

Millets as Nutraceutical Foods: Role of Processing in Health Enhancement

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Abstract

Millets, once regarded as traditional grains of marginal importance, are now gaining global recognition as nutritionally rich and climate-resilient crops. These small-seeded cereals are packed with dietary fiber, essential minerals, vitamins, antioxidants, and bioactive compounds that contribute to human health beyond basic nutrition. Because of these health-promoting properties, millets are increasingly being classified as nutraceutical foods. However, the nutritional and functional potential of millets can be significantly influenced by processing techniques. Traditional and modern processing methods such as soaking, germination, fermentation, malting, roasting, extrusion, and milling can improve nutrient bioavailability, reduce antinutritional factors, enhance digestibility, and create value-added food products. This article explores the nutraceutical significance of millets and highlights how processing technologies play a crucial role in enhancing their health benefits and consumer acceptability.

Introduction

The modern consumer is increasingly seeking foods that not only satisfy hunger but also promote health and prevent disease. This shift has fueled interest in nutraceuticals—foods that provide medical or health benefits beyond their nutritional value. Among the various foods being explored for their nutraceutical potential, millets have emerged as a promising group of grains that combine exceptional nutrition with environmental sustainability.

Millets have been cultivated for thousands of years across Asia and Africa and have traditionally served as staple foods in many rural communities. However, the dominance of rice and wheat in modern diets led to a decline in millet consumption. In recent years, growing awareness about lifestyle diseases such as diabetes, obesity, cardiovascular disorders, and digestive problems has revived interest in these ancient grains.

Millets are naturally rich in complex carbohydrates, dietary fiber, proteins, minerals, vitamins, and a range of bioactive compounds. Their ability to support health and reduce disease risk has positioned them as important

functional and nutraceutical foods. At the same time, processing technologies are unlocking new opportunities to enhance the nutritional quality, safety, shelf life, and consumer appeal of millet-based products.

Millets as Nutraceutical Foods

The term nutraceutical refers to a food or food component that offers health benefits, including the prevention and treatment of diseases. Millets fit this definition because they contain numerous compounds that contribute to improved health outcomes. Different millet species such as pearl millet, finger millet, foxtail millet, little millet, barnyard millet, kodo millet, proso millet, and sorghum possess unique nutritional profiles. They are excellent sources of dietary fiber, which supports digestive health and promotes satiety. Their low glycemic index makes them particularly beneficial for individuals with diabetes, as they help regulate blood glucose levels and reduce sudden spikes in blood sugar.

Millets are also rich in minerals such as calcium, iron, magnesium, phosphorus, potassium, and zinc. Finger millet, for example, is recognized for its exceptionally high calcium content, making it valuable for bone health. In addition, millets contain various phytochemicals, including phenolic compounds, flavonoids, tannins, and antioxidants that help neutralize harmful free radicals and reduce oxidative stress in the body. Regular consumption of millet-based foods may contribute to lower risks of cardiovascular diseases, obesity, type 2 diabetes, certain cancers, and gastrointestinal disorders. These health-promoting attributes have elevated millets from being merely staple grains to becoming important components of functional and preventive nutrition.

The Need for Processing

Despite their nutritional richness, raw millets also contain certain antinutritional factors such as phytates, tannins, oxalates, and enzyme inhibitors. These compounds can interfere with the absorption of minerals and reduce nutrient utilization. In addition, some millet varieties possess a coarse texture, characteristic flavor, or limited shelf life that may affect consumer acceptance. Processing serves as a critical intervention to overcome these limitations. Appropriate

processing methods can improve nutrient availability, enhance sensory quality, increase digestibility, reduce cooking time, and create innovative food products suitable for modern lifestyles. As a result, processing has become an essential component in maximizing the nutraceutical potential of millets.

Soaking and Germination

Soaking is one of the simplest and most effective processing methods used for millets. During soaking, grains absorb water and activate metabolic processes that initiate biochemical changes. This process helps reduce certain antinutritional compounds and improves the availability of minerals.

Germination, also known as sprouting, further enhances these benefits. During germination, enzymes become active and break down complex storage compounds into simpler, more digestible forms. Protein digestibility increases, while vitamin content, particularly B-complex vitamins and certain antioxidants, may also improve. Studies have shown that germinated millet products exhibit enhanced nutritional quality and are particularly suitable for infants, elderly individuals, and people with digestive difficulties. The process also contributes to improved flavor and texture, making millet-based foods more appealing to consumers.

Fermentation and Health Benefits

Fermentation is a traditional processing technique widely used in many cultures. Beneficial microorganisms convert carbohydrates into organic acids and other metabolites, resulting in improved nutritional and sensory characteristics. Fermented millet products often demonstrate enhanced protein quality, increased mineral bioavailability, and reduced levels of antinutritional factors. The acidic environment created during fermentation helps break down phytates that normally bind essential minerals such as iron and zinc. Furthermore, fermentation can introduce probiotic benefits, supporting gut health and improving digestion. Traditional fermented millet foods have long been valued for their therapeutic properties, and modern research continues to validate their role in promoting a healthy gastrointestinal microbiome.

