A horizontal reactor with an internal horizontal mixing shaft and fins of particular design, the Type A bioreactor is a reactor. A double cone container is the fundamental element of the design. The concentration of the created gas in one spot is guided by the design's simple shape. This location, specifically, is the reactor's center, where a hatch contains machinery for extracting gas. The main chamber has two sides so that hot water can pass between them and maintain a controlled temperature. A horizontal, spinning, cylindrical reactor is the Type B bioreactor. All of the components are churned while the reactor body spins in this alternative method, which also features a new mixing logic as a significant component. The bioreactors have a sensor and an automation system and are installed in All4Waste park. The bioreactors are able to manage an estimated amount of 60 t of waste per year and produce high added value products such as bio-methane and biochar.

Keywords: Waste management, Solid anaerobic digestion, biogas

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Computational Optimization of Solid-state Anaerobic Reactor Blends

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Abstract

Solid-state anaerobic digestion (SS-AD) is a promising technology for recovering bioenergy from organic waste with high total solids content (over 15%), thus contributing to climate change mitigation. Nevertheless, SS-AD units face process challenges including poor biogas yields, low reaction rates, and process instability, as well as logistics challenges such as feedstock seasonality and transportation costs. Here we propose a user-friendly model that produces optimal SS-AD feedstock mixtures. For each ingredient, model inputs include (a) monthly availability, (b) mixture ratio range constrains, (c) and characteristic property ranges. The model generates uniform random combinations of ingredients from a hyper-rectangle that are subject to a total volume constraint, and ranks resulting mixtures according to user-defined priorities. Initial parametrization is based on biowaste characteristics of agro-industrial waste characteristic of the Mediterranean which the user can modify. Feed mixture outputs can drive appropriate actions to boost biogas production, such as minimizing the organic overloading and excess ammonia. Model applicability is demonstrated with two 12-month scenarios where the desired mixture (a) has minimum moisture and maximum VS content, and (b) includes 50% pig manure. Preliminary results show that model output is reliable and can be useful to SS-AD facility managers for optimizing mixtures.

Keywords: olid anaerobic digestion, biogas, Mediterranean organic waste, mixture, moisture calculator

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Monitoring and Controlling the Operation of Solid State Anaerobic Bioreactors via an Arduino Electronic System

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Abstract

Energy production from residues produced in the arid or semi-arid regions of the Mediterranean basin, as well as from food residues, is a major field of research with promising results. A main objective of this research field is the development of a dry anaerobic bio-reactor (Solid State Anaerobic Bioreactor), which will be able to manage all the residues of the Mediterranean countryside (agricultural, livestock, agro-industrial and urban origin) in an automated and optimal way, in order to produce the maximum possible volume and optimal composition of biogas. The main operational parameters of such a bioreactor need to be closely monitored and actively controlled in order to be both safe and optimally tuned for maximum biogas production. The development of an electronic circuit, based on the Arduino platform, for monitoring and controlling the Solid State Anaerobic Bioreactor, was the main subject of our work. The system was based on the Arduino nano microcontroller (ATmega328), coupled with various, commercially available, sensors for accurate monitoring of temperatures (inside the bioreactor, as well as ambient and heating water temperature) and acidity (pH). Data logging of all measured values in an SD card was included, for further, post-experiment, analysis. Real time remote monitoring in a mobile phone or tablet, via Bluetooth connection, was developed, using a customizable Human-Machine Interface (HMI) platform. Moreover, active control of the bioreactor pH, by the microcontroller, was achieved by using a peristaltic pump for injection of small quantities of acidic solution, in order to maintain the desired pH level, for optimum performance.

Keywords: Anaerobic Bioreactors ,Arduino, electronic system

Acknowledgments: This work has received funding from the Project "Laboratory of Solid Waste and Liquid Waste Management"

W2E: Waste to Energy (other than anaerobic digestion)

Industrial development and increased energy demand have led to high consumption of fossil fuels with the consequences we all know today: environmental pollution and climate change. Circular bioeconomy is a promising approach to offset CO2 emissions. A large amount of agro-industrial and municipal residues are treated as waste today, but they can serve used as a renewable, and eco-friendly source of thermal and electrical energy, through biological or thermochemical conversion processes.

The RETASTE Waste to Energy session contributions discuss successful examples of food waste to energy conversion from Greece, Bulgaria, Spain, Brazil

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Hydrogen from biomass: A detailed model to determine the potential of the sugarcane industry in Colombia

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Abstract

The hydrogen (H_2) market has an approximate value of 118 billion dollars with a 6.2% annual growth; however, some aspects like the cost of raw materials, high energy consumption, and its environmental trace generate serious concerns about its potential to mitigate the impacts on climate change. Compared to methane catalytic reforming (CH_4, 700 °C, 20 atm), synthesis of H_2 through the fermentative pathway presents a lower energy consumption as it is accomplished at an environmental temperature and pressure (35 °C, 1 atm). Production of H_2 by fermentative bacteria in the dark phase allows transforming simple sugars into a gaseous current (H_2 = 60% and CO_2 = 40%) and a liquid phase constituted by solvents and volatile fatty acids. The annual production of agricultural subproducts reaches 4.5 billion tons, these materials are essentially composed of cellulose (35%) and hemicellulose (25%). The latter suggests a potential production of up to 440 g (glucose) and 340 g (xylose) per each kilogram of generated waste. MethodologyThe best operational condition for the H_2-producing fermentative process was determined by means of a CCD (central composite design)-type factorial experimental design. The variables of interest were the concentration of the substrate (X1) and the concentration of microorganisms (X2), whereas de response variable was the yield of bioH_2 production (mol H_2 mol-1 substrate). Results: We obtained the following bioH_2 (mmol H_2 mmol-1 substrate) yields: 1.7 glucose ($C_6H_{12}O_6$) and 1.9 xylose ($C_5H_{10}O_5$). The latter corresponds to an efficiency of substrate utilization of 42.5% ($C_6H_{12}O_6$) and 57.6% ($C_5H_{10}O_5$). The operational pH (4.7) was a key element to warrant the high yield of the substrate because it allowed controlling the metabolic route, the hydrogenase activity, and the species present in the reaction medium (mainly Clostridium spp.). Yield and production velocity data for the bioH_2 enabled us to develop a stable state model in Aspen-Hysys V8.8 (Aspen Technology, Inc.), in which we estimated the production potential from cane bagasse (cellulose: 40%; hemicellulose: 30%; lignin: 20%; others: 10%). In the geographical zone of the Valle del Río Cauca (Colombia), 7 × 109 (ton/year) of bagasse are available; thus, it is viable to obtain 9.946 (ton BioH_2/year, 99.996% purity). The latter figure represents 0.014% of the worldwide consumption of H_2; however, when compared to the catalytic reforming of natural gas there are notable aspects: 1) 29.3× 106 (m^3 CH_4/year) were not consumed and 100.000 (ton CO_2/year) were not emitted. 2) The use of an aerobic process coupled to the BioH_2 production process allowed recovering 156.800 (ton/year) of CH_4. 3) Catalytic reforming of the generated CH_4 will enable to additionally attain up to 31.360 (ton H2/year). Results suggest that it is feasible to obtain up to 41.360 (ton H_2/year) by using a renewable and abundant raw material like the cane bagasse.

Keywords: fermentation, hydrogen, reforming

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The added-value of food waste: a review of pre-treatments for biofuel production through thermal conversion methods

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Abstract

The United Nations states that one third of the food produced worldwide is wasted (World Food Programme, 2020), an average of 74 kilograms/person being lost every year (United Nations, 2022). In Europe, around 57 million tons of food are wasted per year, meaning approximately €130 billion and around 10% of global greenhouse gas emissions (Directorate-General for Health and Food Safety, 2023). Thus, alternative ways of addressing these wastes should be implemented to benefit the society as a whole, and avoid detrimental impacts (whether these are environmental, economic or ethical/social). Using food waste as a feedstock for waste-to-energy (WtE) techniques may be an option, in the view of sustainability principles. These WtE techniques concern thermal procedures that, in a dedicated reactor and operational conditions (such as temperature, pressure, and presence of oxidizing agents), convert feedstock into an energy intermediate (e.g. heat, vapour, or a synthetic gas) which can further be used for final applications such as electricity, fuels, or chemicals production (Pan, Du et al., 2015). The global trends in biofuel production point to more than 2 million barrels of oil-equivalent per day in a near future, revealing worldwide increasing needs to explore new renewable energy sources (Our World in Data, 2021). With the recent global energetic crisis and the increasing demand for energy dependent-assets, the application of WtE techniques to produce biofuels has been considered a promising integrated approach due to the efficiency and flexibility towards various types of biomasses (Elgarahy, Hammad et al., 2021). This review discusses recent literature on pre-processing procedures assisting biomass waste thermal conversion, to promote the production of biofuels and other commodities. These will ultimately replace fossil-based alternatives under an environment-friendly framework, and contribute to the attainment of circular economy goals. Pre-processing methods enable cleaner and proficient conversions, once a more homogeneous, dry, suitable and consistent feedstock is achieved, lessening the impacts of the overexploitation of natural resources. Key thermal conversion techniques were summarized and the relation among these and the most convenient pre-treatment options was identified. Knowledge gaps and future opportunities to enhance circularity in the field were also detected.

Keywords: food waste, waste-to-energy, biofuels, sustainability

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Bio-coal Production via Torrefaction of Pelletized Food Waste: Effect of Pellet Size

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Abstract

This study produced bio-coals of different sizes via torrefaction of pelletized food waste and evaluated the effect of pellet sizes on the bio-coal quality. The torrefaction was conducted in a fixed bed reactor by changing the torrefaction conditions of temperature and residence time. The temperature was varied from 230 °C to 290 °C temperature and residence time was varied from 15 minutes to 60 minutes. Thereafter, the characterization of bio-coals produced from torrefaction was done using proximate analysis, elemental analysis, lingo-cellulosic analysis, quality parameter analysis, SEM analysis, TGA analysis, and FTIR analysis. Through these analysis, it was shown that bio-coal produced at severe torrefaction conditions i.e. 290 °C temperature and 60-minute residence time was also dependent on size of pellets as opposed to the conclusion of the previous study (Riaz et al., 2021) where it showed that pellet size mattered only at milder conditions. The pellet sizes used in this study were 16, 20, and 28 mm and the smallest size pellets i.e. 16 mm pellets were found to be producing bio-coal of the best quality in terms of mass yield, energy yield, energy density, surface to volume ratio, fuel ratio, H/C ratio, and O/C ratio. Additionally, SEM analysis showed the large pores got developed in 16 mm bio-coal, a desirable property as it would facilitate the movement of oxygen inside the coal and increase the burning rate. Furthermore, the FTIR showed that complete absence of OH, CO, and COOH groups in 16 mm bio-coal that imparted hydrophobicity in that bio-coal, another desirable property in a coal. Finally, the bio-coals developed in this study were compared with the natural coals using Ven Krevelen diagram and it was shown that quality of the bio-coal produced from torrefaction of 16 mm pellets was much closer to the quality of the peat coal.

Keywords: Bio-coal, torrefaction, food waste, pellet

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Thermodynamic Study of Bambusa Tulda's Thermochemical Process for Energy Production

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Abstract

This study shows a path to convert waste into wealth. Slow pyrolysis of Bambusa Tulda or Indian bamboo, was carried out in the presence of nitrogen in a horizontal fixed bed reactor at 300 C, 400 C, 500 C, 600 C, 700 C, and 800 C. Complete characterization of Bambusa Tulda and its biochar was performed which includes SEM, XRD, FTIR, BET Ultimate analysis, and proximate analysis. The effect of pyrolysis temperature on the yield of Biochar, bio-oil, and syngas was studied. Also, the effect of temperature on the calorific value of biochar obtained was studied. The result shows that with an increase in temperature Biochar yield, Bio-oil yield, BET surface area, and calorific value increase and then start to decline after a particular temperature. Whereas the gas yield increases with an increase in temperature. Considering biochar and bio-oil as main components, exergy analysis was performed to find out the energy and exergy efficiency of the pyrolysis system. It was also observed that with an increase in temperature, both efficiency increases.

Keywords: Slow Pyrolysis, Energy balance, Exergy analysis, biochar, bio-oil torrefaction, syngas, calorific value, energy, and exergy efficiency.

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Bioelectrochemical Systems for Wastewater Treatment: Agri-food Waste and Byproducts for the Production of Biochar-based Electrodes

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Abstract

The potentialities of bioelectrochemical (BES) technologies span over a wide range of practical applications such as micro-electrical power production, organic wastes treatment and electro-fermentation of new valuable products from wastes. Among BES, in microbial fuel cells, mixed cultures of bacteria (already present in wastewater), settle on the electrodes and catalyze the oxidation of biodegradable organics (fuel) dissolved in the anodic compartment. The generated electrons, through an external electric circuit reach the air-exposed cathode, where the hindered oxygen reduction reaction takes place. Micro-electrical power is produced while remediation of wastewater is accomplished (Schievano et al., 2019). Several drawbacks in materials and design have still to be overcome in order to reach competitive performance with respect to other more recognized technologies. Many studies are addressing the development of low-cost and environmentally compatible materials to fabricate large-scale electrodes (Marzorati et al., 2019). In this framework, under the guiding principles of circular economy, this project aimed at developing biochar-based conductive materials to be employed in microbial fuel cells systems as microporous layers acting as catalysts for the cathodic reduction reaction. Biogenic ligno cellulosic materials, after cascade processes for their extraction of added-value products, where employed: i) tomato peels waste; ii) silverskin, the thin layer of coffee beans removed during coffee roasting; iii) pumpkin seeds waste. Biomasses were subjected to a 900°C pyrolysis procedure in order to produce conductive biochar, characterized in terms of electrical and morphological properties. Biochar inks were then formulated and employed to produce microporous layers, finally used as cathodic materials in microbial fuel cells. The cathodic electrodes displayed sufficient conductivity and electrocatalytic activity towards the reduction of oxygen. Despite underperforming compared to other more technological and optimized materials, waste-derived biochar opens new frontiers in design and architectures of new generation bioelectrochemical systems, where not the current production, but mainly wastewater treatment and nutrients recovery can be addressed as the main goals.

Keywords: Wastewater Treatment, Green Energy Production, Bioelectrochemical Systems, Biochar

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Grease Trap Waste Valorization Through Hydrothermal Liquefaction and Anaerobic Digestion: A Circular Approach to Dairy Wastewater Treatment

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Abstract

The presence of fats, oils, and greases (FOG) in dairy wastewater can cause sludge flotation in biological treatments, and result in biomass washout and thus process inefficiencies. A common approach is to separate the FOG prior to wastewater treatment using grease traps at the source site. This grease trap waste (GTW) is a complex sludge primarily composed of fatty acids, suspended solids, and water. In this study, hydrothermal liquefaction (HTL) was used to convert GTW into biocrude while the generated wastewater (AP) was subjected to anaerobic digestion (AD) to recover additional energy in the form of biomethane. To maximize the conversion of organic carbon into biocrude and minimize the use of freshwater, we evaluated the feasibility of re-using/-circulating a fraction of the AP as a reaction medium in subsequent HTL reactions (AP-R), contrasting the conventional approach of using freshwater (AP-0) in each HTL reaction. Specifically, the impacts of AP-R *vs.* AP-0 on the performance of the HTL and AD processes were evaluated in terms of the yields and properties of the biocrude produced from the GTW, and the methanogenic biodegradability, biomethane yields, and treatment efficiency of the different APs. Results show that, although marginally, the AP-R approach can increase biocrude yields in comparison to the AP-0 approach (*i.e.,* 77.7 *vs.* 73.4%). Moreover, both biocrudes showed similar HHVs, which were also comparable to that of fossil-based crude oil (*i.e., ca.* 38 *vs.* 41.9 MJ/kg); however, the biocrude produced under the AP-R approach was characterized with a lower fraction of gasoline, kerosene, diesel oil and other lighter hydrocarbons (boiling points <290^{o}C), according to TGA analyses. Batch AD assays using the biochemical methane potential (BMP) showed a methanogenic biodegradability of 64% for the AP-0. Compounds, such as amino phenols, pyrrolidinones, and pyridine derivatives, which are known to be inhibitory to the anaerobic microbiota, were identified in all APs *via* GC-MS analyses, likely hindering methane production. Likewise, a myriad of complex, refractory, and potentially inhibitory compounds were found in increasing relative areas with each recirculation cycle. Indeed, by the 5th recirculation cycle, the biodegradability of the AP had decreased to 47%. Finally, continuous AD using an EGSB reactor operated at a constant OLR of 3 g COD L^{-1} d^{-1}, showed

that biomethane yields and treatment efficiency decreased with increasing fractions of AP-0 fed to the reactor. When the AP-0 constituted 100% of the influent COD, biomethane yields reached 210 mL g-COD^{-1} fed (at STP), whereas 68% of the influent COD was removed and 60% methanogenic biodegradability was achieved. Moreover, when 100% of the influent COD was composed of AP-R, only 45% biodegradability was achieved. Despite of the AP used, the COD of the final effluent was in the range of 630 and 950 g L^{-1}, while the overall energy recovered was 85-87% of that contained in the GTW. Our results demonstrate that the integration of HTL and AD processes allows for recovering a large fraction of the GTW energy while producing a more stabilized wastewater, diverting GTW from landfills, and mitigating GHG emissions.

Keywords: grease trap waste, anaerobic digestion, hydrothermal liquefaction, energy recovery

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Coupling of Steam Gasification of Biomass and Catalytic Plasma Tar Reforming Over Low-cost Catalyst for H2 Production

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Abstract

Biomass gasification is considered as a viable pathway for syngas and hydrogen production which can be further transformed into chemical intermediates, industrial products and energy. The formation of tar in biomass gasification is one of the major challenges which limits development and commercialization of biomass gasification technology (Tao, M.et al., 2018). Formation of tar not only lead to serious maintenance failures, but also reduces gasification efficiency since tar consists of significant amounts of energy in the form of mixture of aromatic hydrocarbons. Various techniques for tar removal/decomposition have been attempted in the literature, including hot gas filtration, water scrubbing and catalytic cracking etc (Chai, Y. et al., 2020). Plasma assisted tar reforming is a novel approach to reduce tar content in gas products by converting tar into gaseous products (Liu, L. et al.,2019; Xu, R. et al., 2021). In this work, steam gasification of olive tree pruning was carried out by a hybrid two-stage reaction system to produce hydrogen. Thermal steam gasification of biomass took place at 850 ℃ by introduction steam (flow rate of 5 ml/h) from top of reactor. Tar containing gas products evolved at the first stage were subsequently passed through dielectric barrier discharge reactor (plasma power of 15 W) at two different temperatures (200 and 500 ℃) in the second-stage plasma reforming process. To enhance the tar reforming, red mud (RM), dolomite (CD) and their nickel doped forms (Ni-RM and Ni-CD, respectively) were used as low-cost catalysts in the plasma-catalytic reforming process. The results revealed that the highest H2 production (51.36 mmol/g) and selectivity (70.64%) was obtained with 7.5Ni-CD at reforming temperature of 500 ℃. It may be attributed to the catalytic activity of Ni and CO_2 adsorption of CD, which can also be confirmed from the lower CO_2 yield when using CD-based catalyst. In case of Ni-CD, increase the plasma reforming temperature from 200 to 500 ℃ enhanced the gasification efficiency, probably due to high catalytic activity of Ni at high temperatures. On contrast, reforming temperature has an adverse effect in case of CD, resulting in slight decrease of H_2 yield (from 26.98 mmol/g to 22.53 mmol/g), implying that higher temperature may be detriment to the positive effect of plasma reforming. Although RM was used as an iron catalyst, less amount of gas products was obtained from gasification in presence of both RM and Ni-RM catalyst at a reforming temperature of 500 ℃. It was concluded that some minerals in the RM melt in the high temperature plasma environment, blocking the active sites of the catalyst and causing weak gasification activity. On the other hand, Ni addition into RM had almost no effect on both

overall gas yield and H_2 production at a reforming temperature of 200 ℃. Moreover, the catalytic effect of RM and Ni-RM was considerably lower than CD based catalysts.

