



Title: Freeze-Dried Plant-Based Additives as Natural Ingredients for Functional Foods

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Abstract:

The aim of this study was to evaluate the technological potential of freeze-dried plant materials as functional additives in food products and to assess their influence on the nutritional, physicochemical, and sensory properties of various food matrices. Particular attention was paid to the effect of freeze-drying on the preservation of bioactive compounds and the applicability of freeze-dried fruits, vegetables, herbs, and edible flowers as natural alternatives to synthetic food additives.

Freeze-drying was applied to selected plant materials under low-temperature and reduced-pressure conditions to minimize thermal degradation of heat-sensitive compounds. The obtained freeze-dried ingredients were incorporated into different food systems. The quality of the enriched products was evaluated based on the retention of bioactive compounds, antioxidant activity, color parameters, flavor characteristics, texture, and storage stability.

The results demonstrated that freeze-drying effectively preserved biologically active compounds, including polyphenols, carotenoids, vitamins, dietary fiber, and natural pigments. The incorporation of freeze-dried plant materials significantly enhanced the antioxidant capacity and nutritional value of the developed food products while improving their visual appearance through the presence of natural colorants. Depending on the type and level of plant additive, changes in texture and flavor profiles were also observed, contributing to improved consumer acceptance. Moreover, freeze-dried ingredients successfully replaced synthetic

colorants, flavorings, and antioxidant additives, supporting the development of clean-label products.

Despite the technological advantages of freeze-drying, the relatively high production costs and energy requirements remain important limitations for large-scale industrial implementation. Nevertheless, continuous advances in drying technologies and process optimization are expected to improve the economic feasibility of this preservation method.

It can be concluded that freeze-dried plant-based additives represent promising functional ingredients for the development of innovative food products with enhanced nutritional quality, desirable sensory properties, and extended shelf life. Their application supports current trends toward natural, sustainable, and health-promoting foods and offers considerable potential for future food product innovation.

Biography

Beata Biernacka is an Associate Professor at the Department of Thermal Technology, University of Life Sciences in Lublin. Her research focuses on food technology and human nutrition, with particular emphasis on drying and freeze-drying process engineering, food quality, the design and development of functional foods, and the application of plant-derived ingredients in food products. She is an author and co-author of over 75 scientific papers published in national and international journals.