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Innovations in the fortification of bread with plant-based proteins

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Abstract

The escalating demand for plant-based dietary options, coupled with the global challenge of malnutrition, has propelled the food industry towards innovative solutions. One such promising avenue is the fortification of bread with plant-based proteins. This review delves into recent advancements, methodologies, and the potential health implications of integrating plant-based proteins into bread products. By examining the sourcing, technological challenges, consumer acceptability, and nutritional outcomes, this article aims to provide a comprehensive overview of the current state and future prospects of fortified bread products.

Keywords: Plant-based proteins, food industry, advancements

Introduction

The fortification of bread with plant-based proteins embodies a transformative approach in the realm of food science, addressing contemporary dietary needs and environmental concerns. This innovative practice merges nutritional enhancement with sustainability, aiming to elevate the health benefits of one of the world's most universally consumed staple foods. The main objective of fortifying bread with plant-based proteins is to increase the protein content and improve the nutritional profile of bread products, making them more aligned with the dietary needs of a diverse and growing global population. This endeavor not only seeks to cater to the increasing consumer preference for plant-based diets but also to address the urgent need for sustainable food production practices that minimize environmental impact (Hoehnel A, *et al.* 2019) ^[1].

The move towards plant-based protein fortification in bread is driven by several key factors: the rising awareness of the health, environmental, and ethical implications of animal-based protein consumption; the global challenge of protein-energy malnutrition; and the growing prevalence of lifestyle-related diseases. Plant-based proteins, derived from sources such as legumes, grains, nuts, and seeds, offer a rich array of essential amino acids, fibers, vitamins, and minerals. Their incorporation into bread can significantly enhance the nutritional value of this widely consumed food, providing benefits such as improved heart health, weight management, and reduced risk of chronic diseases (Jeske S, *et al.* 2018) ^[2].

Main Objective

The main objective of this paper is to critically evaluate and synthesize the latest innovations in the fortification of bread with plant-based proteins.

Fortification of Bread with Plant-based Proteins

Fortifying bread with plant-based proteins involves integrating protein-rich plant-based ingredients into traditional bread recipes to enhance their nutritional value, particularly their protein content. This process aims to cater to the growing consumer demand for healthier, more sustainable dietary options while maintaining the sensory qualities that make bread universally loved. Among the diverse sources of plant-based proteins are legumes like peas, chickpeas, and lentils, which are not only rich in protein but also fiber, vitamins, and minerals, contributing to the bread's nutritional density and improving its profile in terms of essential amino acids (Day L, *et al.* 2013) ^[3].

Grains such as quinoa and amaranth are also favored for their complete protein profiles, containing all nine essential amino acids necessary for human health, and can be milled into flour and used in bread formulations. Nuts and seeds, including almonds, chia, and flaxseeds, offer additional benefits as they are high in protein, healthy fats, and other bioactive compounds that can enhance the bread's nutritional content. These ingredients can significantly improve the bread's content of omega-3 fatty acids and antioxidants, promoting heart health and overall well-being. The incorporation of these plant-based proteins into bread requires careful consideration of their impact on the dough's texture, taste, and baking properties. Protein-rich ingredients can affect the dough's elasticity and gas retention, which are crucial for achieving the desired bread volume and softness. Techniques such as enzyme treatment, hydrothermal processing, and the use of hydrocolloids or emulsifiers are often employed to address these challenges, ensuring that the fortified bread retains its appealing texture and flavor. Furthermore, the process of fortification must navigate the balance between enhancing nutritional value and maintaining consumer acceptability (Nachay K, *et al.* 2019) [4]. This balance involves managing the flavors and textures introduced by plant-based proteins to ensure they complement the bread without overwhelming its traditional characteristics. Consumer preferences for natural, clean-label products have also guided the development of fortification strategies that prioritize minimal processing and the use of whole-food ingredients. As the food industry continues to innovate, the fortification of bread with plant-based proteins represents a key area of growth, driven by consumer interest in healthier eating options and the environmental benefits of plant-based diets. This evolving field promises to deliver products that are not only nutritious and sustainable but also enjoyable, meeting the needs of consumers looking for wholesome, plant-forward dietary choices (Kleba SA, *et al.* 2018) [5].

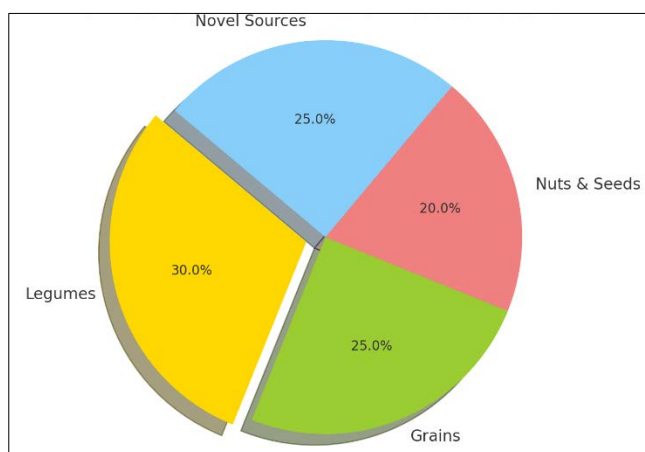


Fig 1: Fortification of Bread with Plant-based Proteins

The diagram provides a visual representation of the distribution of plant-based protein sources used in the fortification of bread, segmented into four categories: Legumes, Grains, Nuts & Seeds, and Novel Sources. This distribution underscores the multifaceted approach to enhancing the nutritional profile of bread, a staple food consumed worldwide, through the incorporation of diverse plant-based proteins. Legumes, which account for the largest segment at 30%, are a prime source of plant-based

