Thermal Processing on the Nutritional Composition and Storage Stability of Barnyard Millet (Echinochloa frumentacea)

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ABSTRACT

Barnyard millet (*Echinochloa frumentacea*) is a nutritious minor millet that can help fight malnutrition and improve food security in areas that face drought. However, its short shelf life and susceptibility to spoilage have limited its widespread use. Thermal processing methods, like roasting and puffing, are increasingly recognized for their ability to improve nutritional quality and extend storage stability. This review looks at recent scientific studies on how thermal treatments affect barnyard millet. It highlights how these processes preserve and enhance bioactive compounds, lower antinutrients, and increase shelf life. The best processing conditions, especially roasting at 130°C for 15 minutes, have been found to greatly boost antioxidant activity, nutrient accessibility, and storability. These findings provide a basis for using thermal processing to create long-lasting, nutritious barnyard millet products, which can support sustainable eating habits and food security efforts.

INTRODUCTION

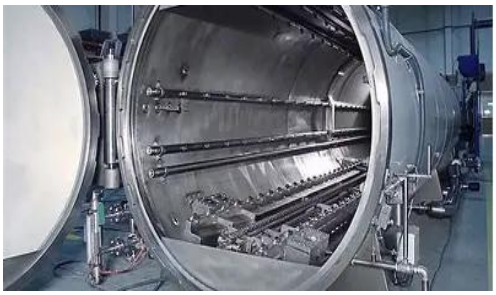
Barnyard millet (*Echinochloa frumentacea*) is an ancient cereal that is rich in protein, full of vital minerals, and capable of withstanding climatic stress in remarkable manners. The cereal is a major agent in the fight against malnutrition,

especially in parts of Africa and South Asia, where drought and low soil fertility limit the development of traditional staple cereals. Even though it is extremely nutritious, barnyard millet is readily perishable and prone to enzymatic attack, thereby restricting its shelf life as well as commercial use. Thermal processing methods like roasting, puffing, and steaming may introduce beneficial alterations in the physical and chemical properties of the grain, improving its shelf stability, flavour, and nutritional content. These heat operations minimize antinutritional compounds such as tannins and phytates inhibiting mineral absorption. Latest research has shown that controlled thermal processing enhances the nutritional content of the grain, antioxidant capacity, and storage life, hence barnyard millet is a potential source for formulating health-food and functional food products. (Bhatt, D *et al* 2023)

Nutritional Enhancements via Thermal Processing

Bioactive Compound Preservation & Enhancement

Polyphenols and antioxidants in barnyard millet are heat-sensitive. In spite of that, controlled roasting of the millet at 130°C for approximately 15 minutes has been found to improve total phenolic content and antioxidant activity by almost 9%. This enhancement is due to the degradation of cell walls, which makes bound phenolic compounds available. This enhancement in antioxidant capacity can be a determining factor in mitigating the risk of disorders brought about by oxidative stress.



Protein and Carbohydrate Quality

Heat treatment enhances protein digestibility by disrupting the complex proteins and inactivating antinutritional factors so that amino acids become more available for absorption. Some heat treatments also promote the development of resistant starch, which promotes improved gut health and helps manage blood sugar levels.

Mineral Bioavailability

Thermal processing serves to reduce the content of antinutrients like phytates and tannins, thus improving the bioavailability of key minerals a critical aspect of eliminating micronutrient deficiencies. Of these procedures, roasting and steaming are most efficient in bringing down the levels of these substances without affecting the general nutritional value of the grain.

Impact on Storage and Shelf Life

Roasting barnyard millet at the best temperature of about 130°C greatly increases its shelf life, keeping it stable for a period of six months (Jog, S. S *et al* 2025) This is achieved by inactivating enzymes responsible for spoilage, reducing moisture content, and limiting lipid oxidation, which subsequently inhibits rancidity—the primary cause of millet spoilage.

Puffing and Higher-Temperature Treatments

Hot air puffing with an approximate temperature of 310°C results in physical expansion of the grains and the creation of

protective surface layers, which assist in minimizing microbial growth and oxidative degradation. Treatment also increases cooking efficiency and quality of the grains, enhancing texture as well as appearance to make them more acceptable to the consumer.

Practical Outcomes

Processing improves the physicochemical properties of barnyard millet grains, such as their swelling capacity and hydration index. These enhancements render the grains more useful for application in a range of food items like snacks, porridges, and gluten-free flours.

Applications in Food Industry

Thermally processed barnyard millet has functional properties that facilitate the production of novel, health-oriented food products.

Roasted millet flour is being more commonly used in bakery items, ready-to-consume foods, and nutritional bars (Nazni P *et al* 2016). Its enhanced shelf life and greater nutrient bioavailability make it suitable for the production of millet-based convenience foods for diabetic and gluten intolerance conditions.

Challenges and Future Perspectives

While there are obvious advantages, the maintenance of efficient thermal treatments during large-scale processing remains challenging. Excessive heat treatment may result in the loss of temperature-sensitive nutrients; therefore, temperature and time of processing should be precisely controlled. Advanced techniques involve microwave-assisted roasting and vacuum-based thermal methods to improve nutrient retention and increase the shelf life of the product. Exploration of nanotechnology-based biofortification coupled with fermentation techniques holds tremendous potential in improving the nutritional and health benefits of barnyard millet. Moreover, long-term storage evaluation studies in various environmental conditions should be carried out to establish reliable industry standards.

Conclusion

Thermal treatment determines the nutritional quality and storage stability of barnyard millet. Appropriately controlled roasting conditions can enhance bioavailability, reduce levels of antinutrients, and extend shelf life, making the millet a highly valued component of functional foods. In the face of growing interest among consumers in healthy and gluten-free climatically resilient grains, proper thermal processing will play an important role in actualizing the potential of barnyard millet for sustainable nutrition and food security.

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