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Extraction of Pectic Oligosaccharides from Industrial Food Waste and Investigation of Their Prebiotic Activity

Emine Gizem Acar and Derya Kahveci

Food Engineering Department, Istanbul Technical University, Turkey

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Abstract

Prebiotic dietary fibres are indigestible compounds that act as nutrients for beneficial bacteria in the gastrointestinal system, preventing the adhesion of pathogenic bacteria, and inducing apoptosis of human colonic adenocarcinoma cells (Arrutia et al., 2020). Various fruit and vegetable industries produce large amounts of waste that can be used for pectin extraction. In this study, pectic oligosaccharide (POS) was extracted from carrot pomace from juice industry, and black carrot pomace from flavour and colouring industry. Conventional acidic solvent extraction was performed using a 1% (w/v) citric acid solution at 80°C. Drying the pomace and increasing the precipitation time from 1 h to overnight resulted in higher yields (p<0.05). Black carrot pomace was chosen as the waste material because its POS yield was more than twice that of orange carrots. Although increasing the extraction time from 1 h to 2 h significantly increased the pectin yield (p<0.05), the difference was not significant when it was extended to 3 h (p>0.05). Since the POS yield (%) was decreased from 12.62 ± 0.26 to 10.87 ± 0.14 as the solid:solvent ratio was decreased from 1:30 to 1:50, the lowest solvent amount was selected. Ultrasound- and enzyme-assisted extractions had significantly lower POS yields than conventional method (p<0.05), therefore, they were combined with acidic extraction as pretreatments. Although higher yields were obtained at shorter reaction times, the highest yield after the carbohydrase enzyme pretreatment was found to be 4.33%, which is quite low compared to conventional acidic solvent extraction (p<0.05). In 37 kHz ultrasonic (US) pretreatment (15 to 45 min), it was determined that the effect of US power was significant, and the highest efficiency was obtained when operated at 240 W. The DE (%) values were ranged between 63.35 ± 15.16 and 82.46 ± 4.12. It has been reported that POS with a lower DE ferment faster, leading to the formation of more free fatty acids, since less complex structure allows for easier utilization and metabolism by the gut microbiota (Huang et al., 2022; Tian et al., 2016; Zang et al., 2025). According to the yield and DE, the prebiotic activity of POS obtained by conventional extraction, 15 min and 45 min US pretreatment were determined. *Lactobacillus acidophilus*, *Lactobacillus casei*, and *Lactobacillus plantarum* probiotic microorganisms all showed growth after 48 h of incubation in MRS broth prepared with POS instead of glucose. *L. plantarum* showed similar growth to the control MRS in all POS substrates, while other probiotics showed higher viability in the presence of glucose (p<0.05). The ability of different probiotics to utilize POS extracted from food waste as a nutrient was promising. It can contribute to sustainability by being used as an upcycled ingredient, particularly in the development of plant-based functional products.

Keywords: Waste valorisation, pectic oligosaccharide, black carrot pomace, prebiotic, probiotic microorganism