Keywords: Hydrogen, Catalytic steam gasification, Plasma

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Thermochemical Conversion of Biowaste to Bioenergy Using the Thermocatalytic Reforming Technology

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Abstract

This work outlines how the thermo-catalytic reforming (TCR®) technology is used to produce biofuels, namely biochar, biooil and biogas, from biowaste containing mostly food waste. About a decade ago, the Fraunhofer Institute for Environmental, Safety and Energy Technology UMSICHT invented the TCR® technology for the conversion of biomass into biofuels. Essentially, it involves the combination of intermediate pyrolysis and catalytic reforming leading to the production of biofuels of improved quality compared to those from pyrolysis. While the generation of biowaste worldwide is quite high, the traditional utilisation is mostly composting for soil improvement. However, the presence of plastics in them causes problems in this direction. Hence, with thermochemical conversion such as the TCR® employed in this work, the plastics are thermally decomposed leaving the char, which can still be used for soil improvement, free of plastics. Moreover, while the abundance of other renewable energy resources like solar and wind vary from place to place, and season to season depending on the place, that of biomass is quite uniform. Even so, while the abundance of the other sources of biomass like wood waste and animal dungs may vary from place to place regardless of the human population, that of biowaste is very dependent on human population. Meanwhile, since energy demand is also dependent on human population and with the need to increase the harnessing of renewable energy resources to reduce greenhouse emissions and ultimately achieve carbon neutrality, generating energy from biowaste is of significant economic importance. More so, while the biofuels can be employed in meeting energy demand with the char being additionally applicable in soil improvement and carbon sequestration, a good quantity of water can be recovered from biowaste to meet water demand. Specifically, water can be recovered from biowaste through both controlled drying (pre-processing) and treatment of the product water from thermochemical conversion (post-processing). This underscores the importance of this work. The feedstock used is biowaste procured from the Sulzbach-Rosenberg Waste Disposal Site. The feedstock is mashed, dried and pelletised. It is then thermochemically converted into biofuels and a reaction product water using a lab-scale TCR® plant with a throughput of 2 kgh-1. Two experiments at post-reformer temperatures of 550 °C and 750 °C, with a reactor temperature of 450 °C each, are carried out. The results show up to 84% (by weight) of the dried feedstock can be converted into biofuels at a post-reformer temperature of 550 °C while up to 90% of it can be converted when the post-reformer temperature is raised to 750 °C. Precisely, when the post-reformer temperature is increased, the yields of the products decrease except that of the biogas which increases enough to bring about a net increase in the yields of the biofuels. Moreover, analyses of the biogases produced from both

experiments show they are rich in green hydrogen with a hydrogen fraction of 31% (by volume) at a post-reformer temperature of 550 °C and 39 % at 750 °C. Analysis of the other products and various applications of the products are also discussed in this work. Overall, the successful conversion of biowaste into biofuels and treatable product water using the TCR® technology is a fundamental feat in waste management, circular economy, and sustainable energy production.

Keywords: biowaste, biofuels, pyrolysis, catalytic reforming, green hydrogen

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Maximizing Wastewater Treatment Efficiency by Coupling a Periodic Anaerobic Baffled Reactor (PABR) with a Microbial Fuel Cell (MFC)

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Abstract

Microbial fuel cell (MFC) technology has been extensively researched to maximize both the efficiency of wastewater treatment as well as the simultaneous power output. MFCs have been coupled with other wastewater treatment methods such as anaerobic digestion or dark fermentation to maximize the treatment efficiency and the energy recovery. Additionally, the quest for cost – efficient materials has led to the use of ceramic-based cathode assemblies as effective anode – cathode separators (Winfield et al., 2016). In this work the MFC technology has been incorporated in a two-stage system, in order to refine the characteristics of the effluent from a high-rate anaerobic digester (the periodic anaerobic baffled reactor, PABR) (Skiadas I.V. & Lyberatos G., 1998), while maximizing the energy recovery from the already treated effluent. The PABR has been fed with a condensate originating from the vapors of dried household food waste (HFW). The MFC cathode set – up consisted of four air cathode mullite electrodes coated internally with a MnO_2 catalytic paste. As MFC anode, graphite granules (250 g) were used for biofilm growth with a graphite rod embedded in them for current collection. The PABR effluent characteristics were a low COD concentration (250 – 550 mgCOD/L), neutral pH (7.9±0.1) and low conductivity (3±0.7 mS/cm). The MFC was fed with the PABR effluent (150 mL) without any pretreatment. Six operation cycles were performed, producing repeatable current output peaks (1.8 – 2 mA). Moreover, the COD removal efficiency ranged from 67% to 93% and the pH presented a small decrease from 7.9 to 7.5. Polarization experiments were conducted on the MFC, measuring a maximum power output of 5.4 W/m^3 and an internal resistance of 78 Ω. The highest electricity yield was measured at the first operation cycle (40 mJ/gCOD/L), along with the highest coulombic efficiency (43%), indicating the effect of residual salts from the phosphate buffer in the graphite granule bed. During the consecutive operation cycles with PABR effluent the MFC performance deteriorated, resulting in 15% coulombic efficiency and 14 mJ/gCOD/L electricity yield. However, the maximum power output of each cycle presented an increase from 0.9 W/m^3 at the 1st operation cycle to 5.4 W/m^3 at the last. This work demonstrated the MFC ability to utilize a treated effluent for maximum energy recovery, while refining its characteristics.

Keywords: PABR, MFC, condensate, Bioelectrochemistry

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Steam Gasification of Biochars derived from Saw Dust and Poultry Manure with Lignite for H2 Production

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Abstract

Hydrogen is considered as a fuel of the future and its utilization as a fuel in transportation has further increased the importance of research on renewable hydrogen production. Today, 18% of the total hydrogen in the world is being provided by coal gasification which is known as the most cost-effective way. However, the countries that ratified the Paris Agreement intend the phase-out coal by reducing coal use gradually and to terminate them by 2050. The management of the move away from coal technology will not be easy and rapid since significant investment on coal gasification technologies had already made. Therefore, a cleaner alternative is seeking to be used in existing infrastructure instead of fully transition of the technology. Biochar, which is carbon rich solid product of biomass pyrolysis, is considered as a promising candidate to replace and/or co-utilize with coal. Biochar can be obtained from wide range of biomass type including waste having disposal issues. In this study, biochars derived from poultry manure (PM), saw dust (SD) and their blends were gasified alone and with lignite in presence of steam to produce H_2- rich gas. Biochars were obtained by slow pyrolysis at 300 °C. Biochar blends were prepared by two techniques, mechanical mixing and co-pyrolysis of biomass wastes. Results showed that SD derived biochar alone produced higher H_2 yield than PM derived biochar alone due to high organic content. In case of gasification of biochar obtained by co-pyrolysis, synergistic effect occurred, resulting in increase of H_2 and overall gas production compared to theoretical yields. On the other hand, no interaction was observed during gasification between PL and SD biochars in mechanically mixed biochars. Gasification of SD biochar mixed with lignite with a 50%-50% ratio gave lower H_2 yield than theoretical values whereas theoretical and experimental yield of PL biochar and lignite gasification was almost same. In case of co-gasification of mixed biochars and lignite, adverse effect was observed between co-pyrolysis biochars and lignite, reducing the H_2 yield. The anti-synergistic effect of mixed biochars in co-gasification runs may be attributed to inhibitory effect of newly formed inorganic compounds during co-pyrolysis. Despite of the anti-synergistic effect during co-gasification, all biochar blends gave higher H_2 yield than lignite alone.

Keywords: biochar, steam gasification, poultry manure, hydrogen production

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Biohydrogen Production by Lactate-based Dark Fermentation from Cheese Whey in Continuous Mode

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Abstract

Cheese whey (CW) is the wastewater generated by the dairy industry during cheese making processing. CW is a yellow-green liquid and produced by the precipitation of casein from milk. Due to its relatively high organic load (40-60 g COD/L), it can be highly polluting if it is released into the environment without proper treatment (Ahmad et al., 2019). Additionally, this residue contains around 50% of milk nutrients, so it can be valorized and used in different fields such as the food industry (modification of physicochemical properties of food), energy (biofuel) and production of other value-added products (Ramos et al., 2021). Dark fermentation (DF) is a promising biological process to produce hydrogen as an energy vector or feedstock from organic wastes and wastewaters. CW is indeed considered a potential substrate for the production of hydrogen and other value-added products through DF. However, the DF of CW is commonly inhibited due to the overwhelming growth of lactic acid bacteria (LAB). Recently, it has been reported that lactate-based metabolic pathways are effective for hydrogen production, provided that lactate cross-feeding occurs between LAB and lactate-oxidizing-hydrogen-producing bacteria (LO-HPB). The objective of this study was to evaluate the continuous production of hydrogen from CW using a specialized biocatalyst able to biotransform lactate into hydrogen. This approach aimed to harness syntrophic interactions between LAB and LO-HPB (García-Depraect et al., 2021). To achieve the main aim, a laboratory scale stirred tank reactor (2.5 L) with a working volume of 1 L was used. The culture conditions were: 35 °C, 150 rpm, pH 5.8 ± 0.02, and hydraulic retention time (HRT) of 24 h and 18 h. CW (103 g COD/L, 13 g/L reducing sugars, 94.8 g TS/L, 82.6 g VS/L) and an inoculum mainly composed of LAB and LO-HPB (10% v/v) were used as substrate and biocatalyst, respectively. The removal of sugars, as well as the productivity of hydrogen (L H2/L-d) were recorded. Regarding the results, a productivity of 6.5 ± 0.5 L H_2/L-d was achieved at 24 h HRT, with an associated yield of 62.3 ± 5.4 mL H_2/g CODfed. A reducing sugars removal of 98.2 ± 0.1% was computed. Further, the change of HRT from 24 h to 18 h resulted in an increase in the productivity, reaching up to 7.8 L H_2/L-d (the highest so far reported for CW) with a corresponding hydrogen yield of 54.6 ± 2.7 mL H_2/g CODfed. No difference was observed in the removal efficiency of reducing sugars compared to that at 24 h HRT. As for the soluble metabolites, the major organic acid detected was butyrate, which peaked up to 33 g/L when hydrogen productivity peaked (7-9 L

H_2/L-d). Hydrogen productivity correlated positively with butyrate but negatively with lactate, strongly suggesting the presence of lactate-driven DF. Altogether, it can be concluded that CW is a promising raw material to produce biogenic hydrogen via the lactate-driven DF. This non-conventional hydrogen-producing pathway is key to overcome issues related to the inhibition of hydrogen production by LAB. Here, marked fluctuations in hydrogen productivity were observed throughout the operation, likely due to the dynamic equilibrium between LAB and LO-HOB. Hence, further research is still needed to ensure long-term stability in hydrogen production via LD-DF.

Keywords: Cheese whey, Dark fermentation, Hydrogen

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LCA: Life Cycle Assessment and Social Life Cycle Assessment (S-LCA) of the different components of the farm-to-fork value chain

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Supporting environmental certification in the agrifood sector through online lifecycle assessment tool: Identification of end-users' requirements

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Abstract

Life Cycle Assessment, also known as LCA, is the most widely acknowledged methodology for the systematic analysis of the potential, cradle-to-grave, environmental impacts of products or services. Within the framework of an LCA study, the potential environmental impacts throughout the entire life cycle of a product or service are evaluated. In this light, the environmental impacts within the phases of production, distribution, use and end-of-life are estimated, following a highly standardized, ISO defined, procedure. Apart from identifying hotspots and improving the environmental performance of a system, LCA is widely used internationally for certification purposes, e.g. for the issuance of Environmental Product Declaration or the development of an ecolabel. However, all LCA software that are available in the market use static data and Life Cycle Inventory (LCI) databases with average values, for the calculation of impacts for any given production process. To that end, in the framework of the “Real-time, environmental assessment of agricultural and agrifood production for the support of certification schemes” project, a real-time, online LCA Engine is being developed, focusing on the agrifood industrial sector, where certification is highly demanded. The tool, apart from exploiting data from available LCI databases (e.g. ecoinvent), also utilizes real-world data, sourcing from sensors. In the present work, we primarily focus on the determination of the potential end-users’ requirements from such a software. The key findings of a survey that has been conducted, are presented. The different needs of a diverse pool of potential end-users, namely farmers, cooperatives, agri-consultants and agrifood producers, are analyzed. The key outcomes of the user requirements survey will be used in order those to be “translated” into functional requirements of the LCA Engine.

Keywords: Life Cycle Assessment, agrifood, sensors, environmental product declaration, Internet of Things

References

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Research on the environmental impact of Massive Food Services and Homemade Meals: A Case Study of Stewed Chickpeas in Chile

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Abstract

In recent years, climate change and its consequences have been a relevant topic worldwide, given its repercussions for both the environment and human beings. Nowadays, the consequences manifest themselves, such as water scarcity, glacier melting, and biodiversity loss. Moreover, drought directly affects food production, as it affects land productivity. In addition, the world's population increases year by year, demanding a higher amount of food. Therefore, taking the corresponding measures to minimize the environmental impacts of producing food for human consumption is of utmost importance.
Related literature concluded that there is still a lack of comparative studies on the entire life cycle carbon footprint of home cooking, restaurant dining, and order.
Therefore, this research aims to compare, through life cycle assessment, the environmental impacts generated by the massive food service offered by a public university in Santiago, Chile, versus making the same recipes at home under two scenarios: following a recipe and without a recipe. The stewed chickpeas are the case study as they represent a typical Chilean recipe. The system boundaries consider that the necessary ingredients for preparing the meal are purchased, processed, and cooked, and, finally, the waste and wastewater are treated. The functional unit is set as one serving of food to compare the different scenarios. The results show that the recipe at the massive food service generates 0,212 kg CO_2 eq, while the recipes homemade, without and with a recipe, emit 0,271 and 0,353 kg CO_2 eq, respectively. However, contrasting with the results obtained from the water footprint analysis, the massive food service recipe generates a higher amount of impact with 1,356 m^3.
Based on the results obtained, massive food services could have a lower environmental impact per serving, given the efficiency of the equipment used to prepare the food compared to the appliances available in a typical Chilean household.

Keywords: Life cycle assessment, massive food service, homemade food, Chile

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Sustainability Assessment of Biorefineries for Waste Valorization from Juice Industries

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Abstract

Bioeconomy, circular economy and sustainable development refer to actions, regulations, frameworks and policies which have recently been introduced into our lives, sharing the common purpose of meeting the Sustainable Development Goals by 2030. While waste volumes reduction is in the core of the above goals, significant quantities are generated from the food processing industries inducing harsh environmental burdens and raw materials scarcity. Around 17 Mt of fruit waste, mainly deriving from juice industries, is produced every year in the EU at the processing and manufacturing stage of the food supply chain. Oranges are among the main fruits being processed in the juice industry, with around 50% of their mass ending up as waste, generating around 2.5 Mt of orange waste in the EU every year. This waste, mainly consisting of peels, internal tissue and seeds, although rich in valuable organic compounds, is treated in a non-sustainable manner, both environmentally and economically, including landfilling, animal feeding and incinerating. Waste management through a biorefinery concept would result in a spectrum of products such as high value-added bioactive materials, biofuels, biochemicals and bioplastics, via the fractionation of the waste into particular waste segments and the implementation of integrated waste valorization technologies. A meta-analysis of the available technologies valorizing waste streams from the orange juice industry is conducted in the context of this study, followed by a comprehensive sustainability analysis of waste management scenarios, evaluating the most critical environmental, economic, energy and mass indicators. Primarily, a mass flow analysis is conducted to determine the orange waste quantities in the EU and its member states individually. Subsequently, incumbent and emerging technologies are compared in terms of their product yield, energy consumption and extraction time. The emerging technologies perform better in energy consumption and extraction time which ranges from 37.4% to 93.0% less time in pectin and essential oil extraction, respectively. Product yield does no show a constant trend in favor of emerging technologies indicating the low TRL of the latter as a presumptive explanation. In terms of the environmental performance, emerging technologies extracting essential oils, pectin and phenolic compounds present 85.1%, 97.5%, 47.9% lower CO_2 equivalent values respectively than the conventional ones. The same pattern seems to apply also on the rest of the environmental indicators such as photochemical ozone formation (POF), ozone depletion (OD), terrestrial acidification (TA)

and freshwater eutrophication (EUF). In addition, the traditional orange waste management scenario of landfilling seems to be the least environmentally benign alternative, followed by thermochemical treatment scenarios and those of biological conversion. Also, cost production seems to be inverse proportionate with the complexity of the scenarios which in turn is analogous to the environmental performance and energy consumption. Finally, trade-offs analysis between the under-study indicators drew critical conclusions, as to the sustainability performance linkage between orange waste management scenarios.

Keywords: waste management, sustainability analysis, juice industry, biorefinery

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Comparison of the Environmental Impacts of Omnivore, Vegetarian, and Vegan Lasagnas Using Life Cycle Analysis: An Approach to Contrast Dietary Choices and their Ecological Footprint.

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Abstract

Recently, climate change and its repercussions have been a relevant topic of study worldwide. The effects of climate change can be noted in the escalation of temperatures, the retreat of glaciers, the scarcity of water, the loss of biodiversity, and other profound consequences. These indicators allow for the analysis, evaluation, and quantification of emissions generated by human activities and their impact on the environment. Among the main sustainability indicators under study are global warming potential (GWP) greenhouse gasses (GHG) and water footprint. Due to existing water scarcity and the inefficient use of this resource, future food security, specifically food production worldwide, is being threatened. According to the Inter-American Institute for Cooperation on Agriculture (IICA), the agricultural sector is responsible for 70% of freshwater consumption. As a result, the water footprint of this sector is excessively high and will continue to grow unless there is a reduction in the carbon footprint produced by human activities. Therefore, it is important to analyze and evaluate dietary choices, seeking to prioritize more sustainable foods, such as locally sourced products or plant-based options. This research aims to explore and contrast the environmental implications of different types of diets through a Life Cycle Analysis, focusing on the three most prominent diets globally: omnivore, vegetarian, and vegan. This study evaluates the impacts specifically associated with the preparation of a lasagna recipe, providing a comparative analysis of the: Global warming potential (GWP) and Water footprint. For the studied recipe, the system boundaries, production processes for each recipe, waste treatment and transportation, and wastewater treatment were defined. To enable a comparative analysis between the diets, 1 serving of food was chosen as the functional unit. The results reveal that the omnivore recipe produces 5 times more CO_2 eq emissions than the vegetarian recipe and 13 times more than the vegan recipe. Regarding water footprint, the meat recipe generates an impact 7 times greater than the vegetarian recipe and 17 times greater than the vegan recipe. These results demonstrate the significant disparity in GWP and water use in the production and preparation of food among different dietary options. It is important to note that the analysis is limited to a specific recipe, and therefore, the comparison may vary depending on the recipe under study. This analysis provides valuable insights into the potential environmental benefits and trade-offs associated

with different dietary choices and can inform individuals, policymakers, and the food industry about more sustainable options for lasagna preparation and consumption.

Keywords: life cycle assessment, dietary choices, homemade food, ecological footprint, Chile

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Environmental Hotspots of the Life Cycle of Pumpkin Pulp: Conventional vs Waste-derived Preservatives

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Abstract

Throughout its entire life cycle, food contributes to several environmental impacts (Poore and Nemecek, 2018). Food waste is of particular interest since resources are being depleted for no practical use in this case, and the need for further treatment implies additional impacts. Consequently, alternatives for food waste valorisation are crucially needed [2]. This is the aim of the project PulpIng – Development of pumpkin pulp formulation using a sustainable integrated strategy – which intends to valorise pumpkin crop by-products, to develop a new preservative for packaged pumpkin pulp, while simultaneously avoiding bio-waste generation, promoting circular economy and substituting typical synthetic preservatives with a bio-based solution. For a thorough evaluation of the environmental benefits of this project's strategy, the potential environmental impacts resulting from packaged pumpkin pulp throughout its life cycle were assessed. All stages of the life cycle were considered (cradle-to-grave), from pumpkin cultivation and packaged pulp production to the end-of-life (which, considering the typical whole use of pumpkin pulp, integrates the end-of-life of the packaging). In the first phase, an assessment of the traditional life cycle environmental impacts of packaged pumpkin pulp production, during which pumpkin by-products are considered waste and pulp production uses traditional preservatives, was performed. The same cradle-to-grave assessment will later be executed considering the use of a preservative derived from the pumpkin by-products. Preliminary life cycle assessment results for the traditional life cycle of packaged pumpkin pulp are now available. These show that the agricultural phase has the highest contribution to most impact categories (13 out of

18 at midpoint level). The production of packaged pumpkin pulp is the second highest contributor in 4 midpoint categories, standing out relatively to the agricultural phase, particularly in terms of potential terrestrial ecotoxicity and fossil resource scarcity. The end-of-life is not a particularly relevant stage in comparison. On the one hand, in the agricultural stage of the life cycle of packaged pumpkin pulp, the hotspot is usually the treatment of the bio-waste, i.e., the by-products of pumpkin which have no use (stems, leaves, rinds, and fibres), which contributes on average to approximately half of the potential environmental impacts. Hence, an alternative to this waste treatment is recommended. On the other hand, in the production stage of packaged pumpkin pulp, preliminary results show that preservatives production may have a relevant contribution to its potential life cycle impacts (the thickening agent is typically the main contributor, however, following it, the most relevant are electricity use, preservatives production, and polypropylene buckets production), implying that the use of alternative preservatives would be beneficial. Thus, the assessment of the current life cycle of packaged pumpkin pulp production supports the idea of intervening both at the level of valorisation of the agricultural by-products and at the pulp additives production, for a relevant reduction of potential environmental impacts.

Keywords: pumpkin pulp, life cycle assessment, agricultural waste, preservatives, bio-waste

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Comparison of Alternative Life Cycle Assessment Scenarios for the Management of Pruning Residues and Wastewater of Olive Oil Production

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Abstract

Sustainable management of olive oil production waste, constituting mainly of pruning residues and olive mill wastewater, as soil amendments (Galliou et al., 2018; Manios, 2004; Manios et al., 2004, 1989) has multiple environmental benefits due to nutrient recycling and carbon sequestration, leading to reduced CO2 emissions (Ryals et al., 2015), combating of soil degradation and eventually climate smart soils (Paustian et al., 2016). Nevertheless, supply chain costing (Argo et al., 2013; Junginger et al., 2011) and waste accessibility problems (Esteban and Carrasco, 2011) are barriers against the widespread use of sustainable management practices like on-site composting, which drive land managers to sub-optimal or even prohibited practices such as pruning residue burning (Manios, 2004). In this context, the CompOlive project developed an on-site composting service that aims to overcome the accessibility and supply chain obstacles using remote sensing imagery to assess biomass availability (Fidani et al., 2023). The service is available to land managers through an online booking system and includes on-site chipping of residues, establishment of static aeration compost piles, and regular aeration and irrigation of the piles with olive mill wastewater. Here we assess the environmental footprint of the service and compare it against business-as-usual (i.e., burning olive tree pruning residues on-site and treating olive mill wastewater in evaporation ponds) and off-site treatment at a centralised composting facility. The Life Cycle Assessment was conducted in OpenLCA by modifying processes from the agribalyse (Colomb et al., 2015) and ecoinvent (Wernet et al., 2016) databases. The environmental footprint of the olive oil production waste end-of-life scenarios were calculated using ReCiPe (Dekker et al., 2020) at the midpoint and endpoint levels based on the selected impact categories. Results show that the carbon footprint of the new service is 15-45% lower that that of business as usual, and roughly equivalent to off-site composting, without taking into account the benefits in land conservation.

