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Unlocking the Potential of Goat Milk: Functional Synergies with Coffee Residues for Sustainable Product Innovation

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Abstract:

In response to the rising demand for sustainable and health-promoting food options, recent research has focused on the innovative utilization of agricultural by-products. Coffee processing generates substantial residues that are notably rich in bioactive compounds, particularly antioxidants. Their valorization not only supports environmental sustainability but also enhances the functional profile of food products, in line with bioeconomy principles. This study explores the development of an innovative goat milk yoghurt enriched with coffee residue extracts, as part of the "Ygeiartos" project (Measure 16, Rural Development Program 2014–2020). The product formulation combines goat milk, coffee extract, milk protein concentrates, and fructose, designed to improve both nutritional value and sensory appeal. The final yoghurt exhibits a cohesive structure, smooth texture, pleasant coffee aroma, and a strong espresso-like flavor. Physicochemical analysis recorded a pH of 4.2, with balanced levels of protein and carbohydrates (8.5% each) and a low-fat content (2%). Microbiological evaluation confirmed product safety, showing minimal yeast, mold, and coliform counts, and no presence of pathogens. Importantly, this research also lays the foundation for the development of a broader range of goat milk-based functional products, such as drinkable yoghurt beverages enriched with coffee extracts. These novel formulations cater to health-conscious consumers seeking nutritious, convenient, and environmentally responsible options. Overall, the study illustrates how upcycling coffee residues into dairy products can support circular economy goals while promoting the consumption of goat milk through innovative, value-added applications.

• Introduction

The global food industry is increasingly seeking innovative solutions that combine health benefits with environmental responsibility. Among animal-derived foods, goat milk offers numerous advantages, including high digestibility, low allergenic potential, and a rich nutrient profile consisting of short- and medium-chain fatty acids, essential minerals, and bioactive peptides (Haenlein, 2004). Parallel to this, agricultural waste valorization has emerged as a strategy to enhance sustainability, aligning with the principles of the circular economy and bioeconomy.

Coffee residues, primarily coffee pulp and husks generated during processing, represent a significant environmental challenge when not properly managed (Murthy & Naidu, 2012). Nevertheless, these residues are rich in polyphenols, caffeine, and fiber, offering potential as functional food ingredients.

This study was designed within the framework of the "Ygeiartos" project to formulate and evaluate a goat milk yoghurt enriched with coffee residue extracts. The central hypothesis was that coffee residues could synergistically enhance the nutritional, functional, and sensory attributes of goat milk products, contributing to both consumer health and waste reduction goals.

• Material and method

Goat milk was obtained from the Menikio cooperative in Greece, pasteurized at 72°C for 15 seconds before use. Coffee residues were collected from local cafes in Thessaly, dried, and processed. by solid/liquid extraction with water as a solvent and dehydrated by the lyophilization technique. The yoghurt was formulated using goat milk, coffee residue extract, milk protein concentrates and fructose. Pasteurization (85°C for 10 min) was followed by cooling (42°C), inoculation, and incubation at 42 for 5h. Physicochemical measurements include pH (digital pH meter), protein content (Kjeldahl method) and fat content (Gerber method), while microbiological analysis was performed for total viable counts, yeasts, molds, coliforms, *Salmonella* spp., and *Listeria monocytogenes*, implementing standard ISO protocols.



• Results and discussions

Physicochemical analysis recorded a pH of 4.2, with balanced levels of protein and carbohydrates (8.5% each) and a low-fat content (2%) (Figure 1)

Nutritional Labelling	Per 100g	Per portion(150g)
Energy kj/Kcal	360 kj/ 86 Kcal	543kj/ 130 Kcal
Fat Of which saturated	2g 1.2g	3.0g 1.8g
Carbohydrates Of which sugars	8.5g 8.5g	12.8g 12.8g
Proteins	8.5g	12.8 g
Salt	0.1g	0.15 g

Figure 1:Chemical Analysis

Microbiological evaluation confirmed product safety, showing minimal yeast, mold, and coliform counts, and no presence of pathogens.

The products exhibits a cohesive structure, smooth texture, pleasant coffee aroma, and a strong espresso-like flavor.

• Conclusions

Importantly, this research also lays the foundation for the development of a broader range of goat milk-based functional products, such as drinkable yoghurt beverages enriched with coffee extracts. These novel formulations cater to health-conscious consumers seeking nutritious, convenient, and environmentally responsible options. Overall, the study illustrates how upcycling coffee residues into dairy products can support circular economy goals while promoting the consumption of goat milk through innovative, value-added applications.

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