proteins for bread fortification. This category includes peas, lentils, chickpeas, and beans, known for their high protein content, essential amino acids like lysine, and additional benefits such as fiber, vitamins, and minerals. The prominence of legumes in this diagram highlights their nutritional value and versatility in bread formulations, offering a balanced amino acid profile that complements the inherent proteins in bread. Grains make up 25% of the sources and include quinoa, amaranth, and barley, among others. These are particularly valued for their complete protein profile, containing all nine essential amino acids, and their contribution to the bread's overall texture and flavor. Grains also bring a variety of micronutrients, such as B vitamins and minerals, enhancing the bread's nutritional density. Nuts and seeds, contributing 20%, are rich in protein, healthy fats, and other bioactive compounds like antioxidants. Almonds, chia seeds, and flaxseeds not only boost the protein content but also enhance the fatty acid profile of bread, offering omega-3 fatty acids which are beneficial for heart health (Rosell CM, *et al.* 2019) [10]. Their inclusion in bread fortification strategies underscores the aim to improve nutritional outcomes and cater to specific dietary needs, such as gluten-free diets. Novel sources, also making up 25%, include unconventional but increasingly popular protein sources like hemp seeds, spirulina, and other microalgae. These sources are recognized for their high-quality protein, containing all essential amino acids, and for their unique nutritional profiles rich in vitamins, minerals, and antioxidants. The exploration of novel sources reflects the ongoing innovation in food technology and nutrition science, aiming to diversify the protein sources in bread fortification and address sustainability concerns (Lai WT, *et al.* 2017) [8].

Innovations in the Fortification process

Innovations in food fortification processes have evolved significantly, aiming to address nutritional deficiencies globally, improve public health outcomes, and meet the increasing consumer demand for nutritionally enhanced foods. These advancements have been particularly important in tackling micronutrient malnutrition, often referred to as "hidden hunger," by enriching staple foods with essential vitamins and minerals;

- Microencapsulation involves encasing nutrients within a protective shell to preserve their stability and control their release. This technique has been widely studied for its application in fortifying foods with volatile or sensitive nutrients, such as omega-3 fatty acids, vitamins, and minerals that might otherwise degrade during processing or storage. Microencapsulation addresses several challenges in food fortification, including improving the bioavailability of micronutrients, masking undesirable flavors, and extending shelf life. However, the cost and complexity of the technology pose challenges for widespread adoption, particularly in low-resource settings.
- Nanotechnology involves manipulating substances at the molecular or atomic level to enhance the bioavailability and solubility of nutrients. This approach has been applied to fortify foods with micronutrients like iron, zinc, and calcium. The potential of nanotechnology in fortification lies in its ability to overcome limitations of traditional fortification methods, such as poor solubility and absorption of

micronutrients. However, concerns over the long-term health effects of nanoparticles and regulatory challenges remain.

- Genetic modification and biofortification aim to increase the nutrient content of crops through genetic engineering or selective breeding. This strategy targets the root of micronutrient deficiencies by enhancing the nutritional profile of staple crops. Genetic modification and biofortification offer sustainable solutions to micronutrient deficiencies. However, public acceptance, ethical considerations, and the need for comprehensive safety assessments pose significant challenges.
- High-pressure processing (HPP) is a non-thermal pasteurization technique that can be used to preserve the nutritional quality of fortified foods by inactivating pathogens and enzymes without the use of high temperatures, which can degrade sensitive nutrients. HPP presents a promising method for preserving the nutritional integrity of fortified foods. The main limitation is the high investment cost for HPP equipment, making it less accessible for small-scale producers.
- 3D food printing offers unprecedented control over food composition, enabling the precise fortification of foods with tailored nutrient profiles. This technology allows for the customization of food based on individual nutritional needs. Studies exploring the use of 3D food printing for creating nutrient-dense snacks have shown promising results in terms of precision and customization. For example, 3D-printed snacks with tailored proportions of protein, fiber, and vitamins have been successfully produced for specific dietary requirements.
- While 3D food printing holds great potential for personalized nutrition and fortification, challenges related to cost, scalability, and the development of suitable "food inks" remain.

Conclusion

The exploration of innovations in the fortification of bread with plant-based proteins reveals a compelling intersection of nutrition science, food technology, and consumer health. As global dietary patterns shift towards plant-based eating for health, environmental, and ethical reasons, the fortification of staple foods like bread with plant-based proteins stands out as a significant advancement. This approach not only addresses the nutritional deficiencies prevalent in various populations but also aligns with the sustainable food production and consumption goals.

The integration of plant-based proteins into bread involves overcoming various challenges, including maintaining the sensory qualities of bread, ensuring the bioavailability of fortified nutrients, and addressing consumer acceptance. Innovations such as microencapsulation, high-pressure processing, and the use of novel protein sources, including legumes, seeds, and algae, have demonstrated considerable promise in enhancing the nutritional profile of bread while preserving its taste, texture, and shelf life.

Moreover, these fortification strategies reflect a broader trend towards personalized nutrition, where foods are tailored to meet individual dietary needs and preferences. As research continues to advance, the potential for 3D food printing and nanotechnology in creating customized,

nutrient-dense bread products could further revolutionize the field.

However, the successful implementation of these innovations requires careful consideration of regulatory standards, cost implications, and the environmental impact of sourcing and processing plant-based proteins. Collaboration among scientists, industry stakeholders, policymakers, and consumers is essential to navigate these complexities and ensure that fortified bread products are accessible, affordable, and acceptable to a wide audience.

In conclusion, the fortification of bread with plant-based proteins represents a dynamic area of food innovation, offering significant benefits for public health and sustainability. As we move forward, continued research and development, along with an open dialogue between all stakeholders, will be key to maximizing the potential of these innovations. This endeavor not only promises to enrich our diets with essential nutrients but also to contribute to a more sustainable and health-conscious food system.

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