Keywords: olive tree pruning residues, olive mill wastewater, compost, on-site treatment

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Exploring sustainable strategies in municipal waste management: A preliminary social life cycle assessment of a pay-as-you-throw pilot program

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Abstract

In the pursuit of a sustainable future, communities worldwide are reevaluating their waste management practices to reduce environmental impact (Vardopoulos & Zorpas, 2021) and promote responsible citizen participation (Poulos et al., 2018). An initiative within the "Circular Economy Implementation in Greece" project (LIFE18 IPE/GR/000013, www.circulargreece.gr) is currently unfolding in the Municipality of Voula-Varkiza-Vouliagmeni (VVV) in Attica, Greece (LIFE-IP CEI-Greece, 2021, 2022). This initiative is poised to revolutionize waste management in the region through the implementation of an integrated pay-as-you-throw (PAYT) system (Hadzi-Nikolova et al., 2021; Maragkaki et al., 2023). PAYT represents a holistic approach involving comprehensive changes in waste management methodologies, aiming to maximize results while promoting responsible waste disposal (Emmanouil et al., 2022; Vardopoulos et al., 2019).
In summary, a pilot waste management scheme in VVV takes into account the unique characteristics of the municipality's building stock and proposes a tailored PAYT approach, ensuring efficient waste collection and encouraging responsible waste disposal practices. Buildings in the municipality have been classified into three categories based on their respective waste generation levels. The first group comprises of buildings with low waste production, encompassing residential, commercial, and office structures. The second group includes buildings with moderate waste production, mainly businesses. The third group encompasses buildings with high waste production, including hospitality establishments, hospitals, and other large enterprises. These categories guide the implementation of different waste management approaches, ensuring compatibility with the area's diverse building types. The majority of the buildings, which are in the first and second groups and collectively account for approximately 60% of the total waste, following an in-depth multi-level analysis, shall adopt a PAYT scheme utilizing pre-paid bags. This choice aligns with the dispersed geographical nature of these buildings and the relatively low number of households per building seen in VVV. The collection of pre-paid bags can occur through door-to-door collection outside the buildings, with or without individual bins. For larger buildings or enterprises with higher waste production (the third group), the PAYT scheme with pre-paid bins is a more efficient and cost-effective solution. Furthermore, a concurrent PAYT system will be introduced for plastic, metal, and drink cartons, paper, and glass, as well as organic waste from both the kitchen (food waste) and the garden. Finally, this pilot initiative encompasses a comprehensive citizen information program covering all fundamental aspects of integrated waste management (LIFE-IP CEI-Greece, 2021, 2022).

To assess the social impacts of the pilot project, a Social Life Cycle Assessment (S-LCA) approach is being adopted in accordance with the Guidelines released by the United Nations Environment Programme (UNEP)/ Society of Environmental Toxicology and Chemistry (SETAC) Life Cycle Initiative (Benoît-Norris et al., 2011; UNEP, 2021). A S-LCA is a multi-step process involving, in layman's terms, defining the assessment's objectives, scope, and boundaries, collecting data on various social aspects throughout the project's life cycle, evaluating potential social impacts, and finally interpreting the results in the context of the goals and objectives set (Abeliotis et al., 2018; Tsalidis et al., 2023). Additionally, the process could involve formulating recommendations and guidelines, undergoing external review and verification to bolster credibility, and adapting the assessment to reflect changes and enhancements within the project.
The findings hold significant promise in delivering invaluable insights into the intricate social ramifications of the PAYT pilot project in VVV, a pioneering endeavor in the implementation of a PAYT waste management system within Greece. Insights could provide crucial information to decision-makers, ranging from governmental authorities to environmental organizations and waste management experts, for better informed strategic decisions by shedding light on the multifaceted dimensions of municipal management (Vardopoulos et al., 2023). Moreover, this preliminary approach, beyond helping to establish a foundation for an effective PAYT waste management system in Greece, also serves as a valuable reference for other countries facing similar challenges on their sustainability journey.

Keywords: circular economy, waste management, waste prevention, sustainability, social impacts

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Environmental assessment of edible parts of wasted food at the household level in Greece

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Abstract

Food waste at any stage of the food supply chain, generates environmental, economic, and social impacts. This study focuses on food waste produced at the household level, which includes the cumulative loss of all embodied resources and energy inputs used to produce, store, and distribute these foods, and therefore may have a greater impact. According to the most recent data, households account for 45% of food waste production in Greece. However, the effects of the phenomenon have not been properly investigated at the national level.
Without diminishing the importance of the socio-economic impact of the phenomenon, the purpose of this study is to investigate the environmental impact of the creation of food waste in Greek households. A total of 1133 households were recruited and provided information on food waste generation patterns through food waste diaries. The environmental assessment was conducted with the Life Cycle Assessment (LCA) methodology according to ISO 14040/44 standards. While the chosen assessment method is the EF 3.0 Method (adapted) V1.00/ EF 3.0, which includes sixteen impact categories related to the: land (land use, minerals, depletion of mineral and fluid resources, Terrestrial eutrophication), the atmosphere (Climate change, ozone depletion, human toxicity, non-cancer effects, human toxicity, cancer effects, particles, HH ionizing radiation, E ionizing radiation (intermediate), photochemical ozone formation, acidification) but also in the water table (Freshwater eutrophication, Marine eutrophication, Ecotoxicity of fresh water, Depletion of water resources). The amount of food waste produced in kg/year/person was chosen as the Functional unit. The analysis was based on the size of the household per food waste category. The categories selected for study were fruit, vegetables, meat, fish, bakery products, dry food and potatoes. While the sample, as mentioned, was studied based on the size of the household and thus a distinction was made into one-member, two-member, three-member, four-member, and more than five-member households. In terms of the results, it was found that in all the studied cases concerning the sample, the food categories with the higher environmental impacts were vegetables and meat. A possible interpretation for this is that a large amount of discarded vegetables was recorded in Greek households, perhaps due to the proximity to their production, as most of them are products produced in the country. As for meat, even though the amount recorded is quite small, the entire life cycle of the meat , is the one that contributes significantly to its environmental footprint. This procedure identifies the categories of food waste with the greatest environmental impact, so that the more onerous may be aimed at preventing and reducing food waste.

Keywords: Circular economy, Life Cycle Assessment, Descarded food, Primary data, Country level.

Acknowledgments: This study is partly co-funded by the European Commission through the LIFE programme “Circular Economy Implementation in Greece” - LIFE-IP CEI-Greece (LIFE18 IPE/GR/000013) and the Green Fund.

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Environmental Assessment of Integrated Robotic Cultivation System for Greenhouse Tomato Production

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Abstract

Modern agriculture contributes to a wide range of environmental impacts (i.e. climate change, acidification, eutrophication etc.), therefore, new cultivation soilless systems have emerged as a promising alternative over traditional agricultural techniques, enabling food production with substantially reduced environmental footprint (Bringezu, 2019; Horion et al., 2016). However, vegetable fruit harvesting and plant protection spraying treatments are still mainly manual with high labor costs and labor intensity (Villa-Henriksen et al., 2021). Thus, automated and intelligent harvesting and spaying of greenhouse cultivations, using robots is receiving increasing attention (e.g., Kounalakis et al., 2021). Even though several scientific reports evaluate the production efficiency of the recently introduced agri-robots integrated in existing cropping systems, their environmental impact in comparison to conventional hydroponic cultivation is still not addressed (Pons et al., 2015). Here we assess and compare the environmental footprint of automated agri-robot as part of the general assessment of hydroponic cultivation of tomato process (RTM) and that of the existing soilless tomato cultivation model (CTM), using Life Cycle Assessment (LCA). Consequently, a total of 18 environmental impact categories were examined separately, namely, (i) fine particulate matter formation, (ii) fossil recourse scarcity, (iii) freshwater eutrophication, (iv) fresh water ecotoxicity, (v) global warming, (vi) human carginogenic toxicity, (vii) human non-carcinogenic toxicity, (viii) ionizing radiation, (ix) land use, (x) marine ecotoxicity, (xi) mineral recourse scarcity, (xii) ozone formation - human health, (xiii) ozone formation – terrestrial ecosystems, (xiv) stratospheric ozone depletion, (xv) terrestrial acidification, (xvi) terrestrial ecotoxicity, and (xvii) water consumption. Information on CTM and RTM LCA variables were documented during the SOilless culture UPgrade (SOUP) Project which designed, developed, and tested a multi-functional greenhouse robot for hydroponic tomato cultivation. The assessment was conducted in Open-LCA. LCA results, indicate that CTM emits 685.20 kg CO_2 eq per 1 ton of produced tomato, whereas RTM emits 537.97 kg CO_2 eq per 1 ton of produced tomato, i.e. 21% less. Approximately 75% of this impact is mainly due to the energy subsystem attributable to the emission of greenhouse gases for electricity production. Concomitantly, the CO_2 eq difference, between the two evaluated production systems, is 147.23 kg CO_2 per year. It is indicative that a car in Greece emits approximately 1.157,34 kg CO_2/year. Interpreting the results becomes evident that the reduction in CO_2 emission of a 1 ha SOUP production system equals to 3 cars annual CO_2 emission (3,535.44 CO_2/year) in Greece. Additionally, tomato production in RTM have 19.5% reduced non-carcinogenic human toxicity compared to CTM cultivation model. At the same time, the

reduction of fertilizers and pesticides impact by 30% and 20%, respectively, demonstrate the significant contribution of RTM technology to the workforce health and safety during the cultivation practices. These results highlight the importance of RTM technology for reducing environmental impact of greenhouse tomato production and, at the same time, improve yield and quality characteristics of the end product.

Keywords: LCA, robotics, greenhouse, tomato, hydroponic

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POL: Policy perspective in all aspects of the farm to fork value chain

Food waste is now mentioned in all major international policy frameworks: it is part of the Sustainable Development Goals and the new Farm to Fork Strategy within the European Green Deal. As food waste policies become more widely accepted, there is increased interest in policy tools to further the growth of waste diversion. Not all regions adopting such policies have the same characteristics and therefore, the degree of success differs. Our speakers today are among the innovators and early adopters of food waste policy. But innovators and early adopters often make mistakes, so identifying the strategies used to expand early adoption and avoid pitfalls is crucial.

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Consumer perception about the adoption of genetically modified foods

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Abstract

Genetically modified organisms (GMO) have been adopted to improve the availability and nutritional features of some foods (Brookes and Xuan-Dinh, 2020). However, their acceptance has been subjected to the potential impacts on health and the environment (Yang et al., 2009). Therefore, this study aimed at estimating the perception of the consumer regarding the adoption of GMO-derived foods and their impact on health and the environment. The study was applied in an educational institution, employing senior university students as the target population. For the development of the study, a Likert-type questionnaire was structured, considering the validity and pertinence of this tool in perception studies. Analysis revealed that some interviewees has no knowledge on the advantages and disadvantages of the use of GMO-derived foods for human consumption; this could be related to the lack of information regarding the characteristics of this type of food (i.e., nutritional, vitamins). On the other part, it was found that the use of labels to identify this type of foods is fundamental. The interviewees expressed concern regarding the effects on health and the environment caused by the adoption of this type of alternatives. However, the study evidenced a lack of knowledge on the actual impact of GMOs on health and the environment, which confirms the need to develop information dissemination strategies that could provide accurate and sustained information to the consumer.

Keywords: Food security, perception, labeling

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PLW: Prevention of Food Loss and Waste: policy, methods and best practices

Prevention is at the cornerstone of sustainability. It is universally regarded as the best waste management option. The food waste reduction potential through prevention is huge - some reports speak about 70% - and it is spread throughout the value chain: the supermarkets, the hospitality sector, even our households. Prevention largely depends on consumer behavior; therefore, it is something dynamic – for this reason, the COVID-19 pandemic may also have had its impact on food waste production.

Case studies presented in the RETASTE 2022 Session on Food Loss and Waste Prevention span from across Europe, from Greece, Cyprus, Spain, Italy, Germany, the Netherlands, the UK, but also across the Atlantic from Canada.

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Tracking Post-Consumption of Restaurant Food and Leftovers: Innovative Digital Solution and Preliminary Outcomes from H2020 LOWINFOOD and REGUSTO

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Abstract

Reducing food loss and waste (FLW) is essential to create a more sustainable food system, which is why its halving has been included in the UN Sustainable Development Goals. A significant amount of FLW occurs at the household, retail levels, and food service, with the latter being the third-largest source of FW in Europe. This study, in accordance with the goal of Task 5.6 included in the H2020 LOWINFOOD project, aims at monitoring and quantifying the FW generated out-of-home and taken away from the restaurant using a Regusto bag. Using a QR code affixed to the bag given to consumers by the restaurants, it has been possible to track the FW deriving, whether it is a complete meal to be consumed at home (take-away) or meal leftovers brought home. This allowed us to understand the effectiveness of these tools for sustainable and optimal food management. The Regusto app and Regusto bag have been used to evaluate their potential to contribute to the FW problem in out-of-home consumption. In addition, two surveys were carried out for restaurants and customers respectively. Firstly, the questionnaire for restaurants aimed at examining whether the use of the Regusto innovation could contribute to changes in awareness, attitudes, and behaviours towards FW including its decrease and cost optimization. Secondly, the customer survey had the objective of tracking the unconsumed food through the Regusto bag. The results reveal that approximately 89.8% of users packed 400 to 500 grams of food in a Regusto bag. Moreover, the study found that the use of the Regusto bag innovation has proved to be positively helpful in terms of reducing FW. Indeed, over 73% of customers leaving the restaurant with a Regusto bag reported that all food packed in the bag was finished. However, the preliminary results suggest that the efficiency in the consumption of the food taken away depends on a person's dining scenario, demographic, and socioeconomic factors.

Keywords: Food waste, Digital innovation, Doggy bag

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Best Practices in Food Waste Prevention Sector Implemented in EU

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Abstract

According to Article 4 of the Waste Framework Directive (WFD; Directive 2008/98/EC on waste and repealing certain Directives), waste prevention has the highest priority in waste hierarchy, so tackling foodwaste is a main goal in the context of circular economy and Sustainable Development.
The aim of this work was to collect and assess the existing foodwaste prevention programs and initiatives at European level. A classification system was put in place to categorize the actions reported, based on the stages of the food supply chain that the waste is originated from, while in parallel, the programs were also grouped in five classes according to their goal and the means to achieve each of them. As for the evaluation process of sub-actions, the following key performance indicators were adopted, based on the recommendations of the European Platform on Food Losses and Food Waste: Quality; Effectiveness; Efficiency; Sustainability; Transferability and scalability and Interpectoral cooperation. Although 209 actions were listed in Europe, the main barrier that was evident is that there exists lack of means of their assessment. Just 12 have been thoroughly evaluated. Some programs could not be assessed due to a lack of data, as the projects reported are still ongoing. Another case scenario is that the information reported described a research project, which for example could show the potential of a change in the production of animal feed that has not yet been put in practice by the industry. Conclusively, this analysis revealed important information gaps that hinder the systematic impact assessment of food waste prevention interventions. A key outcome is that future programs should be designed and implemented ensuring the provision of the data required for their evaluation. Several success stories were identified from which a few were considered as potential replication studies for other countries. In this context, this holistic approach may lead to engrossing outcomes that can lead to a more efficient planning methodology.

Keywords: Cyprus, food supply chain, foodwaste prevention, Municipal Waste Management Strategy

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Avocado Shelf-life Extension Using Edible Active Coatings Containing 4-hexylresorcinol and Sodium Metabisulphite

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Abstract

Food waste is a serious environmental and economic challenge worldwide. A total of 2.2 billion t of municipal solid waste per year is expected by 2025. Food packaging is vital in protecting food products from damage and deterioration and helps retain the quality and extend shelf-life. Non-biodegradable packaging has been shown to have serious environmental drawbacks. The current study aimed at developing a new active packaging with antioxidant potential to extend the shelf life of *Hass* avocados, a short shelf-life fresh produce that poses problems in the food supply chain, including economic losses due to food waste. 4-hexylresorcinol (4-HR, 250 and 500 mg/L) and sodium metabisulphite (SMBS, 1250 and 2500 mg/L), dissolved in water (labelled as additive-only samples) or in sodium alginate film solution (10 g/L) (alginate-coated samples) were used as a coating for ready-to-eat avocados procured from a local supplier in Lincolnshire, UK. The avocados were stored for 10 days at 25 ± 1 °C and 60% RH and sampled after 1, 5 and 10 days of storage for weight loss determination, total soluble solids (TSS) content, pH, firmness and bioyield point (BYP), internal and external colour and appearance, lipid oxidation, chlorophyll content and microbial load. Samples coated with alginate lost less weight and soluble solids. While firmness remained similar for all samples from day 1 to 10, regardless of the coating used, the bioyield point (BYP) was retained in additive-only samples. Samples coated with alginate antioxidant packaging had a better internal and external appearance and colour stability than additive-only samples. The results showed that the samples treated with alginate coatings were less prone to oxidation when compared to untreated control samples. In addition, alginate antioxidant coatings had some effect on delayed chlorophyll degradation and a slight reduction in mould and yeast counts. Alginate-based antioxidant coatings can be a promising sustainable alternative for maintaining avocado quality during storage.

Keywords: Avocado, Alginate, Edible packaging, Shelf-life, Antioxidant

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Building a Sustainable Seafood Sector Through Collaboration: Insight from a Dialogue Between Stakeholders of the Scottish Value Chain

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Abstract

Among the food waste drivers identified by the FUSIONS project (Canali et al., 2014), those related to 'social dynamics' are particularly difficult to address. Indeed, they pertain to interactions between stakeholders with potentially contrasting objectives, primarily financial and ecological sustainability, which may result in suboptimal resource use or externalisation of waste. Addressing these drivers requires mutual understanding and long-lasting collaboration, and is especially relevant for highly perishable products. Thus, within an EU-level project, we develop a social innovation consisting in a whole supply chain dialogue, and apply it to the case of fishing in Scotland, a country where this sector plays a key socio-economic role and the legislation is undergoing rapid evolution following Brexit. We hypothesise that suboptimal coordination results in resource loss, and more efficient allocation can be achieved by promoting discussions among industry stakeholders and between them and researchers, innovators and policymakers. This is demonstrated by sectorial clusters like the Icelandic Ocean Cluster, where fishing companies and innovators are working to achieve 100% use of the catch. In this paper, we illustrate the rationale of our innovation, the challenges of implementation, and some preliminary results and recommendations. Our dialogue has four goals: develop an in-depth overview of waste hotspots; identify gaps and opportunities with existing policy and innovations addressing waste; promote awareness of innovative solutions with a potential to reduce waste; and favour adoption by creating new relationships or strengthening existing ones. To achieve these goals, we have been contacting industry stakeholders via their associations and using a range of methods (emails, phone calls, letters, in-person visits) followed by snowballing. We offer them the opportunity to build new connections for exchanging ideas as well as fish products and by-products. We gathered data through interviews and surveys and organised networking events. A detailed protocol has been elaborated and refined along the process. Involving stakeholders proved challenging, raising the issues of trust between industry and researchers, and whether the latter have enough to offer in terms of connections and financial or reputational gains. Nevertheless, we managed to build some mutual understanding, involving more than twenty stakeholders dealing with fish for human and non-human consumption: fishermen's and processors' associations, primary and secondary processors, retail companies, by-products users, policymakers, and research and innovation institutions. We found that due to the high value of seafood products, the supply chain is efficient in allocating them to the most profitable and sustainable use along the waste pyramid, 'waste' being barely mentioned. Nevertheless, some mismatches between

stakeholders' economic and environmental objectives remain, and waste quantification is poor. Issues such as the offshore disposal of unwanted catch remain difficult to discuss and assess. Furthermore, fragmentation and spatial dispersal of companies make the transportation of by-products towards potential users unprofitable in many instances, even more when these innovative users are located overseas. Successful cooperation requires to build trust between industry and researchers, and to avoid blaming small actors for their allegedly unsustainable practices, which are often the only choice to preserve economic viability given the current power asymmetries.

