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From Pumpkin Processing By-Products to Novel Beverages: Sensory Profiling of Fermented Pumpkin–Apple Drinks Using the RATA Method

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Abstract

The increasing need for sustainable food systems has led to the exploration of alternative strategies to valorise agro-food by-products and underutilized plant materials. Pumpkin pulp is one of the agro-food by-products resulting from the processing of oil pumpkin (Cucurbita pepo var. styriaca) seeds. The pulp is rich in nutrients but is commonly discarded. Fermentation is an ancient process that has recently been considered as an effective tool for improving technological properties of plant-based ingredients. Accordingly, the present study aims to investigate the potential of fermented pumpkin puree as a valuable ingredient for fruit-vegetable beverages and to explore the sensory properties of the resulting products. Fermentation was performed on pumpkin purees obtained from oil pumpkin (*Cucurbita pepo* var. *styriaca*) and Muscat pumpkin (*Cucurbita moschata*). The fermented pumpkin puree was used to produce fruit-vegetable beverages by mixing it with apple juice at different concentrations (10%, 20%, and 30%). A control sample was prepared by mixing apple juice with non-fermented pumpkin puree. The physicochemical properties, mineral composition, and colour of the fermented pumpkin purees and fruit-vegetable beverages were measured. The sensorial assessment of the fruit-vegetable beverages was also examined by using the RATA test. The RATA test is a sensory analysis approach that enables the evaluation of the presence of multiple sensory attributes. The sensory panel was asked to rate the intensity of the following attributes: colour intensity, apple aroma, pumpkin aroma, sweet taste, acidic taste, texture, and global liking. The results were analysed by using analysis of variance (ANOVA). The multivariate relationship between the samples was also examined by using Generalized Procrustes Analysis (GPA). The results showed that the concentration of fermented pumpkin puree had a significant effect on the sensory properties of the fruit-vegetable beverages. The fruit-vegetable beverages with lower concentrations of pumpkin puree had a higher intensity of apple aroma. Among the evaluated formulations, the beverage containing 20% fermented *Cucurbita moschata* puree achieved the highest overall acceptability (mean score 3.56), whereas the control sample containing non-fermented pumpkin puree showed moderate acceptability (mean score 3.31). Beverages formulated with fermented oil pumpkin puree showed slightly lower sensory scores but remained within acceptable sensory ranges. This study finding demonstrates that fermentation represents a promising strategy for the circular valorisation of pumpkin processing residues and their incorporation into innovative plant-based beverages. The obtained results highlight the potential of fermented pumpkin puree as a functional ingredient capable of improving sensory complexity while contributing to the

sustainable utilisation of agro-food by-products.

Keywords: circular food systems, pumpkin by-products, fermentation, plant-based beverages, RATA sensory profiling

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