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Development of Fibre-Source Muffins Using a By-Product from the Plant-Based Beverage Industry.

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Abstract

The demand for plant-based beverages has grown steadily worldwide, with an estimated annual growth rate of 10.2% between 2020 and 2024. This increase is partly driven by the need to replace cow's milk in individuals with cow's milk protein allergy (CMPA) or lactose intolerance. In addition, dietary choices associated with vegetarian or vegan lifestyles, as well as personal preferences, have contributed to this trend (Markets and Markets, 2020). Plant-based beverages are produced from homogenised extracts of plant matrices. Their manufacture involves particle size reduction of the grains, extraction with water, and subsequent separation of the liquid fraction from the solid residue by filtration (Bocker et al, 2022).
In this context, the present work addresses the development of an oat- and quinoa-based beverage using high hydrostatic pressure as a strategy to extend shelf life. During production, a solid by-product consisting of cereal residues is generated, representing more than 20% of the processed mass. This by-product has a high moisture content (73.7±1.9%) and is therefore dried at 105°C until the moisture content is reduced to 5.58±0.10%, preventing microbial growth. Subsequently, it is milled and sieved through a 500 µm mesh to obtain a flour-like material. Compositional analysis of this flour revealed a high protein content (18.12±0.04%) and a total dietary fibre content of 21.36±0.02%, highlighting its potential as a functional ingredient. Based on these characteristics, muffins were developed by partially replacing wheat flour with this by-product, hereafter referred to as oat and quinoa flour (OQF). A control formulation containing traditional ingredients (wheat flour, sugar, oil, egg, salt, baking powder, and emulsifiers) was prepared, together with three formulations incorporating different levels of OQF substitution: 10%, 25%, and 50%. The formulation with 50% substitution was designed to meet the requirements for a "source of fibre" claim (≥3 g of fibre per 100 g of food). In all cases, the manufacturing process was kept constant, applying the same mixing steps, mixing times, and baking conditions. The four formulations were evaluated through sensory analysis with 12 trained panellists, who assessed 14 descriptors using 10 cm unstructured scales. The sample with the highest OQF content exhibited greater colour intensity in both crust and crumb, a less homogeneous structure, increased dryness and graininess during mastication, more intense cereal flavour and aroma notes, and slight astringency. Analysis of variance (ANOVA), followed by Tukey's test, was used to identify significant differences among formulations ($p<0.05$). Overall, the results suggest that oat and quinoa by-product flour could be successfully used as a functional ingredient in the development of fibre-source muffins, contributing to the valorisation of residues from the plant-based beverage industry. The formulation with 50% substitution was selected for future

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consumer acceptance studies in order to validate its application potential.

Keywords: Plant-based beverages, high hydrostatic pressure, fibre-source muffins

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