Keywords: food loss and waste, social innovation, fish, supply chain, EU project

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Scoping Key Opportunities for Systemic Food Waste Prevention in Collaboration with System Stakeholders – an Applied Methodology

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Abstract

Globally, around 14% of the world's food continues to be lost after harvest (FAO, 2019), whilst a further 17% of our food ends up being wasted in retail, food service and particularly in households (UNEP, 2021). This makes reduction of food waste and losses a crucial sustainability challenge. Food waste can be understood as a symptom of an unsustainable food system. In addition to symptom control, e.g. reducing or reusing food waste streams, interventions to reduce or prevent food waste should also be directed towards the underlying system structures, behaviours and the paradigm that make food waste happen again and again. This means a systems approach is needed. Several types of systems approaches and frameworks can be found in literature, both general (e.g. Bagherzadeh, 2019) or used in national cases (e.g. Muth et al, 2019). In this project, an 'iceberg model' was used as framework for a systems approach. This iceberg model is based on the leverage points theory of Meadows (2008) and Maani&Cavana (2007). It has 4 layers: symptoms (the tip of the iceberg) with underlying system behavior, structures and the mental model or paradigm that shapes the system. In the project "Reduction of Food Waste in the Dutch food industry", the potential of this framework to identify leverage points to reduce food waste and losses was explored in a number of fresh food supply chains in the Netherlands, including dairy, meat and fresh produce. Through a participatory approach, entire food chains were mapped in a simplified version of 4 chain segments: (1) primary production- e.g. the farm, (2) secondary food production- e.g. the milk factory, (3) retail and (4) food service. In this project food waste at the consumer/household level was excluded. With this work we present the necessary steps in scoping opportunities for systemic change. Methods used are qualitative interviews, participatory creation of iceberg models, validation in cocreation sessions, finding solutions through future backcasting, iteration of iceberg models and engaging stakeholders. Across multiple food chains (dairy, meat, fresh produce) the most important food waste leverage points (so called food waste hotspots) within the 4 chain segments were defined and iceberg models were created. During the cocreation sessions, several potential interventions were discussed such as valuing wasted food products during the innovation process for future human consumption instead of going to feed. Central outcome of this work are the steps required in order to scope key opportunities for systemic

food waste prevention in collaboration with stakeholders. In the oral presentation we will present the most important food waste hotspots in each food chain.

Keywords: food systems approach, food waste hotspots, food chain, leverage points, future backcasting

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Analyzing the Use of Accounting Methodologies for Assessing Sustainability in Food Waste Prevention and Reduction Actions from ToNoWaste HEurope Project Approach

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Abstract

The identification, validation, and demonstration of innovative and effective ways to reduce food losses and waste is a key issue for a sustainable development. JRC workshop '*Food waste accounting: methodologies, challenges, and opportunities*', concluded that "*a harmonized methodology for food waste accounting is not yet defined and there is the need of improving and matching methodological aspects and policy questions as the information needs are different depending on the area of policy intervention*" (Corrado et al., 2019). Consequently, it is necessary to advance in the development of sustainability food loss and waste prevention and reduction (FLWPR) accounting methodologies that integrate economic, social, and environmental issues which overcome current limitations. In this context, the goal of this paper is twofold. First, to analyze the current strengths and weaknesses of existing accounting methodologies for assessing sustainability in FLWPR actions to define an integrative sustainability assessment methodology. For this, a systematic mapping study of European Research Projects is conducted with the aim of identifying and analyzing the recent research projects developed in Europe focused on FLWPR to take them as a solid foundation for the future research on this area. Specifically, this study adapts the research method proposed by García-Holgado et al. (2019) for mapping studies and choses as sources to conduct this research two main databases: CORDIS and BBI JU. Moreover, the study covers European research projects from 2013 to 2023. To define this searching period, the previous FUSIONS H2020 Project was taken as a reference of the analysis of FLWPR accounting methodologies. Finally, a total of 21 projects were considered in the analysis process. Based on the proposal of Bocken et al. (2014), a previous classification of projects was estimated needed to make a proper analysis considering the specific particularities of each kind of project. This classification was made attending to the nature of the solutions to the problem of food losses and waste proposed by each project. The categories considered are solutions based on technological aspects, social aspects, and organizational aspects. Second goal is to test the assessment proposal by assessing some aspects related to the sustainability of a specific FLWPR action, with the objective of showing how this method could help to overcome the current limitations of existing accounting methodologies. In this line, the testing process of this study will be mainly focused on the technological based solutions.

Keywords: food loss, food waste, accounting methodologies, sustainability

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A Review of Food Waste Within the Food Service and Hospitality Sector: Mapping the Causes, Effects and Technological Opportunities for a Sustainable Future

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Abstract

Food production is a resource intensive process accompanied by a wide range of environmental impacts. To add insult to injury, almost one third of the food produced for human consumption is wasted on a worldwide scale, amounting to a total of 1.3 billion tonnes per year, rendering all of the resources utilized for producing, processing, transporting and packaging that food also wasted. Not only does this waste further deteriorate environmental impacts, but it also raises social and humanitarian concerns by increasing food insecurity. In 2019, the food service and hospitality sector was found responsible for nearly 26% of the total food waste and despite its wasteful character being politically acknowledged, this topic still remains quite understudied in the academic field. In this paper, a review is carried out to shed light on this aspect of food waste. Through the mapping of the causes, effects and technological opportunities emerging from academic papers published from 2002 to 2022, this paper aims to contribute to the understanding of the true magnitude of the issue by policy makers, practitioners, academics and consumers, and the identification of significant research gaps. After reporting descriptive statistics, a content analysis of the papers evaluated ensued, revealing several valuable insights. The review divulged that a number of programmes have been developed around the world to mitigate food waste in such operations through the provision of proactive strategies, consumer awareness, redistribution of excess food as well as recycling and composting. These programs are designed to create a "chain reaction" to encourage the industry to minimize food waste and subsequent environmental impacts, while increasing revenue and customer satisfaction. However, although the interest in the adoption of food waste management practices by food service and hospitality businesses has grown exceptionally, there is still no standardised methodology on how to assess the volume and characterise the content of food waste resulting from the operation of the food service and hospitality sector. Several state-of-the art technologies have started to be applied for such purposes, including artificial intelligence, machine learning, Internet of Things (IoT) and smart sensors as well as blockchain. However, even though there is evidence of successful mitigation, as evidenced by efforts made by food service and hospitality businesses on a global scale, there is no comprehensive list of good operational practices that could be universally adopted and used in a single management framework.

Keywords: food waste, food service and hospitality sector, food security, blockchain, Internet of Things

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Applying "Design Thinking" to address Food Waste in University Campus

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Abstract

Food waste is a persistent wicked problem in the global agenda linked to both ethical and environmental issues. Around one-third of all food produced globally is lost or wasted across the food system [1], from farm to fork, much of which is avoidable. This poses an ethical and moral dilemma as, in one hand, access to nutritious and quality food is not widely available for many vulnerable groups [2]. On the other hand, food waste is not only related to the food per se, but it also includes all embedded resources required to produce it (water, land-use, human labor, etc.) which are usually forgotten [3]. Promoting sustainable and responsible consumption is key for higher education institutions as these incentivize better practices among future professionals [4] who will further their impact outside of the academic scope. Moreover, higher education institutions and their canteens are directly concerned with food waste issues as these educational centers (and public administrations) must set an example of good practices in the matter. Under these considerations, the Industrial Engineering School (ETSII), one of the sixteen Engineering Schools at Universidad Politécnica de Madrid (UPM) in Spain, and in collaboration with the European Engineering Learning Innovation and Science Alliance (EELISA), under the umbrella of the EELISA community Circular and Regenerative Campus (CRC) has proposed a Food Waste Challenge (FWC) aiming to generate ideas to reduce food waste in the canteens. This challenge is bravely undertaken by first year engineering students in groups of 3 to 4 students, during a period of a semester and, as part of a class under a supervision of two main instructors. The FWC follows ”Design Thinking” methodology which consists of generating innovative solutions considering the needs of the users. The students must perform a set of steps to understand the problem (discovering and definition), ideate different technical solutions and receiving the feedback of their classmates and instructors to choose one of them, use a hands-on approach to design a prototype, iterate after reviewing the feasibility with the instructors, and present their final proposed solutions. The students have total freedom deciding which part of the problem, and how, they intend to tackle. This means, that two groups could decide to review the same problem (e.g., unconsumed bread) from completely different points of view and develop different technical solutions (e.g., composting & animal feed). The results show that students become more aware of the issue when they experience it first hand and become more engaged in identifying and proposing possible technical solutions. These solutions cover a wide scope, ranging from availability of take-away packaging (reusable), providing different sizes and prices for the different food, downcycling cardboard plates to use it as recycled paper for different projects, to complex systems which use solar panels to heat ovens to create “healthy snacks” with vegetables. The FWC has taken place at UPM and EELISA

community for the last two years, increasing its impact from 50 students working in seven canteens during the first round, to 50 students working in nine canteens from different engineering schools during the second round.

Keywords: regenerative economy, zero waste, higher education institutions

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The Interplay Between Restaurant Food Waste Decisions, Context, and Externalities: Results from a Systematic Mapping Review

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Abstract

Food waste in the food service industry is an area of interest in research and policy, especially as it is estimated that this sector is responsible for 12% of global food waste (Tostivint et al., 2016). The regulatory frameworks to reduce and mitigate food waste are contextually and geographically variable (Dhir et al., 2020) and the extant body of literature is emerging (Munir, 2022). Current research suggests a wide scope of exogenous and endogenous factors are linked to food waste including: managerial decisions (processes and practices of surplus handling), local policy, competition, revenues, and procurement (Dhir et al., 2020; Martin-Rios et al., 2018; Papargyropoulou et al., 2016). Furthermore, research suggests a correlation between manager attitudes, behaviours, experience, and their mitigatory actions (De Visser-Amundson, 2020; Filimonau et al., 2018; Martin-Rios et al., 2018; Principato et al., 2018; Souza Monteiro et al., 2020). Previous reviews, namely Dhir et al. (2020), Munir (2022), and Filimonau and De Coteau (2019), have offered contextual insights into the magnitude of research gaps, but this systematic mapping review (following the guidelines of Petersen, Vakkalanka and Kuzniarz (2015)) presented an exploratory approach to contextualising food waste within, specifically, the restaurant setting. This was achieved by comparing and interrelating the internal and external factors that hold prominence in restaurant food waste. Variables related to geography and PESTLE (a framework to categorise externalities relating to Political, Economic, Social, Technological, Legal, and Environmental factors), and SWOT (a framework to identify internal factors of Strengths and Weaknesses and external factors of Opportunities and Threats) were explored. These were also combined with restaurant characteristics, food waste practices, and methodological research approaches to provide an overall picture of the state of the art of food waste management in restaurants in Europe, North America, Australia, and New Zealand. Findings suggested that exploring the concept of restaurant food waste at different scales (e.g.: restaurant-level, local, regional, or national) presented the clearest path to identifying systemic opportunities, gaps, or contradictions. This led to the main conclusion that context matters, highlighting that both opportunities and threats relating to the various components of the PESTLE were intricately linked at different scales, but were also inherently different, complementary, conflicting, or contradictory. For example, policy opportunities at a local level to encourage correct food waste disposal in restaurants could be hindered by a lack of national support, funding, and infrastructure, which could render local initiatives challenged or even redundant. Furthermore, the findings appeared to indicate that defining and situating the restaurant as an operational entity within the context of its operational activities could provide some insight into their chosen food waste activities.

It was concluded that internalities such as restaurant characteristics (service type, restaurant type, price point, etc.), and other externalities (such as locality, competition, local infrastructure, etc.) might also contribute to processes and practices adopted in a restaurant. As such, this review presents evidence that could contribute to the design and implementation of inclusive and effective policies whereby the complexities of context, the external environment, and internal operation are considered.

Keywords: restaurant, context, food waste, externalities

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Economic and Environmental Sustainability Assessment of Recycling Versus Upcycling Surplus Bread

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Abstract

Effectively managing surplus bread is essential due to the considerable environmental and economic burden associated with disposing of excess bakery products. Inadequate bread waste management contributes to increased waste production and inefficient use of resources. However, the implementation of upcycling methods offers a valuable solution by transforming surplus bread into valuable products. This approach not only mitigates the adverse environmental impacts of bread waste but also fosters a more sustainable and circular economy. By adopting efficient upcycling techniques, the challenges associated with bread waste management can be addressed, resulting in enhanced resource utilization, reduced waste generation, and potential economic advantages. While upcycling is generally considered beneficial for reducing waste and promoting resource efficiency, it is essential to conduct combined environmental sustainability and economic viability assessments to ensure environmental sustainable economic investment implying that potential unintended consequences or negative impacts are not overlooked. This evaluation is invaluable for decision-making, enabling the identification of areas for improvement and the implementation of strategies to maximize the sustainability of upcycling practices. Life cycle assessment (LCA) is an environmental analysis tool that provides a comprehensive framework for evaluating the environmental impacts associated with the entire life cycle of upcycling methods. This study aims to examine the environmental impacts of upcycling surplus bread in Slovakia. The system boundary is defined from the inclusion of bread waste in the production process to the final production of BetaFerm. The functional unit for this research is set as the treatment of one ton of surplus bread. In the next step, all energy, emissions, and materials are calculated and recorded to complete the life cycle inventory. Then, environmental characterization is performed using the ReCiPe2016 hierarchy as midpoint levels. The results are interpreted, and short-term and long-term solutions are discussed. Ultimately, it can be concluded that the integration of environmental assessment, particularly LCA, in bread waste management facilitates the development of more sustainable practices and supports the transition towards a circular economy.

Keywords: BetaFerm, Bread waste, Life cycle assessment, ReCiPe2016, Upcycling

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A pathway to sustainable policy: Unraveling the interplay of socio-cultural factors, local contexts, and institutional dynamics in food waste reduction

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Abstract

In the pursuit of understanding and addressing the pressing issue of food waste (FW), it is essential to recognize that its generation is not merely a consequence of inaction but is significantly influenced by behavioral and cultural factors (Yetkin Özbük & Coşkun, 2020). Policymakers have been striving to combat this phenomenon through legislative measures and targets (European Parliament & Council of the European Union, 2023). However, they have encountered challenges rooted in behavioral marginalization and cultural exclusion (Phasha et al., 2020). To navigate these complexities and foster effective change, a framework guided by historical institutionalism is proposed, which sheds light on how policies are created and altered. This approach acknowledges that public policy plays a pivotal role in the continuous advancement of society, functioning not just as a set of rules but as a means of learning and education. Examining the sociocultural aspects of FW generation, we find that agro-dietary habits, behavioral marginalization, and cultural exclusion, in addition to conceptual and terminological diversity, contribute to the problem (Vardopoulos et al., 2022). Cultures around the world exhibit unique practices that can either mitigate or exacerbate FW. In Brazil, the "comida por quilo" culture in restaurants allows customers to choose and serve themselves as much as they desire, leading to potential overordering and waste (de Oliveira Pontes et al., 2022). In China, over-ordering is perceived as a gesture of hospitality or a demonstration of one's ability to provide for their family (Wang et al., 2022). The African culture of 'Ubuntu', embraces extravagance in food as an expression of love and acceptance (Phasha et al., 2020). Religious beliefs also influence FW generation; for instance, Judaism promotes the concept of 'Bal Tashchit,' prohibiting wasteful destruction, and the Muslim Quran urges against wasteful excess (Minton et al., 2020). Additionally, state-funded school meals in countries like Sweden, Finland, and Estonia have institutionalized a social culture around food. Known as 'pedagogic meals,' these programs promote balanced, nutrient-rich diets, home economics, and resource management, thereby attempting to reduce FW (Silvennoinen et al., 2015). However, such welfare state models are distinct from liberal welfare regimes found in countries like the USA and Australia, where convenience and pre-cooked food are widely endorsed. Beyond cultural practices, the intricacies of food preparation techniques also contribute to FW. High-end culinary traditions, often involve complex and refined cooking methods, resulting

in a higher percentage of FW, particularly with exotic fruits that have substantial inedible components. Likewise, the desire to take restaurant leftovers home is influenced by cultural and social norms, as well as environmental awareness. These diverse examples underscore the complexity of reducing FW through policy measures that desperately need to account for the context-specific nature of FW (Abeliotis & Lasaridi, 2022). Historical institutionalism and rational choice institutionalism provide a logical framework for comprehending policy change. The evolution of institutionalism in social science led to a shift from focusing on formal structures to considering how people and behaviors shape policies (Doukas et al., 2023). This emphasizes the importance of historical and local context in policy decision-making, laying the foundation for historical institutionalism (Doukas & Petides, 2021). Key to this understanding is the concept of path dependency, where established institutions tend to persist, making policy changes difficult and costly (Andreou, 2018). Critical junctures are pivotal moments with significant impact on institutional trajectories, shaped by the institutional environment and political behavior. Recognizing their transformative potential is essential for crafting effective FW reduction policies (Capoccia, 2015). Thereafter, to achieve sustainable FW reduction, the policy architecture should be flexible and rational. Encouraging collaboration with compatible policies and allowing adaptability to diverse circumstances and objectives is also essential. Embracing institutional resilience can enhance the policy's effectiveness in the face of unexpected challenges. This research serves as a call to action, urging policymakers, researchers, and stakeholders to come together in a collaborative effort to combat FW and pave the way for a more food-secure and environmentally sustainable future.

Keywords: policy-making, stakeholder engagement, waste prevention, food waste, circular economy, sustainability, SDG 12.3

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On the use of herbs and herb extracts for minimizing food loss in plant protein instant meals

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MadeEasy SCE

Abstract

The growing world population demands increased high-quality protein-rich food sources. According to the EU protein strategy, investing on plant-based proteins' is an environmentally sustainable means to improve EU's food security (including physical availability, accessibility, nutrient intake, and stability over time). To exploit the advantages of plant protein sources and enhance their benefits for society, it is necessary to create attractive meals that are adapted to the modern lifestyle and at the same time enhance the shelf life of the meals with minimal use of chemical preservatives. In the last years we have explored the design and manufacturing of a plant-based protein instant meal based on pulses, in particular fava beans. The meal is shaped as a de-hydrated powder to the extent that micro-organisms such as mould, yeast and bacteria cannot grow, in order to enhance shelf life. Interestingly, much of the nutritional benefits of the original natural food, such as protein content, are not destroyed by drying and are retained for many months when the meal is stored. To further extent the shelf-life of the pulse puree meals we examined the effect of adding dried oregano and dried oregano extract in the puree powder. In both cases the use of oregano is shown to enhance the control of microbial growth and additionally improve the flavour of the meal. Accordingly, the present study confirms the results of previous works such as Sikora et al. (2021), reporting that the integration of herbs and herb extracts into foods may act as a natural preservative. Following our results, the use of herbs and herb extracts into the food supply chain offers a natural way to leverage better food stock management and significantly reduce food losses, particularly for plant-based instant meals.

Keywords: Food Drying, Natural Preservatives, Plant protein meal,

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FWM: Measurement of Food Loss and Waste

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Lost Vegetables, Lost Value: Assessment of Carrots Harvest and Post-harvest Losses in a Large Italian Producer Organisation

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Abstract

Food loss (FL) quantification is still an open issue in the harvest and post-harvest phase. There is a lack of data from direct quantification on field, with few primary data available (Fernandez-Zamudio et al., 2020; Corrado et al., 2019; Corrado et al., 2018; Caldeira et al., 2019). There is evidence that the fruits & vegetables sector is particularly affected by FL, due to many reasons, such us agronomic practices, diseases, deteriorations, storage, humans' mistakes or defects (Ishangulyyev et al, 2019, Gustavsson, 2011). The aim of this research is to assess through an on-site direct measurement the quantity of the carrots FL in the harvest and post-harvest stages of the supply chain. The quantity of FL is assessed over two productive seasons (2022 and 2023) in terms of mass and percentage of product that has been downgraded due to non-compliance with private quality standards imposed by retailers, and therefore directed on alternative – less profitable - marketing channels. The quantification of carrots FL takes place in a large Italian Producer Organization (PO), for which carrots are the core business. Batches from different fields are considered as unit of measure, and the losses are measured from the field until the end of the processing at the warehouse. The quantification methodology consists of two steps. The first step is the quantification in the field, to assess the mass of non-harvested carrots due to their size or shape, mechanical damages during the harvest. The second step is held in the PO warehouse, to detect the FL during the selection and cleaning of carrots, before they are packed and delivered to the buyer. FL is quantified in mass and % of quantity that is sold for fresh market, food industry and that is lost. Data on the value of the product going to different marketing channels is also collected in order to assess the economic loss due to FL and downgrading of products. During the season 2022, the total quantity of carrots produced is 24,152 t, out of which 76% is sold for fresh market at an average price of 0.52 €/kg, 15% is sold to food industry (0.26€/kg) and 9% is lost. In total, 3,623 t of carrots are sold to the industry, among which 2,899 t are already foreseen, while 724 t are downgraded to this channel due to non-compliance with the cosmetic standards required by retailers for selling fresh carrots. This corresponds to an economic loss of 188,266 € over one season. This situation is confirmed in the season 2023, with a more detailed assessment of the reasons of non-compliance. Although this is a first quantification for the Italian market of carrots, the results suggest that private quality standards – especially on cosmetic features of carrots – create a bottleneck at the harvest and post-harvest phase of the supply chain. As a result, huge quantities of carrots are lost, and farmers have to bear the related economic loss.

Keywords: food loss, food waste, post-harvest, fruit and vegetable value chain, direct measurement

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Increasing Sustainability in the German Bakery Trade: Reducing Bakery Returns and Improving Sales Performance by Using Forecasting Order Optimization Software

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Abstract

In Germany, the bakery trade comprises 9,607 businesses with total sales of 16.27 billion Euros (Zentralverband des Deutschen Bäckerhandwerks e.V., 2023). Bread and bakery goods are the second most frequently consumed foodstuff in Germany (Statista, 2023a). In total, 4.7 million tonnes of bakery goods are produced annually in Germany, of which 1.7 million tonnes are wasted. The return of unsold bakery products accounts for 36% of the total waste amount, being the second largest cause after households (49%) (Schmidt et al., 2019). Hence, at the value chain intersection between production and sale of bakery products lies a great potential for the reduction of bakery returns and its associated resources.