Malting and Nutritional Enhancement

Malting involves controlled germination followed by drying. This process is commonly used to improve nutritional quality and functional properties. During malting, enzymatic activity breaks down starches into simpler sugars and partially hydrolyzes proteins, enhancing digestibility. Malted millet flour is frequently used in weaning foods, nutritional beverages, and health supplements because of its improved nutrient availability and desirable sensory characteristics. The process also contributes to better flavor development and increased consumer acceptance.

Roasting and Thermal Processing

Roasting is a widely practiced method for improving the flavor, aroma, and shelf life of millet grains. Controlled

heat treatment can reduce moisture content, inactivate undesirable enzymes, and enhance storage stability.

Roasting also promotes the development of pleasant nutty flavors that increase consumer appeal. While excessive heating may result in some nutrient losses, properly controlled roasting can preserve most nutritional components while improving overall product quality. Other thermal processing techniques, including steaming and puffing, are also used to create ready-to-eat millet products that cater to the growing demand for convenient and healthy foods.

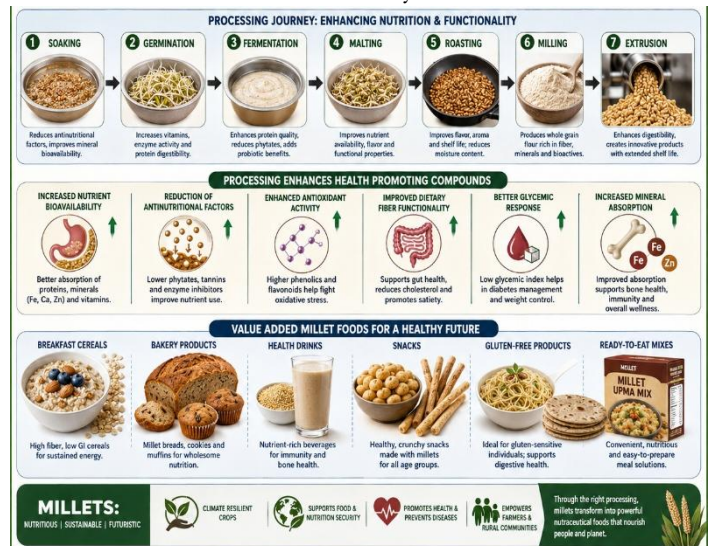


Fig. 1. Processing Technologies Enhancing the Nutraceutical Value of Millets

Extrusion Technology and Functional Foods

Modern food industries increasingly employ extrusion technology to produce innovative millet-based products such as breakfast cereals, snack foods, pasta, and instant mixes. Extrusion combines heat, pressure, and mechanical shear to transform raw ingredients into attractive products with desirable texture and appearance. This process can improve starch digestibility, reduce microbial contamination, and enhance product versatility. Extruded millet products provide consumers with convenient options while retaining many of the nutritional advantages associated with whole grains. The growing popularity of millet-based extruded snacks demonstrates how advanced processing technologies can help bridge the gap between traditional nutrition and modern consumer preferences.

Milling and Product Development

Milling is one of the most common processing methods used to convert millet grains into flour. Millet flour serves as the foundation for a wide range of value-added products, including breads, biscuits, noodles, pancakes, porridges, and bakery items. However, milling must be carefully managed because excessive removal of outer layers may reduce dietary fiber, minerals, and bioactive compounds. Advances in milling technology now allow the production of whole-grain millet flours that preserve many of the health-

promoting components present in the grain. The development of millet-based functional foods is expanding rapidly as food industries respond to growing consumer demand for nutritious and gluten-free alternatives.

Processing and Disease Prevention

The health-enhancing effects of processed millets extend beyond improved nutrient availability. Many processing methods increase the concentration or bioaccessibility of antioxidant compounds that help protect cells from oxidative damage. Improved mineral absorption contributes to the prevention of nutritional deficiencies, particularly iron and calcium deficiencies that remain widespread in many populations. Enhanced dietary fiber functionality supports digestive health and may contribute to better cholesterol management. Processed millet products with lower glycemic responses can aid in diabetes management and weight control. Consequently, appropriate processing not only improves food quality but also strengthens the disease-preventive potential of millets.

Conclusion

Millets are among the most promising nutraceutical foods of the twenty-first century, offering a unique combination of nutritional richness, health-promoting bioactive compounds, and environmental sustainability. Their potential to combat lifestyle diseases, improve nutritional security, and support preventive healthcare has attracted renewed global attention. However, the full benefits of millets can only be realized through appropriate processing techniques that enhance nutrient bioavailability, reduce antinutritional factors, improve digestibility, and increase consumer acceptability. Traditional methods such as soaking, germination, fermentation, and malting, along with modern technologies such as extrusion and advanced milling, play a pivotal role in unlocking the health-enhancing properties of these ancient grains. As research and innovation continue to advance, processed millet-based foods are poised to become important components of healthier and more sustainable food systems worldwide.

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