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Commentary

Efficacy of Natural Plant Extracts as Bio-Preservatives against Spoilage Microorganisms in Dairy Products

Maja Kranjc*

Department of Food Science and Biotechnology, University of Ljubljana, Slovenia

DESCRIPTION

The increasing demand for clean label and preservative free foods has prompted researchers and food producers to explore natural alternatives to synthetic preservatives, especially in perishable products like dairy. Dairy products, particularly those with high moisture content such as cheese, yogurt, and fresh milk, are highly susceptible to microbial spoilage due to the growth of bacteria, yeasts, and molds. This study investigates the antimicrobial efficacy of selected natural plant extracts as bio-preservatives, focusing on their ability to inhibit spoilage microorganisms in commonly consumed dairy products. The use of botanical compounds as food grade preservatives has gained popularity due to their antioxidant and antimicrobial properties, coupled with consumer preference for natural ingredients.

In this investigation, six plant extracts were selected based on existing literature and their traditional use in food preservation: rosemary (*Rosmarinus officinalis*), thyme (*Thymus vulgaris*), clove (*Syzygium aromaticum*), oregano (*Origanum vulgare*), sage (*Salvia officinalis*), and green tea (*Camellia sinensis*). Each extract was obtained using ethanol extraction, concentrated, and tested at varying concentrations against common dairy spoilage organisms including Lactobacillus spp., Pseudomonas fluorescens, Candida albicans, and Penicillium spp. The antimicrobial activity was measured using agar diffusion assays, Minimum Inhibitory Concentration (MIC) testing, and time-kill studies. The dairy matrices tested included yogurt, semi-hard cheese, and pasteurized milk, stored at refrigeration temperatures over a 14-day period to simulate real storage conditions.

The results demonstrated that all six plant extracts exhibited antimicrobial activity to varying degrees, with clove and oregano extracts showing the most consistent and significant inhibitory effects. Clove extract, rich in eugenol, was particularly effective against both bacterial and fungal strains, achieving MIC values as low as 0.2 mg/mL for Candida albicans and Pseudomonas fluorescens. Oregano, containing high levels of carvacrol and thymol, also displayed broad spectrum activity, especially against Penicillium spp., which are major spoilage agents in cheeses. Rosemary and thyme extracts showed moderate activity, with better performance against gram-positive bacteria, while green tea and sage had more selective effects, mostly bacteriostatic rather than bactericidal.

When incorporated into dairy matrices, clove and oregano extracts significantly delayed microbial growth and extended shelf-life. In yogurt samples, the addition of clove extract at 0.5% concentration reduced yeast and mold counts by over 70% compared to controls by day 10. In semi-hard cheese, oregano extract inhibited mold growth on the surface, reducing visible spoilage by nearly half by day 14. Importantly, sensory evaluation conducted with a trained panel revealed that, at appropriate concentrations (≤0.5%), these extracts did not negatively impact the flavor or texture of the products. Higher concentrations, however, particularly of clove and sage, were noted to impart strong, pungent flavors that could affect consumer acceptability.

The study also explored the stability of the antimicrobial compounds during storage. Gas chromatography mass spectrometry (GC-MS) analysis confirmed that the key active components in clove and oregano remained stable throughout refrigerated storage, retaining their bioactivity. Additionally, no significant degradation or adverse chemical interactions were observed between the extracts and dairy components such as proteins or fats. This highlights the feasibility of using these plant-derived compounds in commercial dairy formulations.

Despite the promising results, the study recognizes certain limitations. Natural variability in plant extract composition, influenced by factors like harvest time, origin and extraction method, can affect consistency in antimicrobial activity. Moreover, regulatory approval and labeling requirements for the use of plant extracts in food differ across jurisdictions and may pose challenges for widespread commercial adoption. Nonetheless, the findings support the potential of integrating natural preservatives into dairy processing to enhance product safety and meet consumer expectations.

Correspondence to: Department of Food Science and Biotechnology, University of Ljubljana, Slovenia, E-mail: maja.kranjc@ul-foodsl.si

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In conclusion, the incorporation of natural plant extracts, particularly clove and oregano, presents an effective strategy for controlling spoilage microorganisms in dairy products. These extracts offer a natural, consumer-friendly alternative to synthetic preservatives, contributing to extended shelf life and improved microbial safety. The antimicrobial efficacy observed in both in vitro and in product applications demonstrates their practical viability, especially for refrigerated dairy items prone to spoilage. Future research should focus on optimizing formulation techniques, ensuring batch to batch consistency, and evaluating long term storage impacts. The integration of natural bio-preservatives not only aligns with clean label trends but also promotes sustainable and health-conscious food preservation practices in the dairy industry.