Reducing bakery returns is not only reasonable from an ecological and ethical point of view. Additionally economic benefits can be achieved, which is especially interesting for bakeries as production cost have strongly increased, e.g grain prices increased by 54,7% worldwide in the past year (2022) compared to the index baseline of 2014-2016 (Statista, 2023b). Forecasting order optimization software (FOOS) in the bakery trade sector helps to prognose future sales of individual bakery products within each single bakery store. The prediction is based on historical and ongoing data from the ERP system and also considers other influencing factors, e.g. weather and public holidays. Based on the predicted sales data for each bakery store, the quantities ordered from the central production site can be optimised. The objective of such software is to avoid sell-outs, to serve the customers the products they ask for and simultaneously reduce the quantities of returned bakery products, which are otherwise left unsold at closing time. The software-driven approach helps to digitalise the bakery trade, mitigates bakery returns and provides valuable field data, accelerating food waste quantification as part of international and national sustainability targets such as SDG 12.3.

This field study has three objectives: Firstly, to extend the current knowledge about the amount of bakery returns in Germany. Secondly, to analyse the potential influence of a FOOS on food waste reduction; this quantitative data on the bakery returns is obtained before and after using the FOOS in three participating bakeries with a total of 33 bakery stores. Product categories such as bread and rolls, snacks, pastries and cakes are considered. Thirdly, to reveal chances and barriers regarding the implementation and usage of FOOS in the bakery trade. The latter qualitative data is obtained by a focus group interview with the management of the respective bakeries.

At the time the abstract was prepared, the results to be presented at the Retaste conference

2023 were still being analysed. The results will comprise the absolute (in kg/year) and the relative (in %) returned quantities before and after the usage of the FOOS for each given bakery product category and in total for the respective bakeries. In addition, the monetary effect for the bakeries is also determined.

Keywords: Food waste, bakery returns, digitalization, intelligent software, forecasting tools, bakery trade, return rate, food waste reduction potential

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Food loss and food waste in hotel sector: Insights from empirical data and strategies for reduction

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Abstract

Food waste is a multidimensional problem and reducing it is the means to achieve other goals, such as improving food security for all, reducing greenhouse gas emissions, reducing the overexploitation of natural resources and increasing production and economic development at the global level and at the country level. (Ocicka and Raźniewska, 2018) The purpose of this specific study is to develop and test a methodology for the qualitative and quantitative analysis of food loss and waste in the context of the circular economy in the hotel sector. The study is based on the investigation and mapping of the food waste generation system with an analysis of the processes, composition and management thereof. Data were collected from three 5-star hotels. On-site measurements were combined with interviews and questionnaires to enable us to understand the hotel operation and the material flows without affecting the smooth operation of the hotel. The indicator that was chosen according to the bibliography (Afzal et al., 2022) to describe the current situation is "food waste per guest per day" and the values vary from 0.3 gr to 1.3 kg/person day. The need for a more specific indicator was noted. "Food waste per person" gives a clearer picture due to the fact that most five-star hotels have restaurants accessible to non-residents as well.Measuring the current situation of food waste will give a general overview of the food waste produced by the hotel as well as the activities that cause this production. In this way the processes with the greatest loss and opportunities for change can be identified.

Keywords: Food loss / food waste / hotel unit / circular economy / sustainable development

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FOLOU Project: Developing a new Methodological Framework for the Quantification of Food Loss in Primary Production in Europe

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Abstract

Food loss (FL) and waste are environmental and social challenges. Despite a consensus on the urgency of reducing their magnitude, there is still lack of definite numbers on the current situation. The European Commission has implemented reporting requirements for food waste. Yet, there is a lack of an official framework on how to estimate and report FL. Currently, there are no European reporting obligations for FL in primary production, and only a small percentage of countries internationally report FL to the FAO. Furthermore, the definition of FL varies widely in literature and working documents, making it challenging to compare studies. Establishing a common understanding of FL and developing a standardized measurement approach would increase the knowledge on the nature and magnitude of the problem, leading to more effective policy interventions. FOLOU EU-funded project (http://www.folou.eu/) aims to develop a comprehensive methodological framework, including a shared definition, for quantifying FL in primary production across Europe. A systematic review including grey literature was conducted in Scopus and Google Scholar. Additionally, records were included through snowballing. Once the review was completed, interviews were conducted with international stakeholders including academics, researchers on similar initiatives, producers, and public officials. The purpose of these interviews was to validate preliminary findings and gather further insights. The FOLOU project is currently on development and the framework will continuously be updated through the project, which extends December 31st, 2026, to ensure its usefulness for quantification. Out of the initial 754 records found, 117 publications were included in the review. The main topics covered in these publications incorporated quantification experiments, life-cycle assessments where FL was recorded, measurement guidelines, and literature reviews. Primary methods identified for FL quantification were surveys conducted with producers, direct weighing, and pre-existing data sources, predominantly administrative data. Surveys were the most used method, despite their tendency to underestimate FL value, as direct weighing poses logistical challenges in terms of cost. In some instances, a combination of surveys and direct weighing was employed. It is worth noting that FL was recognized as a heterogeneous problem, requiring specific methodologies for different food commodities. Administrative data seemed to be a useful tool, particularly for certain commodities like animal products and aquaculture. These initial conclusions were validated by experts. Additional insights were obtained, emphasizing the importance of developing a practical methodology guideline, including specific definitions for the different commodities, that complements existing efforts

and contributes to the construction of a comprehensive FL framework. A common FL definition is crucial to develop a useful quantification methodology. Our results build upon the existing efforts and seek to establish a European framework. If this framework were to be accepted, it would homogenise the collection of results, generating more robust FL estimators. While this project is still in development, it is crucial for the framework within the FOLOU project to adopt a practical approach. Furthermore, it should take into consideration the unique characteristics of different food commodities and production systems and incorporate existing efforts to ensure its usefulness and contribution to research on FL.

Keywords: food loss, food security, primary production, measurement methodology, waste reduction

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Disentangling the Roots of Food Losses in Primary Production

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Abstract

Primary production is often overlooked when it comes to addressing food losses (FL) and waste, despite accounting for a significant portion. Since FAO's 2011 1/3 of FL and waste was published (FAO, 2011), efforts to measure and understand FL in primary production lag behind those focused on food waste throughout the supply chain. Although precise targets and reporting obligations exist for food waste, FL is still considered complementary. To tackle this issue effectively, it is crucial to develop a profound understanding of the underlying causes that lead to FL. Gleaning, is a traditional activity of collecting surplus food after harvest. It now serves as a valuable tool for researching FL volumes and their causes, while simultaneously raising awareness and preventing FL. This study aims to address the issue of FL by conducting a comprehensive analysis of the causes within the fruit and vegetable sector in Catalonia, Spain. By utilizing gleaning, FL volumes were estimated and associated to their specific causes. A literature review and in-depth interviews with farmers and cooperatives were developed to gain a better understanding of the causes of FL and categorize them into different dimensions. Gleaning records provided valuable data for estimating FL volumes in terms of frequency, volume, and food commodities, as well as identifying their causes. Two panels of key actors were convened to validate the results. The causes were iteratively revised using the '3 whys' methodology, which aims to identify root causes and comprehend complex problems. Finally, a problem tree was created to summarize and structure the findings. Fieldwork data was analysed to estimate the relationship between 9 dimensions and their frequency and impact per food commodity. Nine main dimensions of FL causes were created by aggregating all the causes contributing to FL in the fruits and vegetables sector. These dimensions encompass various factors that include: aesthetic requirements of crops; low crop prices; lack of personnel; absence of buyers for harvested produce; inadequate in-farm infrastructures; absence of competitive processing plants; crops unsuitable for human consumption; insufficient out-farm public infrastructures, and failure to meet quality requirements for European Union commercialization. Through gleaning records (n=60), interactions among dimensions contributing to FL were observed, considering their combined effects. an interaction of the dimensions leading to FL adding their effects was observed. Additionally, it was found that the factors causing FL most frequently in the field did not necessarily correspond to those resulting in the highest quantities of FL. Additionally, distinct patterns and frequencies of causes were associated with different crop types (fruits, vegetables, and tubers/bulbs). This study confirmed that FL in the fruit and vegetable sector are a complex problem arising from the interaction of various causes, each contributing to FL with its own effects. It was

observed that the causes occurring more frequently do not necessarily correlate with higher volumes of FL. Finally, gleaning emerges as a promising initiative for understanding, analysing, and preventing FL in primary production.

Keywords: food loss, fruits and vegetables, primary production, food loss and waste prevention, gleaning

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Influence of Packaging Related Characteristics on Product loss - a Case Study in the Dairy Industry

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Abstract

Food loss is a significant global challenge that has far-reaching environmental, economic, and social implications. In recent years, the role of packaging design in mitigating food loss has gained increasing attention. Packaging design plays a crucial role in protecting food during transportation, extending its shelf life, and reducing spoilage. However, packaging can also be a source of food loss if not designed and implemented effectively. One way to determine food loss by packaging design is the factor of emptiability. Emptiability refers to the ease and efficiency with which a product or packaging can be emptied or completely depleted of its contents. It is a concept that considers the practical aspects of using and accessing the full quantity of a product without leaving a significant amount of residual material behind. The emptiability of a product or packaging is crucial for several reasons. First, it ensures that consumers can fully utilize the product they have purchased, maximizing their investment, and avoiding unnecessary waste. Secondly, efficient emptying contributes to reducing food waste and minimizing the environmental impact associated with the disposal of unused or leftover products. Lastly, from a user experience standpoint, products or packaging with high emptyability provide convenience and satisfaction to consumers, as they can easily access and utilize the entirety of the contents. Several factors influence the emptyability of product packaging. The design of the container plays a significant role, including factors such as shape, size, and materials. A well-designed container will facilitate the complete removal of its contents, allowing consumers to easily pour, squeeze, or otherwise extract the product without leaving significant residue. Additionally, features like opening size, appropriate closures, and ergonomic designs can enhance emptiability by enabling efficient pouring or dispensing. The characteristics of the product itself also impact emptiability. For example, the viscosity or flow properties of liquids, creams, or pastes influence how easily they can be emptied from their containers. Thick or sticky substances may require specialized packaging or dispensing mechanisms to ensure complete emptying. In the framework on a comprehensive sustainability assessment of dairy product packaging in the DACH region (Germany, Austria, Switzerland) food loss was used as an indicator for indirect environmental effects of food packaging. A methodology for emptiability was developed and applied to various product categories in the segments drinking milk (n=66) and yoghurt products (n=57). The methodology thereby imitates an eco-conscious consumer and is based on the intended handling of the packaging. The packaging systems include different sizes and shapes of beverage cartons, cans, pouches, jars, cups and bottles of various materials. For each type of packaging a specific method was developed, partially based on existing research by Meurer et al. (2017) and Wohner et al. (2019). The results show significant differences based on the packaging type

and design, consumer handling, as well as fat content. Food residues in cups in the category fruit yoghurt vary between 0,99 % and 1,91 %, with one exception, where one cup retained 32,00 % of total product content due to design aspects of the cup pared with a small packaging size. Residues of fruit yoghurt in a pouch were determined with 5,24 %. For buttermilk the amount of residues is up to four times higher, if no instructions to shake the product before opening are given to the consumer. These examples show high differences in food waste based on packaging design and handling and can be seen as a call for action towards product and packaging producers.

Keywords: food waste, food loss, packaging, packaging design, emptiability

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Mapping the Progression of Small-scale Mining into Croplands: a Satellite-driven Perspective

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Abstract

More than half of Ghana's land area is covered by agriculture. In the past decade, the proliferation of small-scale mining is progressively impacting the agriculture sector. The regions which serve as agro-ecological zones coincide with large deposits of mineral resources (Gilbert, 2022) driving an agriculture to mining transition and tree cover loss (Nyamekye et al., 2021). Soil mercury concentrations in intensive mining areas has increased, rendering land unfit for cropping and incapable of sustaining plant growth. Such impact also propagates the food-supply chain and evidence reveals the possibility of heavy metals in foodstuff. Despite the economic benefits of mining, small-scale mining (SSM) has reduced agriculture labour and overall agricultural productivity in mining communities Gilbert (2022) raising concerns for food availability and safety. The wisdespread nature of the activity calls for the use of geospatial technologies in mapping and monitoring efforts (Forkuor et al., 2020; Gallwey et al., 2020; Barenblitt et al., 2021) including the assessment of mining expansion after the government of Ghana temporarily banned the activity (Nyamekye et al., 2021). Geospatial technologies allow for a large-scale perspective of earth dynamics through the continuous availability of satellite images, facilitating rapid mapping compared to ground surveys. Although the use of these technologies is precedent in the mapping of mining sites, the focus is often on the spatio-temporal expansion of the menace and less on its impact on agricultural land. Harnessing the availability of open-access satellite imagery, we map the progression of mining sites over time and quantify its expansion into croplands to inform food-security decisions. For this study, satellite images over mining communities are collected for three periods: prior to the enforcement of SSM ban, during the ban period and the present year. As in (Gallwey et al., 2020), artificial intelligence techniques are employed to segment land use classes in selected mining communities. The concept of segmentation is to partition an image into segments based on spectral similarity allowing the reduction of isolated misclassified pixels often associated with pixel-based approaches (Nyamekye et al., 2021). However, (Gallwey et al., 2020) consolidates vegetation cover into one landuse category hindering the separation of croplands and the evaluation of the impact of SSM expansion on agriculture. Our work in progress overcomes this limitation, by distinguishing cropland area from general vegetation cover.

Keywords: food security, mining, remote sensing, machine learning

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Food Waste Reduction Using a Smart Scale Device in German Catering Facilities

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Abstract

German restaurants produce about 414.410 t of food waste per year, of which around 55% could be avoided (Schmidt et al., 2019). A reduction of food waste contributes to Sustainable Development Goal 12.3 which aims to halve food waste in the consumption stage until 2030 (United Nations, 2015). Furthermore, reducing food waste also lowers input cost: foodservice businesses may reduce their input by about 5% when using waste-tracking technology (Read and Muth, 2021). Using automated tools helps to collect continuous and detailed data (Eriksson et al., 2019). In this poster presentation, first results of the innovation Kitro which was tested in the Horizon 2020 project LOWINFOOD will be demonstrated. Kitro is a smart device consisting of a scale and camera which can be integrated into any kitchen waste bin. When installed, the device takes a picture automatically every time something is thrown into the bin. The weight is measured by the scale at the same time. The pictures are then analysed using artificial intelligence to identify the wasted food item. Both category and weight of the food waste can be viewed via an online dashboard. Here, guest numbers and input prices can be entered by kitchen management so that relative values, such as waste per guest, are calculated. Kitro staff helps interpret the data and suggest measures to reduce food waste fitted to the specific facility. The study has the goal of showing extensive food waste data originating from two different catering settings (business and hotel catering) in Germany. In the organisations under study baseline measurements over a period of four weeks were conducted without the use of the Kitro dashboard. Subsequently, the device was used over a period of 11 months. The data gained from this study will be analysed and presented at the RETASTE conference. In detail, the daily guest count and food waste in kg were recorded. Both guest count and food waste are further spliced into time of day. From this information, it can be analysed which meal of the day causes the most food waste, including differentiating between weekdays. Because the food waste was separated into food categories as well as the waste categories unedible plate waste, edible plate waste, overproduction, and preparation waste, it can be shown which category was the least and most influenced by the Kitro innovation. As this data was collected for three different settings, the differences will be presented. At the time of abstract submission, the described data is still being cleaned and evaluated.

Keywords: food waste, artificial intelligence, food service

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Reducing Food Waste on University Campuses

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Abstract

The problem of food waste has continuously gained relevance in the global agenda, claiming the attention of different stakeholders as policymakers, practitioners, academics, and the general public. Moreover, Targets 2.1 and 2.2 of the second goal of Sustainable Development Goals (SDG) aim to end hunger, achieve food security, and improve human nutrition [1]. It is estimated that around 3.1 billion people worldwide cannot afford healthy diets and suffer from malnutrition and hunger [2]. Moreover, around one-third of all food produced globally is lost or wasted across the entire food chain [3], from farm to fork, much of which is preventable. This food loss and waste (FLW) can be addressed through quantitative approaches (estimating and optimizing food flows existing in the supply chain) and qualitative approaches (understanding food attributes reduced over time and their connection to consumption patterns). Higher education institutions (HEI) face this latent issue in their canteens, where FLW is preventable [4]. This seems to contradict the intention of HEI on teaching and researching sustainability [5] and serving as an example of good practices [6] while not being able to tackle these issues behind closed doors by understanding behaviors and consumption patterns and creating intervention schemes to change them. To address these concerns, the Industrial Engineering School (ETSII) at Universidad Politécnica de Madrid (UPM) in Spain and the Food and Retail Operations Lab at Massachusetts Institute of Technology (MIT) in the USA have decided to cooperate through a Ph.D. research visit to propose ways to reduce the FLW in the canteens at both university campuses. Although previous research through undergraduate and master theses and projects have been performed at both universities to identify the FWL flows, it seems that definitive solutions have not yet been identified. Therefore, the primary purpose of this project is to understand waste generation and management at the end-user level, intending to identify hot spots and most common waste-related behaviors from the end-users point of view. The methodology to be carried on this project follows a Learning-based Research technique supported by field data collection through canteen visits (observational and experimental), followed by interviews with suppliers and students (quantitative and qualitative data collection), and culminating with final data analysis. This will allow both HEI to accurately understand and assess their food supply structure, take the necessary actions to properly address their FWL issue, and complement current initiatives at both institutions.

We identified waste drivers and modified consumption patterns by providing more information, vouchers and other incentives to students, faculty and staff members to change their waste-generation habits. Several strategies were created to ease decision-making processes for canteens and we found different archetypes of consumers more (or less) prone to support food recovery and food waste reduction.

Keywords: regenerative economy, zero waste, food supply chain, strategic intervention schemes

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Waste Prevention: The Case of The Municipality of Halandri

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Abstract

Food loss and waste accounts for approximately 24% of landfilled and combusted municipal solid waste in the US [1]. Food “loss” occurs before the food reaches the consumer, while f ood “waste” refers to food that is fit for consumption but consciously discarded at the retail or consumption phase [2]. The societal impact is great as 36.2 million people cannot afford a quality meal every second day. Regarding the environmental impact that is described as 8-10% of global greenhouse gas emissions induced by food decomposition in the landfills. The UN Sustainable development goal 12.3 has set as a target to halve per capita food waste at the retail and consumer level by 2030 [4, 5]. Saving food and preventing food waste production has been adopted recently as a strategic goal by the Municipality of Halandri, Athens, Attica. The wide number of food retailers and hospitality businesses located in Halandri discard significant quantities of food daily that the waste management services of are called to handle. Based on the findings of the EU Horizon Waste4Think project, that was implemented in Halandri in 2016-2020, the household food waste can be collected separately and subsequently utilized in a number of ways, thus lightening the burden of urban waste management. The product FORBI that was produced in Waste4Think has been successfully tested as an alternative fuel for cement producers and has been also used as a composting enhancer and for the production of bioCNG via anaerobic digestion. Since October 2022 three EU funded projects called FoodRUs, ToNoWaste and FodoFood Connections fuel the drive of the change regarding food waste in Halandri. A comprehensive survey to set the baseline has been launched and the first outcomes are obtained. All available methods to measure food waste have been employed. Citizens of the Municipality have participated with diaries and questionnaires by Households, retail shops and HoReCa alike (HORECA FW). Two compositional analyses were also conducted. Two public nurseries have participated by measuring their food waste on a monthly basis. All public nurseries of the municipalities

have also completed questionnaires. The results show 127 kg /year/ca HHFW (household food waste), 25% of which could have been avoided. The HORECA FW results show that 50% of food waste could have been avoided, the same for one of the two nurseries. It is concluded that a significant portion of the daily discarded edible food could have been avoided. Awareness raising and educational workshops may play a significant role towards the above-mentioned scope. Participating in monitoring of food waste has been proven to contribute to that scope. Locally focused actions where the separate collection of HHFW significantly fosters this effort. The Municipality of Halandri has been actively engaging the society' stakeholders to the mentioned activities, aiming to empower each actor towards food waste prevention.

Keywords: Food waste, households, UN target, food loss, food waste prevention

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Assessment of Food Waste Generation in China's Dining Scenarios and Its Environmental Implications

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Abstract

This study rethought the food waste in China, highlighting that the edible portion of cooked food waste (EFW) is the real food waste. Surveys revealed that EFW amounts for restaurants, takeaway services, canteens, and household meals were 84.6, 57.5, 60.4, and 24.6 g/(person-meal), respectively. The percentages of EFW in food waste (FW) generated per person per meal in the four scenarios were 50.5%, 52.2%, 47.2%, and 27.6% respectively, suggesting that EFW is not synonymous with FW, but significantly lower. Restaurant dining waste has decreased compared to the average waste of 93.0 g/(person-meal) in the 2018 China Urban Dining Food Waste Report, indicating that the implementation of *Anti-Food Waste Law of the People's Republic of China* has achieved initial results. Greenhouse gas (GHG) and typical pollutant emissions were assessed for the four scenarios, with emission patterns consistently ranking as restaurant > canteen > takeaway > households. GHG emissions per person per meal in the four scenarios ranged from 52~185 g CO_2-eq, photochemical oxidant formation potential varied from 28~388 mg NMVOC-eq, and particulate matter formation potential spanned from -15~203 mg PM10-eq. In terms of the overall EFW generation process, the processing and cooking segments were the key GHG and environmental pollutant emission segments for the four scenarios, while the procurement, transportation, storage, sales, and distribution segments had less environmental impact. With respect to residual food disposal, the management of FW from restaurants and canteens is relatively standardised, where all FW can be collected and transported centrally for oil and grease extraction, followed by entering the anaerobic digestion treatment process. FW generated by takeaway services and households is sorted into anaerobic fermentation or industrial composting treatment systems in regions where waste classification is more effective, but this has not yet been achieved nationwide. Finally, we recommend that China should initiate a more extensive and continuous monitoring project in the future, establish artificial intelligence-based monitoring platforms in representative regions, and create a network for monitoring FW. Additionally, a hierarchy of FW management in China should be established as soon as possible. This hierarchy would clarify the types, sources, and amount of FW that are appropriate for each level and quantify the corresponding FW reduction and recovery potential.

Keywords: Food Waste, Carbon Neutrality, Life Cycle Assessment, Environmental impact, Challenges and Perspective

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Assessment of food waste generation in the primary production

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Abstract

In relation to primary production, the Commission Delegated Decision EU (2019) 1597 provides guidelines for effectively evaluating and reporting food waste (FW). The inaugural pan-European assessment of FW levels in 2020 indicated that primary production constituted approximately 11% of the total FW generated within the EU. Notably, there is an absence of data regarding food loss (FL) due to the European Commission's yet-to-be-defined official methodological framework for estimating and reporting such losses. The measurement of FW within the primary sector poses significant challenges owing to the inherent characteristics of the sector, including the wide variety of produce, diverse nature of farms, and various cultivation practices. Furthermore, only a small number of farmers actively measure and maintain records of food losses and waste (FLW). Nonetheless, nearly all farmers, regardless of the size of their farms, possess a robust understanding of where food is lost during the production process and can provide rough estimates of the quantities lost. This study delves into both the focal points and reasons behind FLW in the primary production sector, as defined by EU standards, within Greece. It is part of an ongoing comprehensive study focused on quantifying FLW in the country, conducted within the EU LIFE-IP CEI-GR project. The research methodology included a combination of questionnaires and interviews to collect data (244 questionnaires were administered, and 11 participants were interviewed). Producers were requested to furnish data concerning their primary products, estimates of FLW, the edibility of discarded food, and their disposal practices. An analysis of the results reveals that FL is intricately linked to factors such as cultivation methods, the timing of cultivation and harvests within a growing cycle, and the specific plant species. The susceptibility of products to associated FLW varies significantly based on cultivation techniques, cultivated species, or even specific plant varieties. To illustrate the extent of this variation, according to producer statements, greenhouse tomato cultivation results in a mere 0.1% of FL and waste, of which 5% is suitable for consumption. In contrast, field-based tomato cultivation yields 5% FL and waste, with 50% of it being fit for human consumption. The primary commercial agreements and practices between producers and traders are structured such that the trader assumes responsibility for receiving the products, conducting sorting (instead of the producer), and assessing quality, without compensating the producer for the quantity deemed unsuitable for marketing. As a result, waste stemming from harvested products is primarily recorded during the marketing phase rather than the production phase.

Keywords: Food loss, food waste, primary production, Greece

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Food waste generation in the grocery retail sector

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Abstract

When considering food production, it is approximated that about one-third of all food intended for human consumption is lost or wasted when assessed by weight [1]. However, when assessed in terms of caloric value, food wastage accounts for roughly one-quarter of the total food produced. Within the European Union (EU), food waste generation in 2011 is estimated to have reached 129 million metric tons, which represents approximately 20% of the total food produced in the region [2].
In particular, within the "Retail and Other Distribution" sector of the food industry, it is roughly estimated that around 4.6 million tons of food waste were generated in the EU in 2012 [3]. Although the retail sector's share of food waste along the supply chain may seem relatively small, addressing it is crucial due to its substantial influence on food waste generation in other stages of the supply chain, including suppliers, primary production, and consumers. In this study, a major supermarket chain in Greece has committed to supporting SDG 12.3, which aims to halve food waste in its own operations and contribute to reducing food waste among its suppliers and customers. To achieve this, the retailer collaborated with Harokopio University to establish a baseline for food waste in its entire supply chain for the year 2019. This collaboration aimed to provide external verification for the retailer's annual food waste assessments in its own operations, estimate food waste generated by its suppliers and customers, and lay the foundation for implementing or intensifying various food waste prevention activities.
This study presents the variation and composition of unsold food quantities, food waste, and food donations in the chain's operations (including stores and warehouses) for the years 2019 and 2020, with the goal of developing an effective waste prevention plan.
Detailed data regarding the quantity and value of each unsold food item, referred to as "shrink" hereafter, were extracted from the company's database into Excel files. Depending on the type of product, the quantity was recorded either in weight units or as the number of items, with all entries eventually converted into weight. Net weight (excluding packaging) was used for this purpose. In cases where such information was not available, typical unit weights from nutrition and dietetics databases were applied.
Furthermore, the monetary values of the total food handled by the chain were provided, and these were converted into weight units using value-to-weight coefficients for each year, as determined from the shrink files. Unsold food may be directed towards donation, returned to suppliers, or disposed of directly. The latter two pathways are classified as food waste.
The data were analysed based on:
i. the main store activity departments, i.e. fruits and vegetables, grocery, meat, fish, frozen, bakery, and pastry. and

ii. the main reason for food not been sold as reported by the retailer, namely food donation, store food waste, warehouse food waste and store returns.

The results indicate that the main food waste quantities are generated by the fresh fruits and vegetables store department, followed by the dairy product department. The key outcome of this study is that food retailers can make meaningful changes to help limit food waste. The first, crucial step towards this direction is the establishment of reliable food waste baseline.

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Keywords: food waste, measurement, retail sector

CFW: Consumer Food Waste Prevention - awareness and behaviour change models and interventions

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Innovation as an Intervention: How Being Involved in Innovations Against Food Waste Changes the Individuals' Awareness, Attitude, and Behaviours Towards Food Waste?

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Abstract

Food loss and waste imply the waste of significant amounts of resources used to grow, process and prepare food, with serious environmental and climate consequences especially when the food is landfilled. Individual awareness must increase to improve attitudes and behaviours with regards to food waste. Passive interventions such as campaigns, in which participants are provided information, have proved to have little to no effect in promoting pro-environmental awareness, attitudes, and behaviour. On the other hand, experiences entailing the implementation of concrete tasks have been found to promote change in attitudes and awareness and thus effectively modify behaviours in the anticipated direction. While previous research has demonstrated the role of personal experiences and active involvement in raising awareness and promoting change in attitudes and behaviour, it remains to be investigated whether being involved in the implementation of innovations (either in the workplace or at home) may act in a way similar to an active intervention. Answering this question would help proper accounting of the additional social value created by public investments to support and test innovations that target pro-environmental outcomes, such as circular use of materials and productive use of resource. To contribute to filling this gap, we hypothesise that taking an active part in the implementation of innovations acts as an active intervention by increasing awareness and improving the attitude and behaviour of participants towards wasting food. We test this hypothesis in the framework of a Horizon 2020 Innovation Action project aimed at demonstrating innovations to combat food waste in three supply chains characterised by perishability as well as in the household and catering sectors. We implement surveys among the employees of organisations (businesses and schools) and the members of households involved in the testing of innovations. Our theoretical framework is based on the Theory of Planned Behaviour. The participants are asked to rate the same statements of a multi-item Likert scale both before (to establish a baseline) and after the implementation of the innovations. This approach allows us to assess the changes resulting from involvement in the demonstration while reducing the possible desirability bias that could emerge if asking direct questions. The research participants in the workplace innovations are company employees aged 16 and above. For households, the innovations concern instead daily routines related to food. Data collection is ongoing. We will examine how the rating of various statements differs depending on whether they come from a participant implementing a workplace-based or a household-based innovation, and how changes in responses between the baseline and the post-implementation phase compare across different levels of

involvement, demographics, and innovation types (e.g., technological, organisational, or social). We expect an increase in awareness of the food waste problem, including the levels of food waste generated in the workplace or at home, and a change towards attitudes less favourable to food waste. The design and results of the research will provide useful insights about active participation's role in triggering positive behavioural change and increasing the social impact of the public funding to sustainable innovation.

Keywords: food loss and waste, innovation action, Theory of Planned Behaviour, multi-country survey, social impact

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Consumers' Awareness and Acceptance Towards Upcycled Foods

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Abstract

Food loss and waste has been a global problem recently that led to several attempts both to reduce and to utilize food waste. One of the approaches in the field is using side or waste streams of the food industry to develop new food ingredients as well as new food products, so called upcycled foods. Upcycled foods are defined as "food products that elevate food that would otherwise be wasted to higher uses and have tangible benefits to the environment and society" (Spratt et al., 2020). Researchers and industry are already aware that the acceptance of such products among consumers requires special attention and several work has already been published looking at this aspect. The present talk will provide an overview of the current situation regarding the upcycled foods market, and focus on the consumer awareness and acceptance towards such products. Accumulated evidence applying consumer interviews or polls, together with the authors' own work with Turkish consumers (Yilmaz & Kahveci, 2022), will be evaluated based on the factors that affect consumer acceptance, such as consumers' country, sociodemographic (Coderoni and Perito, 2020) as well as lifestyle variables (Asioli and Grasso, 2021), knowledge of and expectations from upcycled food products (Aschemann-Witzel et al., 2022), in order to draw general conclusions that could help the newly growing market.

Keywords: Upcycled foods, Food waste, Consumer behavior

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Food Waste in Hungarian School Catering System

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Abstract

The school catering system is a significant player in the food supply chain since children and young people spend most of their days at an educational institute. Unfortunately, the school food system generates high amounts of food waste indicating that the system is not effective. The served food rarely will be fully consumed resulting in varying amounts of leftovers. Moreover, the amount of unserved food is also significant. Since a huge amount of food is wasted in school catering, the sustainability of this sector is questionable. It is insufficient to calculate the nutritional compositions of school food and serve healthy and local meals because if it is not appealing to the pupils they will reject or consume partly the given meal. This study aimed to obtain relevant data regarding food waste amount and composition in the Hungarian school catering system. Food waste data will be used to understand the operational efficiency of the school catering system and to contribute to the assessment of food waste dynamics. Data were collected from 92 educational institutes where more than 9,000 pupils were served daily. All catering units were surveyed at least once per year. Only lunch was involved in this survey, breakfasts and snacks were not considered. Data were collected in the years 2021-2022. As a survey method we used weight measurement which is a markedly time-consuming and labour-intensive method, but we found it the most reliable. School food waste was separately collected as the first course (which is always a soup) and the second course and if possible it was further divided into protein, carbohydrate and vegetable ingredients. The unserved food and plate waste were analysed according to different ingredients. The amount of served meals was compared to the consumed food quantities. By analysing the served portions and the amount of plate waste, we can estemate the real quantities of the consumed food. In 2021, 5,769 kg of food were prepared for 7,915 consumers, of which 1,872 kg were unserved food and 1,235 kg were returned plate waste. In 2022 the data slightly changed where 6,274 kg were the prepared food (for 9,590 consumers), 1,634 kg was the unserved food and 1,370 kg is the returned plate waste. More detailed analysis of these data will help to better understand the reasons of food waste generation, which is a good starting point for developing a sustainable and more effective school catering system.

Keywords: school meal, food waste, school catering, plate waste

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Willingness to Pay for a Certification Scheme Against Food Waste: The Influence of Perceived Behavioural Control and Perceived Responsibility

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Abstract

Food waste is a very relevant topic in the context of food consumption sustainability. Many studies have explored individuals' attitudes and willingness to pay (WTP) in relation to certification schemes related to diverse ethical attributes, such as organic, fair trade, locally grown, and so forth. Little research has been conducted on the effect of a certification scheme based on food waste prevention, and the premium price individuals may be willing to pay for it (see La Barbera et al., 2014; Del Giudice et al., 2016). In the current study, a five-round experimental auction has been conducted with 79 participants to assess their willingness to pay a premium price for bread certified against food waste. The auction was non-hypothetical and subjects received an endowment to participate. In addition, we sought to explore the influence of personal sense of control, intended either as perceived behavioural control or perceived responsibility. This distinction has never been explored, even if previous research has shown the significance of control in relation to food waste (e.g., La Barbera et al., 2022). Perceived behavioural control is the individual's belief of being capable of implementing a behaviour, such as reducing food waste. Perceived responsibility is the personal sense of being responsible, directly and at least partially, of a certain situation or behaviour. In other terms, perceived behavioural control is connected with sense of efficacy, whereas perceived responsibility has more to do with the locus of control. Results show that participants are willing to pay more for bread certified against food waste. Premium price for the certified product is positively affected by perceived behavioural control (beta = .25, $p < .05$): when individuals think they are able to reduce food waste, and reducing food waste does not appear as a too difficult task, they are willing to pay a higher premium price for the bread certified against food waste. On the contrary, the premium price is not affected by perceived responsibility (beta = .04, p = ns). Results are robust as regards participants' income and gender. Theoretical and practical implications are discussed.

Keywords: consumer behavior, locus of control, self-efficacy, experimental auction

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Worth a Thousand Words: Visualizing Food Waste Through the Lenses of Foodservice Professionals

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Abstract

Food waste has become a global issue and a major challenge aggravated by its role in climate change, land, water and biodiversity scarcity, groundwater pollution, and global deforestation. Tackling food waste prevention and recovery is a priority area. Yet, the meaning of food waste is subject to interpretation and is not a universally accepted phenomenon. This is evident across the steps in the food value chain, particularly the downstream levels, where a myriad of businesses operates across a broad spectrum of economic, political, socio-cultural, and technological dimensions. This complex system entails recognition of the professionals' views on what constitutes food waste and the factors that may affect their awareness, sensemaking, and reflection. The purpose of this paper is to contribute to the ongoing debate on the discursive construction of food waste as a "wicked problem" by exploring the broad perspective of 'wastage' from the perspective of professionals in institutional and commercial foodservice and retail food stores. This study applies participatory and visual research methods to achieve a more socially embedded sustainability research that strives to offer solution options to the complex challenge of food waste minimization and management. Food waste management must avoid two decision-making traps: falsely assuming one-size-fits-all solutions and lack of innovative waste prevention management from overwhelming complexity. A food systems approach can help avoid these traps.

Keywords: food waste, foodservices, professionals, visual wisdom, wicked problem

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Game-changer in tackling food loss and waste: Minecrafting a sustainable future

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Abstract

The challenge of food loss and waste (FLW) has reached alarming proportions, with recent reports indicating that approximately one-third of the world's food production, amounting to roughly 1.3 billion tons, is lost or wasted annually (Parfitt et al., 2021). The consequences of FLW reverberate across various domains, posing significant implications for the environment, economy, and society (Abeliotis & Lasaridi, 2022). Environmentally, the squandering of substantial volumes of food leads to unnecessary resource depletion. This includes the wastage of arable land, water, and energy used in production, contributing to a strained ecological footprint (Scherhauferet al., 2018). Additionally, decomposing food in landfills emits greenhouse gases, notably methane, intensifying climate change impacts (ibid). On an economic front, FLW translates to substantial financial losses for both producers and consumers (Kotykova & Babych, 2019). The resources invested in cultivating, harvesting, transporting, and processing lost or wasted food represent a missed opportunity for economic growth (ibid). This inefficiency undermines the sustainability of agricultural systems and has ripple effects on global markets (ibid), potentially destabilizing food prices (Doukas, 2023). In the social realm, FLW exacerbates food insecurity and inequality (Loizia et al., 2019). The food that is lost or wasted could have alleviated hunger for millions (ibid). Instead, it underscores disparities between regions of abundance and those plagued by insufficient access to nutrition (ibid). Moreover, the ethical dilemma of discarding food while a considerable segment of the world's population suffers from inadequate nourishment prompts profound inquiries concerning societal principles and the distribution of resources (Fanzo, 2019). Addressing FLW is paramount. As a challenge of global significance, it aligns with the Sustainable Development Goals set forth by the United Nations, particularly Goal 12: Responsible Consumption and Production (Lasaridi et al., 2021). By minimizing FLW, societies can simultaneously enhance food security, reduce environmental strain, and foster economic stability. Tackling this challenge requires a collaborative effort, and unquestionably education plays a pivotal role in this endeavor. Integrating comprehensive

educational initiatives empowers individuals with the knowledge and skills needed to make informed choices about food consumption and waste reduction (Fraj-Andrés et al., 2023). Educating students, communities, and stakeholders about the environmental, economic, and social consequences of FLW fosters a shared dedication to responsible behaviors, which in turn leads to the development of practical approaches on individual and broader scales. This type of awareness creates a ripple effect that resonates across industries, governments, and communities, amplifying the potential to achieve meaningful, lasting change. It fosters a global ethos of mindful resource management and sustainable consumption, driving positive impacts for current and future generations (Chawla & Cushing, 2007). Along this narrative, the 'Boosting school Awareness about FOod loSs' (BAFOS) project (www.bafos.eu), co-funded by the Erasmus+ Programme of the European Union, offers a pragmatic and innovative approach to combating FLW. By creating the 'FoodWaste' adventure game in 'Minecraft Education', a specialized version of the popular video game 'Minecraft' that is designed specifically for educational purposes, the project utilizes digital platforms to raise awareness and stimulate insights, aiming to empower individuals to navigate complex challenges through creative collaboration. BAFOS seeks to equip the younger generation, specifically targeting Generation Z through technology (Närvänen et al., 2022), with essential insights and tools to effectively tackle FLW and foster proactive solutions. Seamlessly integrating education and gaming, the project strives to cultivate a sense of responsibility and awareness. This initiative is more than an engaging game; it is a transformative journey of interactive education, fueled by a shared commitment to educate and enlighten the younger generation about the significance of addressing FLW. This endeavor not only illuminates the pressing issue of FLW but also paves a practical path forward. By cultivating awareness, aligning with sustainability objectives, and harnessing educational technology, this initiative exemplifies the capacity for positive transformation, while stressing the imperative of collaborative action in addressing FLW and alluding to the wider ramifications for a more conscientious and sustainable society.

Keywords: food waste, environmental awareness, education, innovation, gaming, sustainability

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Household food waste prevention - Can experiential learning be used as a tool for reduction?

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Abstract

1. Introduction
Food waste is a multifaceted issue that affects the environment (emissions, pollution, land use etc.), food management systems (all stages of the food chain) and society (food insecurity, hunger). In Greece, according to the EU Statistics in 2020, household food waste was reported at 87 kg/inh./year (Eurostat, 2022), of which 40 kg are considered to be avoidable food waste (Lasaridi, 2022).
Youths are a key stakeholder for a sustainable environment on the other hand the WRAP - Food waste trends survey 2021, the age group that produces most avoidable food waste is between 18 and 34 years of age.
The target of the study was to investigate whether experiential learning can stimulate pro-environmental behaviour for household food waste prevention among young people in Greece. Experiential learning according to Kolb (1984, p. 21) is “a holistic, integrative perspective on learning, that combines experience, perception, cognition and behaviour”.
2. Materials and Method
In this study, a combination of methods (i.e. questionnaire) and approaches (i.e. focus group, experiential learning) have been used targeting to investigate the Greek youths’ theoretical knowledge regarding: a) awareness on the food waste problem, b) the impacts (environmental, economic, and social) of food waste and c) food waste prevention methods. Experiential learning was used as an intervention to provide skills for household food waste prevention.
The participants were six in total (male and female), between 19 and 21 years old university students, living with their parents. The research used the focus group method (Gill et al., 2008), as the participants belonged to the same age group, had the same educational background, studied at the same university and the same subject.
3. Data collection
The data collection consisted of four phases, starting with a questionnaire and a focus group, thereafter the intervention and finally a second focus group.
2. Results discussion
The data from the four different phases were analysed separately using thematic analysis method, as described by Braun and Clark (2006, p.79).
During focus groups food waste was discussed, where the misconceptions, and misunderstandings relevant to what is food waste surfaced. As it has been identified by Abeliotis et al. (2016). The participants sources of information on food waste are the awareness campaigns, the internet, while parents and family play a significant role in consumption habits and environmental behaviour (Grønhøj and Thøgersen, 2012).

Youths' theoretical knowledge and understanding on food waste was satisfactory. During the intervention were addressed the issues raised during the focus group while working together for cooking a full meal. This was practical knowledge was gained, giving confidence and reassurance to the participants and a feeling of becoming part of the solution. As it is identified by Visschers et al. (2015) skills training can promote pro-environmental behaviour.

5. Conclusion

For successful food waste prevention the following conditions need to be met a) awareness on the subject b) awareness of the personal responsibility c) theoretical knowledge, and d) practical knowledge/ cooking skills. Experiential learning can be used as a tool through which to stimulate youths to adopt pro-environmental behaviour for food waste prevention.

6. References

Keywords: Food waste prevention, SDG's, experiential learning

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Sociodemographic determinants of household food waste in Greece

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Abstract

According to Eurostat, households are the primary contributors to food waste generation within the European Union (EU), accounting for 53% of wasted food across the EU food chain, a total of roughly 31 Mt, or an annual average of 70 kg/ca (Eurostat, 2023). National-wide estimates reveal that Greek households product approximately 87 kg/ca per year. Apart from the quantification of food waste, understanding its underling factors that drive food waste generation and prevention behaviors is crucial to developing effective strategies to address this problem (Abeliotis et al., 2016; Ilakovac et al., 2020). Sociodemographic characteristics are associated with influential factors that have a causal relationship with food waste. Prior research in Greece identified household size (Abeliotis et al., 2019) and educational levels of the respondent (Abeliotis et al., 2016) as significant determinants. However, recent relationships between sociodemographic factors and food waste, as assessed within the context of the EU legal framework, remain unexplored. This study aims to fill this research gap by presenting the most up-to-date evidence regarding the sociodemographic profiles of a national representative sample in Greece.

An online diary-based survey was conducted in 2021 with the aim of investigating food waste generation in Greece. Facebook advertisements were used for recruitment, targeting private households, while excluding collective housing and foreign diplomatic staff (EL.STAT., 2020). Stratified sampling across the thirteen NUTS2 regions was utilized to ensure geographical representativeness. Participants were instructed to weigh and submit daily electronic logs of their household food waste for a week. Adjusted generalized estimating equations (GEE) models accounting for inter- and intra-person potential predictors of daily food waste generation were employed to investigate the influence of sociodemographic factors. Covariates included sociodemographic variables, diaries' length, each diary day's characterization as typical or unusual, and time effects associated with the completion day. All hypotheses were two-sided, with the statistical significance level set at $p < 0.05$ and Bonferroni correction performed on multiple comparisons.

The final sample encompassed 1,133 households, totaling 3,231 individuals, and was fairly representative of the Greek population based on the NUTS2 regions and household size (EL.STAT., 2011). Nonetheless, due to the study's design, women and highly educated individuals were overrepresented, whereas those aged 18–24 and 65 years or older, as well as people with lower education, were underrepresented.

Holding all other predictors constant, household size exhibited a negative association with per-capita food waste, but a positive correlation with per-household estimates. In particular, a one-person increase was linked with a 16% decrease in per-capita total food waste ($\beta=0.177\pm0.021$, $p<0.001$), while daily per-household total food waste increased by 20%

(β=0.182±0.019, p<0.001). Notably, relationships in the same directions were observed for food parts that were edible (per-capita: β=-0.186±0.035, p<0.001; per-household: β=0.177±0.033, p<0.001) and inedible (per-capita: β=-0.166±0.025, p<0.001; per-household: β=0.191±0.022, p<0.001) at the time of disposal. Furthermore, the presence of children was weakly related to higher daily total food waste generation rates by nearly 11% (per-household: β=0.102±0.054, p=0.057) compared to households without children, with marginally greater levels of food parts that were edible at the time of disposal (per-capita: β=0.142±0.083, p=0.085; per-household: β=0.161±0.086, p=0.061). A borderline significant positive relationship was also found between mean annual household income and total food waste (β=0.038±0.019, p=0.050).

After adjusting for all remaining covariates, increasing diarists' age was associated with statistically significant increases in daily amounts of total food waste (per-household: β=0.041±0.020, p=0.043) and its inedible parts (per-capita: β=0.086±0.027, p=0.001; per-household: β=0.090±0.027, p=0.001). Additionally, male respondents recorded less total food waste (per-capita: β=-0.322±0.062, p<0.001; per-household: β=-0.301±0.062, p<0.001), as well as both inedible (per-capita: β=-0.372±0.069, p<0.001; per-household basis: β=-0.342±0.070, p<0.001) and edible (per-capita: β=-0.276±0.113, p=0.015; per-household: β=-0.276±0.114, p=0.0019) food parts, compared to women.

The relationships between residences' NUTS1 regions and diarists' educational level did not reach the levels of statistical significance.

In conclusion, beyond quantifying food waste, investigating sociodemographic factors is an essential prerequisite for implementing interventions tailor-made to the profiles of households and their members.

Keywords: food waste, household, sociodemographic factors

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FLW: Any other aspects of FLW prevention across the entire food value chain

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Reducing Household Food Waste by Dietary Meal Planning

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Abstract

This research aims to reduce food waste at the household level by formulating menu plans. One-third of global food production is lost or wasted. Food waste is a significant contributor to climate change, as food waste is estimated to generate 8% of global greenhouse gasses. Of the total food waste in Europe, about 50% is caused by households. Planning is identified as one of the main drivers of food waste. Poor planning leads to the wastage of food because of, among others, difficulties consumers face with inappropriate packaging sizes and managing leftovers. Diet modelling has proven to be an effective method for solving food planning problems. It has mainly been used to find nutritious and affordable diets using mathematical optimization techniques. However, diet modelling has not yet been considered for reducing household food waste. In this research, food waste is defined according to the EU definition: “any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans”. Currently, in literature, food waste is frequently expressed in weight. However, if the purpose of reducing food waste is to mitigate climate change, other units of measure might be more appropriate. For instance, environmental impact indicators such as greenhouse gas emissions (GHGE), land use, and water use. A dietary meal planning model based on mixed-integer programming is developed to estimate to what extent food waste can be reduced at the household level when planning is optimized. The model formulates menu plans by selecting optimal combinations of recipes while taking package sizes, perishability, and nutritional value into account. Multiple conflicting objectives, such as costs, overall environmental impact, and food waste are considered. It is assumed that grocery shopping is done on the first day of the menu plan. Perishable foods not finished by the end of the menu plan are considered waste. The Netherlands is taken as a case study, the Dutch National Institute for Public Health and the Environment and a large Dutch supermarket chain are the main data sources for dietary reference values, recipes, and package data. The model is used to formulate dinner menu plans for an average Dutch family of 4 persons for 5 days. The results show that menu plans can be formulated to minimize waste (0 g waste), environmental impact (15681 g GHGE), and costs (€33.11), respectively. Trade-offs in the results show that, for instance, the menu plan with minimum waste has relatively high GHGE (21118 g GHGE) and cost (€52.12). Furthermore, the cheapest menu plan suggests large package sizes, which leads to more waste (1028 g waste). It is possible to formulate healthy, affordable menu plans and corresponding shopping lists that result in neglectable waste. Moreover, our analysis suggests that environmental impact is more suitable than weight as the unit of measurement for food waste. This study shows that optimizing menu plans is a promising way to reduce household food waste and the environmental impact of diets.

Keywords: mixed-integer linear programming, food waste, carbon footprint, recipes, menu plan

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Exploring the Valuable Compounds and Antioxidant Activity in the Peel of New Zealand Grown Buttercup Squash (Cucurbita maxima)

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Abstract

The untapped potential of New Zealand buttercup squash or buttercup pumpkins encourages innovative ways of repurposing and valorising food waste to contribute towards efforts in creating a circular economy. This cultivar of the *Cucurbita maxima* was chosen due to its mass production in New Zealand where 65,789 tonnes were produced in 2021/22 (HEA, 2022). The pumpkin industry across the globe generates significant waste from byproducts such as the peel which is often discarded despite being a valuable source of nutrition and bioactive compounds for human health and well-being. These compounds include phenolic acids, flavonoids, and carotenoids among others are proven to possess beneficial properties such as antioxidant, anti-inflammatory, antifungal, antibacterial, antiviral, antitumour, antidiabetic, neuro-protective, and cardio-protective activity (Badr et al., 2010; Hussain et al., 2021; Salami et al., 2020). The unique environment of New Zealand with its high UV radiation exposure provides opportunities to discover unexplored variations in qualitative and quantitative information regarding bioactive compounds. This provides motivation to identify and quantify such beneficial compounds to give insight into their potential values and applications. While there has been some investigation of the applications of these compounds as new ingredients in the food and agricultural sectors, their promising uses in the cosmetic, pharmaceutical, and dietary supplement industries remain largely unexplored. The study evaluated both fresh and dried pumpkin peel of buttercup squash, utilising ultrasound assisted extraction. The extractions from the processed peels were carried out using water or 70% ethanol with a sample:solvent ratio of 1:10 and 1:3 (w/v). The greatest yield was achieved using dried pumpkin peel, with a ratio of 1:10 (w/v) and 70% ethanol as the solvent. Qualitative phytochemical screening of the samples revealed the presence of different classes of plant metabolites, including phenols, flavonoids and tannins. HPLC and various other quantitative analytical methods revealed the presence of lutein, beta-carotene, zeaxanthin, vitamin E and vitamin A. GCMS analysis identified the presence of compounds shown to have biological activity, including limonene, a-pinene, b-dihydroagrofuran, thujopsen, lactic acid, linalyl anthranilate, benzyl benzoate, among others. The Folin-Ciocalteu assay revealed a total phenolic content of 113.1±5 mg GAE / 100 g dry weight for a 25% solution of the extract. The antioxidant activity was measured through in-vitro 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay where the dried ethanolic extracts had the highest radical scavenging activity of 68.3 ±1%.

Keywords: New Zealand Curcubita maxima, pumpkin peel, waste valorisation, antioxidant activity,

phenolics

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Apple and Pomegranate Waste Extracts by Hydrodynamic Cavitation for Vegan and Gluten-Free Cookies Fortification

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Abstract

Nowadays, a big challenge is to reduce food waste, creating a circular economy within food cultivation and processes, to reduce costs and environmental impact. Focus was made on two fruit wastes: damaged apples (*Malus Domestica sp.*) and pomegranate peels (*Punica granatum sp.*). Apple is the main produced fruit in Italy (2.3 million t/y), with a harvesting loss of 230 thousand t/y, due to diseases or not conformed appearance. Instead, pomegranate waste is represented by the peel, discarded after juice production. Due to their chemical composition, both wastes are well known for nutraceutical and technological applications. Apples are a well-known source of pectin, which can act like technological agents, but lately studies on their phenolic content are gaining interest. On the contrary, pomegranate peel's main peculiarity is the high presence of phenol compounds, and new studies are pointing out its good amount of pectin. In order to exploit the potential of these wastes, an extraction is needed. Hydrodynamic Cavitation (HC) is a "green" and low temperature extraction process that requires water, good for scale up. The aim is to propose functional and "green" food additives, useful for improvement of nutraceutical and technological properties of baking products. Vegan and gluten-free cookies with HC extracts from apple and pomegranate waste were chosen for this study. Cookie samples were prepared as follow: control recipe (CON); with apple extract substituted to 5% and 10% of flour + sugar (M05 and M10); with pomegranate peel extract substituted to 5% and 10% of flour + sugar (B05 and B10); without the 5% and 10% of flour + sugar (S05 and S10). Physical (weight, spread ratio, colour, texture), chemical (total phenolic content, antioxidant power as IC50) and sensory analysis were carried out immediately after production (t0) and after one month of simulated home storage (t1). Cookies samples were statistically different in spread ratio ($p < 0.001$), with higher values at higher extract concentrations. Moreover, B05 and B10 were harder ($p < 0.05$) than all the other samples. These characteristics were respectively influenced by the free sugar content and the fiber/pectin content of the extract. Total phenolic compound and antioxidant power were significantly higher ($p < 0.001$) in B05 and B10 than all the other samples. In particular, B05 and B10 had higher antioxidant power than M05, M10, and CON, while S05 and S10 scored the lowest values. Total phenolic content and IC50 values were not statistically significant during conservation, indicating an antioxidant stability of cookies. Trained panel evaluated cookies with apple extract as

“sweet”, “sour”, “fruity”, “vanilla aroma”, “caramel aroma”, and pomegranate peel cookies as “bitter”, “astringent”, “fruity”, “whole aroma”, “toasted”. In conclusion, the HC extract from apples is more functional for technological proprieties, since it improved aspect and sensory characteristics. Instead, HC extract from pomegranate peel resulted more functional for nutraceutical proprieties, due to high antioxidants presence, but its use should be limited, due to the bitterness.

Keywords: Hydrodynamic Cavitation, apple by-product, pomegranate by-product, cookies fortification

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Untangling the Complexities of Decision-making in Food Loss and Waste Valorisation

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Abstract

Approximately one-third of food produced for human consumption is lost or wasted annually, resulting in an estimated carbon footprint of 3.3 GT of CO_2 equivalents per year. Food loss and waste (FLW), generally downcycled, also results in other environmental issues such as water eutrophication, arable land depletion, and biodiversity loss. Food Waste Valorisation (FWV) is an emerging solution inspired by the generic concept of Circular Economy to address FLW. However, the lack of structured frameworks for orchestrating the valorisation of food towards higher-valued applications, coupled with divergent goals and approaches, hampers the implementation of FWV. To address these challenges, we conducted a comprehensive literature review to identify the key building blocks necessary for decision-making in FWV. The objective is to provide clarity on the decisions that need to be made and the methods that can be employed to support effective decision-making. Based on the results of our review, we will present the existing frameworks, criteria, and decision-support tools, as well as identify missing criteria specific to food-to-food pathways. By bridging these gaps, we aim to overcome barriers hindering the integration of decision-making and facilitate the successful implementation of FWV. This research contributes to untangling the complexities of sustainable food waste management and propels the transition towards more circular and resource-efficient food systems. Based on the review, we generalized a four-phase decision-making framework for FWV, comprising: i) context analysis, ii) scope selection, iii) identification of FWV options, and iv) evaluation and implementation of the delineated roadmap. Within this framework, we elucidated the specific decisions required at each phase and identified suitable decision-support approaches for each decision. Furthermore, we conducted a review of indicators and criteria applicable to assessing FWV performance. Ultimately, this study aims to facilitate more efficient decision-making, thereby promoting the implementation of FWV initiatives.

Keywords: food loss and waste, food waste valorisation, deicison-making, sustianable food system

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Assessing Rodent-induced Greenhouse Crop Yield Losses and Management Options in Crete, Greece

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Abstract

The presence and activity of rodents in urban and rural areas causes serious negative impacts on public health and the agricultural economy, while uncontrolled spread can also disrupt the ecological balance in local ecosystems. It is indicative that from 1930 to 2018, the estimated cost of rodent activities across all sectors amounted to $3.28 billion, with constantly increasing trends (Diagne et al., 2021), while the World Food Organization and the World Health Organization estimate food losses due to rodents at 5% of the annual quantities produced, a fact that is particularly burdensome for underdeveloped countries (Jurišić et al., 2022). Synthetic (chemical) rodenticides constitute the most common method for dealing with rodents. In recent years, this method has been considered ineffective due to the development of resistance in targeted species, the direct and indirect impacts on non-targeted species, and the induced environmental pollution. Furthermore, climate change is projected to exacerbate the problem, as rodents have a greater ability to adapt in vegetation changes compared to other mammals (Kholoud et al., 2020) and rodent predator populations are projected to decline (Cameron and Scheel, 2001; Mougeot et al., 2019). To address these challenges and to mitigate rodent-induced food losses and the detrimental environmental impact of synthetic (chemical) rodenticides, Ecologically Based Rodent Management (EBRM) has been proposed as a comprehensive approach that integrates biological, ecological, physical, and cultural methods. However, the widespread adoption of EBRM is still limited. The Mediterranean region is particularly vulnerable to both rodent activity and climate change, and therefore the adoption of EBRM can have multiple benefits. In Crete, the second largest Mediterranean Island, rodents are among the pests that threaten the local lucrative greenhouses production, nevertheless, evidence on the methods used against them, their effectiveness, and therefore the environmental pressure remains unclear. To address this knowledge gap, we conducted a two-stage survey between 2021 and 2023, involving 785 greenhouse managers from 2,179 greenhouses (16.95% of the total number of greenhouses in Crete). The aim was to collect information, specifically focusing on greenhouse managers perception on EBRM. Preliminary results indicate that the majority of greenhouse managers (49.9%) rely on chemical measures, followed by those who use a combination of chemical and non-chemical methods (40.6%), while a small percentage (9.6%) use only non-chemical measures. Among the surveyed greenhouses, 40.9% reported a rodent infestation problem in the past 3 years. From these cases, 28% used exclusively chemical control to eradicate the

problem, only 1.4% relied solely on non-chemical means, and 71.1% used a combination of chemical and non-chemical control such as traps and predators. A second-stage survey reached a sample of 79 greenhouse managers who had participated in the first stage and experienced rodent issues in the past. The result revealed high satisfaction (91.1%) with the common commercial rodent control products. However, there was also significant interest (78.4%) in non-chemical methods such as EBRM. Findings highlight the need to increase awareness and adoption of EBRM among local greenhouse managers.

Keywords: rodent, greenhouse, methods, crop, yield, losses, management, Crete, EBRM

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Upcycling Polyphenols from Industrial Olive Oil Waste

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Abstract

Olive oil production plays a vital role in the economy of Mediterranean countries, being one of the most important industrial activities. However, it generates a significant waste product called alperujo. Alperujo is composed of a mixture of water, solid parts of the olive, and fatty residues. In Spain, the largest producer of olive oil, the production of olive oil was ca. 1.2 million tons in the 2019/2020 campaign, followed by Italy and Greece with productions of 0.34 and 0.3 million tons respectively. This means a production of alperujo of more than 7 million tons in these three countries. Due to its large annual production and its polluting properties, the disposal of alperujo poses significant legal and environmental challenges in Mediterranean countries, since uncontrolled dumping can cause soil deterioration in nutrient content, pH, conductivity and water retention capacity, odor problems and pathogen transmission (Garcia-Ortiz, 2016). Moreover, due to its recalcitrant nature, the presence of polyphenols in wastewater hinders the application of traditional biological treatments (Muñoz-Palazon et al., 2023). To address this issue, a novel approach is proposed in this study, which involves utilising alperujo as a raw material for extracting valuable polyphenols. It is worth noting that alperujo is a waste material and therefore, it is not used in food applications. Polyphenols are highly sought-after products in the food, nutraceutical, pharmaceutical, and cosmetic industries. The process entails using water, an environmentally friendly solvent, to extract polyphenols at low temperature. Experiments were performed to test the impact of water:alperujo ratio, extraction temperature, and time. The total polyphenolic content (TPC) was measured using Folin-Ciocalteu analysis and HPLC. The highest TPC observed at the laboratory scale was 354 mg GAE/kg alperujo at room temperature after 10 minutes of extraction with an alperujo water ratio of 1:4. Furthermore, a pilot plant has been designed to process 5 tons of alperujo per day and produce 7000 kilograms of polyphenols per day with a final concentration of 1900 mg GAE/L. The pilot plant consists of two main steps: (i) the extraction unit and (ii) the concentration of polyphenols using a series of membranes. This design is based on a previous pilot plant at a smaller scale which was able to obtain 9 g of polyphenols/kg residue from a winery industry. The dephenolised alperujo produced during this process will be treated in an anaerobic digester for biogas generation. The overall process developed in this study demonstrates both technical and economic viability as a sustainable and zero-waste solution for managing olive oil waste, thus, contributing to the development of the circular economy within the olive oil sector.

Keywords: polyphenols, alperujo, circular economy, green solvents

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Food waste in EU level: a spatial and statistical approach

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Abstract

The European Union's circular economy action plan places a high priority on addressing food waste and transitioning to a more sustainable model of production and consumption. To gain a comprehensive understanding of the challenges posed by food waste, further research is needed to examine various factors associated with this global issue, which impacts both developed and developing economies at all stages of production and consumption. Spatial analysis is a valuable tool for tackling intricate problems with geographical components. It allows for the exploration and comprehension of data through a geographic lens, facilitating identifying relationships, quantifying perspectives, trend analysis, and predictive modeling to support decision-making. Spatial analysis goes beyond mere mapping, enabling the study of spatial characteristics and the relationships that evolve within these spaces. It is particularly useful for addressing questions that cannot be adequately answered through traditional statistical analysis, as it takes into account spatial context, including factors like location, proximity, and distance. This study has three main objectives: i) Mapping various parameters related to food waste in the European Union, ii) Applying spatial analysis techniques to investigate potential spatial relationships and patterns in food waste generation, both by country and across different stages of the supply chain, and iii) Combining spatial analysis tools with traditional statistical methods to explore possible correlations and associations between food waste and other socioeconomic factors at the national level. These insights can inform strategies to mitigate the environmental, economic, and social consequences of food waste, which not only lead to substantial financial losses but also contribute to environmental issues like greenhouse gas emissions, water pollution, and land degradation (Evans et al., 2012).
This study encompasses a spatial and statistical analysis of food waste across 24 European countries. The initial data were sourced from the Eurostat database, and ArcGIS Pro software was utilized to create maps illustrating the geographical distribution of food waste. Subsequently, spatial analysis was conducted to identify hotspots and investigate potential contributing factors. The outcomes of this analysis can serve as a foundation for crafting policies and interventions aimed at reducing food waste in Europe, aligning with the broader goal of fostering more sustainable and equitable food systems. Moran's I index was employed to assess the spatial autocorrelation of food waste data in conjunction with selected indicators in European countries. Specifically, the study revealed a significant positive autocorrelation between the level of food waste at the primary production stage and each country's vegetable consumption potential. However, it is essential to acknowledge the complex underlying factors influencing food waste, including food production, consumption

patterns, and food handling practices. These findings align with prior research on food waste, which has identified systemic factors such as supply chain inefficiencies, consumer behavior, and waste disposal practices as key contributors (Neff et al., 2015). In conclusion, the positive autocorrelation observed in certain study variables suggests that efforts to reduce food waste should encompass a multifaceted approach, addressing interconnected factors and tackling the root causes of waste, rather than relying solely on short-term solutions (Gustavsson et al., 2011).

Keywords: Food Waste, Comparison, Spatial Analysis, Autocorrelation, GIS, T-test

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A Review of Endemic Plant Species of Greece for Managing Rodent Damages in Agriculture

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Abstract

The use of plant parts or extracts, which can be used as rodenticides or as rodent repellents, is one of the main components of Ecologically-based rodent management (EBRM), which strives to control food losses in agriculture while reducing the application of controversial synthetic (chemical) rodenticides. The use of endemic plant species has additional value since EBRM substances can be sustainably produced locally, nevertheless, use of such measures is not widespread due to limited knowledge. Here we review plant species, endemic to Greece, the successful use of which as rodenticides or as rodent repellents been documented in the literature. It total, 9 plant species present EBRM significance of which 3 are rodenticides and 6 rodent repellents. Among rodenticides, *Urginea maritma* (Red Squill) contains the toxic agent scilliroside and has rodenticidal properties either in the form of the bulb extract or using it as a dried powder (Verbiscar et al., 1986). Also, *Nerium oleander* contains substances toxic agents oleandrin and nerine, which are cardiac glycosides (Akhtar et al., 2014b). The consumption of leaves damaged heavily the liver and kidneys of the rats (Al-Yahya et al., 2000), while the extract from the leaves has adverse effects on significant hematological and histopathological parameters (Akhtar et al., 2014b). Finally, *Calendula aegyptiaka* flower extracts with ethanol, contain amounts of cardiac glycoside, flavonoides, saponins, tannins and triterpens, which have intense lethal properties to rats(Abou-Hashem, 2012) . Among rodent repellents, the essential oils extracted from *Citrus bergamia* (bergamot), contain components such as limonene, linallol, and linalyl acetate, which have a repellent effect on rodents either using them alone or in combination with essential oils of Thymus vulgaris and *Lavandula angustifolia (Jokić et al., 2017a)*. Furthermore, the essential oils extracted from *Mentha piperita* L. (peppermint) in combination with *Gaultheria procumbens* (wintergreen) and *Citrus bergamia* essential oils, prevent rodents from approaching the sprayed zones by promoting a repellent effect (Kalandakanond-Thongsong et al.,2014), as well as the fermented juice of Trifolium alexandrium sprayed on food and raw materials that we wish to protect(Kandil et al., 2021) . The results of this study highlight potential tools to be included in EBRM applications and will be used to further specify required active ingredient concentrations in greenhouse crop protection against rodents.

Keywords: EBRM, endemic plant species, rodent repellent

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BDZ: Biodiesel

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Optimal Production Capacity of Biodiesel Production from Spent Coffee Grounds in Supercritical Ethyl Acetate: Computer Simulation

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Abstract

The amount of spent coffee grounds (SCGs), solid waste generated from the coffee industry is increasing annually worldwide. Furthermore, SCGs is the promising feedstock for biodiesel production due to the high lipid content, approximately 23 g oil per 100 g dried SCGs. Hence, valorization of SCGs as biodiesel feedstock simultaneously reduce the amount of waste and produce renewable biofuel. In our previous work, we used ethyl acetate as green solvent to extract coffee oil from SCGs and to react with coffee oil in supercritical condition to produce biodiesel. Instead of glycerol, the interesterification reaction of coffee oil and ethyl acetate generates triacetin–a fuel additive improving cold flow properties of biodiesel. The objective of this work is to estimate the optimal capacity of biodiesel production plant from spent coffee grounds by using ethyl acetate as extracting solvent and reactant. Aspen plus V11 was used as simulation software in this study. Since linoleic acid is a major fatty acid in coffee oil, trilinolein was assumed as a mimic feedstock in the simulation. The process flow diagrams were constructed comparing with the conventional catalytic process at the same the SCGs input. The result shown that biodiesel production with supercritical ethyl acetate gave a higher amount of biodiesel product than that of the conventional process. However, the net annual profit still did not make the positive net present value (NPV) until the feed flow rate of SCGs t reached 46,675 kg/hr. The biodiesel production capacity of 30,000 ton/year generated the internal rate of return (IRR) of 23% and the payback period of in the process is 7 years.

Keywords: Biodiesel, Spent coffee ground, Supercritical fluid, Economic analysis

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Biotechnological Application of Indigenous Microalgae Chlorella sp. T4 for Wastewater Treatment and Biodiesel Production

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Abstract

Microalgae are considered a promising novel alternative for sustainable wastewater treatment and algal biofuel production due to their ubiquity and high growth rate. In this study, hyper lipid-producing microalgal strains, Chlorella sp. T4 was isolated from a freshwater sample in KwaZulu-Natal, South Africa. The strain showed high Lipid productivity with a balanced fatty acid profile for biodiesel production. Optimization of growth conditions significantly increased the lipid productivity of Chlorella sp. T4 and triggered increased expression of Acetyl-coenzyme A carboxylase carboxyl transferase subunit beta, ketoacyl-ACP synthase-1, omega-6 desaturase and omega-3 desaturase genes responsible for lipid biosynthesis. The fatty acid methyl ester produced under nitrogen-limiting conditions was found to be more suitable for the production of quality biodiesel with enhanced oxidative stability and cold flow properties. Furthermore, Chlorella sp. T4 was able to utilize poultry and dairy wastewater as growth mediums and reduced nutrient content in the wastewater. The biomass yield was significantly increased when cultivated in wastewater and contained significant amounts of lipids (16.2–25.7 % dry wt.), carbohydrates (20.7–33.1 % dry wt.), and proteins (24.5–34.6 % dry wt.), regardless of the wastewater type. The biodiesel properties of lipids extracted from the cell grown in poultry and dairy wastewater complied with most of the international standards (ASTM D6751 and EN 14,214). In conclusion, this indigenous hyper lipid producing Chlorella sp. T4 showed potential for biofuel production after proper optimization of the growth conditions. The ability of Chlorella sp. T4 to utilize different wastewater with high nutrient concentration confirms its potential application for large scale cultivation in wastewater for biofuel production to simultaneously address this problem of energy crisis and water shortage.

Keywords: Biodiesel, Biomass, Chlorella sp. T4, Lipids, Wastewater

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New Yarrowia lipolytica Strains Engineered for Erythritol and Citric Acid Biosynthesis from Glycerol

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Abstract

Due to the ease of genetic manipulation, undemanding cultivation conditions and short generation time, yeasts are increasingly perceived as attractive microbial cell factories. *Yarrowia lipolytica* is a particularly intensively researched microorganism presenting great potential in the production bulk. Moreover, this non-conventional yeast has the remarkable ability to assimilate carbon sources from various agro-industrial wastes or by-products, including sugars from lignocellulosic biomass hydrolysates, fatty acids derived from animal fat and waste cooking oils or crude glycerol which is the main by-product of the biodiesel industry. Moreover, biodiesel production is projected to reach 53.2 billion liters in 2026, therefore large amounts of waste glycerol will be available as well. *Y. lipolytica* in the presence of hydrophilic substrates produce e.g. organic acids, polyols, and carotenoids, used as food additives (Bilal et al., 2021). The aim of the study was to evaluate *Y. lipolytica* yeast transformants obtained in the Wratislavia 1.31 strain in terms of growth and ability to metabolize glycerol towards overproduction of citric acid and erythritol. The strains were constructed by overexpressing the *GUT1* gene, encoding glycerol kinase, *CIT1*, encoding citrate synthase and *YALI0E34672g*, encoding the mitochondrial succinate fumarate transporter (Tomaszewska-Hetman et al., 2021). As a result eight strains were obtained, which contained multiple copy of one, two or three genes.
Growth parameters, such as ODmax and the maximum specific growth rate (μmax) were determined in the cultures performed in the Bioscreen apparatus. Next, strains were compared in terms of glycerol utilization rate and citrate production in shake-flasks experiment. Production cultures were carried out in 5-L bioreactor BIOSTAT B Plus with a working volume of 2 L. The growth curves obtained in the Bioscreen cultures indicated that transformants reached the stationary phase later than Wratislavia 1.31 strain but at a higher ODmax value. The value of the μmax parameter ranged from 0.065 h^{-1} (1.31.GUT1/6) to 0.097 h^{-1} (1.31. CIT1/3), while for the parental strain it amounted to 0.081 h^{-1}. In shaken cultures, under the conditions of growth limitation by low concentration of the macronutrient – nitrogen, the strains with an additional copy of the *GUT1* gene were distinguished due to the rate of glycerol utilization and presented a 1.4-times higher citrate production compared to the Wratislavia 1.31 strain. In the bioreactor culture, the strain 1.31.GUT1/5 produced 98.7 and 77.4 g/L of citrates from 150 g/L of pure and waste glycerol, respectively. The rate of citrates production from waste glycerol was higher for the transformant 1.31.GUT1/5 (0.97 g/Lh) than for Wratislavia 1.31 (0.79 g/Lh). Under conditions of increased osmotic pressure (for erythritol biosynthesis), strains with the *GUT1*

gene utilized glycerol the fastest. However, the high dynamics of glycerol consumption was not related to the production of erythritol. In the case of strains 1.31.GUT1/5 and 1.31.GUT1/6 mannitol production was the highest. Three strains, 1.31.GUT1/5.CIT1/3.E34672g, 1.31.GUT1/6.CIT1/3.E34672g and 1.31.CIT1/3, produced more erythritol than the parental strain, while the productivity was higher for all transformants, ranging from 0.6 to 0.8 g/Lh. As a result of the transformations, strains with improved dynamics of glycerol utilization and good biosynthesis parameters of both citrates and erythritol were obtained.

Keywords: Yarrowia lipolytica, transformants, crude glycerol, citric acid, erythritol

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Effective Production of α-ketoglutarate from Crude Glycerol by Yarrowia lipolytica

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Abstract

Crude glycerol is a main by-product derived during biodiesel production. Although pure glycerol is a valuable product with thousand applications, the excessive cost of crude glycerol refining makes the latter a problematic waste. Considering market availability, the possibility of crude glycerol valorization to valuable products creates the possibility of additional income for biodiesel plant. It was already proved that raw glycerol might be successfully used as the substrate in microbiological production of different high-value compounds e.g. single cell biomass, lipids, erythritol, mannitol or citric and pyruvic acids with the use of *Yarrowia lipolytica* yeast. In turn, for the production of α-ketoglutaric acid substrates metabolized via beta-oxidation are usually applied, because the use of substrates utilized via glycolysis - including glycerol - results in a high by-production of pyruvate, which reduces the process selectivity. Moreover, the impurities present in crude glycerol may affect yeast metabolism and additionally lower the process yield. The aim of the work was to verify the possibility of glycerol application in the production of α-ketoglutaric acid by *Y. lipolytica*.
In the study pure glycerol and crude glycerol (86%) were used as the sole substrates for the production of α-ketoglutarate by *Y. lipolytica* A-8. In the batch-bioreactor cultures total substrate concentration was 300 g/L and the yeast growth was performed in a simple mineral medium supplemented with thiamine. The impact of thiamine concentration (18-40 µg/L) on the α-ketoglutarate biosynthesis was evaluated in the cultures in which pure glycerol was used at concentration of 100 g/L at the beginning and fed twice in equal portions of 100 g/L every 24 hours of the cultivation process. Biomass concentration was observed to increase (15.8 - 39.5 g/L) simultaneously with the increased thiamine concentration. Production of α-ketoglutaric acid increased from 72.2 to 90 g/L in the cultures with 18 and 30 µg/L of thiamine, respectively. In the same cultures pyruvic acid formation showed the opposite trend, and lowered from 65.3 to 2.8 g/L. In all the cultures comparatively high erythritol production (16.9-36.2 g/L) was observed. The change of substrate dosing strategy - 50 g/L of glycerol applied at the beginning of the process and the rest of the substrate (250 g/L) fed into the culture at a constant rate of 6.4 g/Lh - allowed to reduce erythritol concentration to 0.9-1.2 g/L. Application of this dosing method and crude glycerol resulted in α-ketoglutaric acid production of 86.7 - 117.7 g/L, depending on the substrate dosing rate (6 - 9 g/Lh). The best results were achieved in the culture with feeding rate of 8 g/Lh in which 41.4 g/L of biomass was determined and α-ketoglutarate production reached 117.7 g/L, corresponding to volumetric productivity and selectivity of 0.58 g/g and 91%, respectively. The obtained results showed that biosynthesis of α-ketoglutaric acid by *Y.*

lipolytica was possible in the media with both pure and crude glycerol. However, the effective process of α-ketoglutarate production required an appropriate biomass level, which was controlled by supplementation of thiamine and selected substrate dosing conditions.

Keywords: α-ketoglutaric acid, crude glycerol, Yarrowia lipolytica

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RAC: Risk Analysis, Assessment and Management in Circular Economy

This session covers the subject of risk analysis, assessment and management in Circular Economy. The concept of circular economy (CE) has proven that this notion is indispensable, on the one hand, due to the shortage and insufficiency of appropriate resources, and on the other hand, due to the quantities of the wastage of natural resources which lessen the environmental purity by the pollution and contamination. Therefore, the adoption of the CE idea in the supply chain becomes day after day vital and significant. Although the CE concept itself is reasonably simple, operationalizing can be complicated. Without doubt, the international efforts to develop CE models aimed to prevent waste production. Moreover, due to the composite nature of processes and activities in the circular supply chain (CSC), risk analysis, assessment and management (RAAM) becomes a priority to avoid upheaval. In the scientific literature, there is not available enough discussion concerning RAAM in the context of CSC. Therefore, to replenish this literature gap, this session focuses on identifying, analyzing and assessing the risks in order (i) to promote effectual circular initiatives in CSC in the framework of manufacturing industry, and (ii) to diminish harmful environmental impact.

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Investigation of dangerous infrasound and audible noises on OSH, produced by the vibrancies of diesel engines using biofuels, in the work-environment of sustainable engineering projects

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Abstract

Every vehicle's engine is one of the most important sound sources of a variety of frequencies. By studying the oscillation frequency of the sound source, we can draw conclusions about the frequencies of the sound signals produced and their effects on the human safety/health that is exposed to the corresponding produced sound waves, in the working environment of sustainable engineering projects. This research provides evaluation of experimental results regarding the exposure to infrasound (infrasonic) noise (i.e. below the lower limit of human audibility) and audible noise of the operator in diesel engine motors when a specific amount of biodiesel is used as fuel in normal working conditions. The results showed that in specific rpm (2000) there is emission of sound frequencies below of (or close to) 20 Hz (~10 Hz – 23 Hz). They are characterized by an amount of infrasound effecting the operator, and may cause possible negative results on the sense of hearing, during the driving inside the closed cab of a vehicle (or carriage) at a workplace, and consequently there is an increased risk for the occupational safety and health (OSH). The measured detectable noise levels can conceivably deploy inaudible effects. Investigated diesel motors produce significant levels of noise close to infrasonic level and also show a tendency to go beyond the occupational exposure limits. Low frequency sounds can cause unusual or unpleasant feelings in people despite the fact that they cannot be perceived. Although the last decade there has been an explicit technical improvement in abatement of infrasound subjected at the vehicle's drivers' workplaces there were no regulations regarding the infrasound produced, because there is a variety of fuels that can be combusted by a vehicle (Biodiesel, LPG, CNG).

Keywords: Biodiesel, Vibration, Infrasound, Noise, Occupational Safety and Health

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Cryptosporidium Implications to Agriculture and Beyond - Risks and Research Needs

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Abstract

Cryptosporidiosis is a significant diarrhoeal disease for both people and animals worldwide. Several species of this protozoan parasite can cause the disease. *Cryptosporidium* oocysts have a ubiquitous presence in the environment. *Cryptosporidium* oocysts transmission can occur following direct or indirect contact with an infected host, usually via the faecal-oral route. Person-to-person contact, zoonosis, and consuming contaminated food or water are well-known mechanisms for faecal–oral transmission, with a significant risk of infection from ingesting a single oocyst. Among the agricultural sectors, livestock plays an essential role in the supply of global food security. The growth of the farming and livestock industries has affected the environment, driving the depletion of natural resources, pollution, and greenhouse gas emissions, which concerns these practices' sustainability and future viability. The management of waste, especially agricultural waste, considering the principles of circular economy is crucial for the future viability of these activities; the recovery of by-products, energy, nutrients, and water reuse is fundamental to the closure of the materials cycle. The present article critically reviews scientific research on *Cryptosporidium* species related to the agriculture sector. It summarizes the knowledge about the risks of cryptosporidiosis in agricultural production, emphasizing the sources of contamination, the importance of animal production in parasite transmission, and the role of farmed animals as hosts. The zoonotic potential and the risk to farmers and household members are also highlighted. In contrast, the necessity of a training strategy for farmers and the One Health approach are advocated for controlling and preventing zoonotic cryptosporidiosis.

Keywords: Cryptosporidium, agriculture, water treatment, farms, animals, humans, food, environment

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Assurance of Food Loss and Waste Disclosure. Adoption of a Risk-based Approach to Evaluate the Materiality and Quality of Information

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Abstract

Sustainability Reports (SR) are essential to encourage transparency by showing in a balanced manner, information regarding environmental and social performance of organizations. This is essential to all stakeholder in its decision-making process (García-Sánchez, 2021). Nevertheless, since the content of these reports may be quantitative and qualitative, as well as prospective and retrospective, this information is complex, sometimes subjective, and difficult to compare between years and firms (CSRD, 2022). Based on the signalling theory, the information contained in SR can be used as a signal by the organization to its stakeholders about the level of sustainability performance, however, the reliability of this information is in doubt and, an assurance process is an understandable signal about the reliability and quality of the report (Hummel et al., 2019; Spence, 1973). An assurance engagement helps to reduce information asymmetries and increase the transparency and objectivity of the report, thus improving the credibility perceptions of stakeholders (Junior et al., 2014; Yan et al., 2014). The assurance provider should have basic requirements as professional judgement, scepticism, independence, ethic, expertise and skills and training on sustainability, due diligence and auditing issues. However, there are different standards and levels for an assurance engagement that influences its quality (ISAE 3000, AA1000AS, ISO26000, SA8000, among others). Most current engagements are performed in a limited level (IFAC, 2022), where the risk of expressing an inappropriate conclusion is higher than a reasonable engagement. For this reason, the quality of assurance processes and its outcomes is questioned due to the lack of generally accepted regulation and methods. In parallel, since organizations need to address and manage sustainability risks, this information must be subject to a high-quality assurance process due to its complexity and relevance. As Maroun (2020) stated, “the current assurance model is narrow in audit risk model (…)”. For this purpose, adopting a risk-based approach making use of available science-based assessment tools is crucial to enhance assurance quality. In this study, we focus on the Food Loss and Waste (FLW) information from the agri-food system due to its high social and environmental impacts. According to Eurostat (2022), it is estimated that around 10 percent of food in the EU available to consumers may be wasted whereas, 32.6 million people cannot afford a quality meal every second day (Eurostat, 2021). For this purpose, stakeholders are demanding increasingly information regarding accurate data of FLW, circular economy strategies and actions to prevent it and reduce it, and its impacts in the food supply chain. In this sense, SR need to include this material information and the assurance process must verify if this information is not materially misstated or omitted, and if proportionated, evaluate the quality of this information. Having this into

consideration, the objective of this study is to examine how FLW information is treated in the Assurance of SR from agri-food organizations, and study whereas the materiality and quality of this information is evaluated adopting a risk-based approach to enhance quality reporting.

Keywords: Sustainability Report, Assurance, Food Loss and Waste, Circular Economy, Risk Assessment

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Controlled Environment Agriculture: Innovations, Challenges, and Directions for a Sustainable and Circular Future

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Abstract

This study focuses on the rapidly growing field of controlled environment agriculture (CEA), a modern and technology-driven approach that typically uses artificial lighting, climate control and soilless cultivation in fully enclosed structures such as greenhouses and plant factories. CEA allows for continuous crop production throughout the year and is resilient to climatic extremes and disease risks. CEA represents a dynamic intersection of various disciplines, including plant science, data science, automation, artificial intelligence, robotics, logistics, architecture and elements of the circular economy. Such an interdisciplinary environment boost innovation and development and pushes the boundaries of traditional agriculture. From a sustainability and circular economy perspective, CEA systems are characterised by high efficiency in the use of resources, especially water. Compared to traditional farming methods, they also rely significantly less on the use of chemicals. Despite the promising opportunities CEA, there are many challenges, such as substantial investment costs combined with high energy consumption, which represent economic hurdles that need to be overcome. The relatively high energy demand requires targeted development and innovation to improve energy efficiency and further strengthen the sustainability and circularity of CEA systems. CEA offers significant advantages in regions where traditional farming methods face difficulties due to environmental or logistical constraints. It provides a viable alternative for consistent food production, enabling communities to address food insecurity and support local economies. Furthermore, the selection of crops for CEA is determined by several factors, including market value, shelf-life, growth density, light utilization efficiency for photosynthesis and suitability for automation. Several plants have been identified as particularly suitable for the controlled environment conditions. Future CEA research efforts should focus primarily on reducing energy consumption and optimising light distribution. Special attention should be paid to improving the efficiency of LED light sources and refining the precision of climate control systems. Moreover, the development of sophisticated plant sensors and further advances in automation and robotics will play an important role. From a plant science perspective, there is an urgent need to deepen our understanding of plant responses to various environmental factors. Optimal control of these factors can then help to increase both yield and quality further. In addition to technical improvements, effective public engagement and policy reforms are also crucial. These initiatives are key to integrating CEA into urban planning, global supply chains, local and global regulatory frameworks and the wider circular economy. These efforts will help strengthen public support for CEA and establish it as an important component of future agriculture.

Although CEA does not aim to replace traditional agriculture in the near future completely, it is capable of playing an important role in the broader framework of agriculture. With escalating environmental problems and the urgent need to secure food supplies, CEA is proving to be an innovative and effective solution. Developing and applying CEA will play a crucial role in shaping the future of global agriculture as we address the complex challenges of the 21st century.

Keywords: Controlled Environment Agriculture (CEA), Interdisciplinary innovation, Sustainability and circularity, Energy efficiency, Crop selection, Yield optimization, Public engagement and policy, Future research

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