Article ID 240203-S-03

Finger Millet: Processing Innovations and Value Addition for Enhanced Utilization and Market Potential

Puja Das[1]*, Robin Subba[2], Radha krishnan Kesavan[1], and Prakash Kumar Nayak[1]

[1]Department of Food Engineering and Technology, Central Institute of Technology Kokrajhar, Kokrajhar 783370, Assam, India

[2]Department of Processing and Food Engineering, College of Agricultural Engineering and Post Harvest Technology, Ranipool, Gangtok-737135, India

*Corresponding Author: pdas12994@gmail.com

Millets, classified as minor cereals in the grass family (Poaceae), serve as a vital alternative food source for the expanding global population. They play a crucial role in mitigating challenges such as water scarcity, escalating food prices, and various socio-economic impacts. Particularly in arid and sub-arid regions, millets are often hailed as the staple food for the most economically disadvantaged. These small-seeded, annual cereal grasses are well-adapted to tropical and arid climates, demonstrating remarkable resilience in less fertile soil. Currently, millets occupy approximately 11.4 % of the total area allocated to cereals and contribute around 4.1 % to the total cereals output. Cereals constitute a significant portion of the human diet, serving as a vital source of starch and other dietary carbohydrates, including dietary fibre, which are crucial for meeting energy requirements and ensuring nutrient intake. Following rice, sorghum, and wheat, millet ranks among the most important cereals and has served as a dietary cornerstone in many African and Indian communities for millennia. Notably, millet cultivation is viable in poor sandy soils with low rainfall, underscoring its value as a resilient crop.

India leads globally in the production of small millets, including finger millet, kodo millet, foxtail millet, proso millet, and little millet. These millets collectively cover approximately 2.5 million hectares annually, with finger millet alone occupying 40-50 % of the global crop area. Karnataka stands out as the top producer of finger millet in India, contributing a significant 58 % to the total output. Despite this impressive contribution, finger millet ranks sixth in production nationally, following wheat, maize, sorghum, rice, and bajra. Finger millet stands out for its richness in slowly digestible starch, resistant starch, calcium (344 mg per 100 mg), and iron (3.9 mg per 100 mg), making it a highly valuable cereal. Finger millet's nutritional superiority over other common cereals, particularly in terms of its high calcium and magnesium content, is noteworthy. It is utilized in the production of various bakery products and is suitable for individuals with celiac disease due to its gluten-free nature. Processing methods include milling, malting, popping, and decortications.

Figure 1: Pictorial view of Finger millets

Nutritionally, finger millet stands out for its protein and fat content, comparing favorably to rice, and surpassing both rice and wheat in mineral and micronutrient content. Its high dietary fibre and phenolic compound content further enhance its nutritional profile. Finger millet grains are utilized in the production of a diverse array of products, including porridge, puddings, pancakes, biscuits, roti, bread, and snacks. Malted finger millet serves as a nourishing food for infants and is considered a wholesome dietary option for diabetic patients.

Diving into the Nutritional Advantages of Finger Millet

Finger millet is a valuable source of nutrients, particularly calcium, minerals, and fibre, offering excellent nutritional value. It contains approximately

6 % to 8 % protein, 1 % to 1.7 % fat, 65 % to 75 % starch, 2 % to 2.25 % minerals, and 18 % to 20 % dietary fibre. Compared to wheat, maize, sorghum, and rice, finger millet has a superior proximate composition in terms of dietary fibre, calcium, and several micronutrients. The seed coat of this millet is particularly rich in phenolic compounds, minerals, and dietary fibre.

Dietary fibre: Finger millet grain boasts an impressive total dietary fibre content of 22.0 %, surpassing that of most other cereal grains such as wheat (12.6 %), rice (4.6 %), maize (13.4 %), and sorghum (12.8 %). Dietary fibres are classified into water-soluble and insoluble categories.

Mineral content: The mineral content of finger millet includes essential nutrients such as calcium, iron, magnesium, and potassium. Compared to other cereals, finger millet is particularly rich in calcium, with values ranging from 344 mg to 387 mg per 100 g of grain. Iron content is also notable, with values ranging from 3.9 mg to 5.3 mg per 100 g. Additionally, finger millet contains significant amounts of magnesium (137-283 mg per 100 g) and potassium (408-433 mg per 100 g), making it a valuable source of these essential minerals.

Protein content: Finger millet is known for its relatively high protein content compared to other cereals. It typically contains between 6 % to 8 % protein, making it a good source of plant-based protein. This protein content, combined with its rich mineral and fibre content, contributes to the nutritional value of finger millet. In addition to its protein content, finger millet is also a good source of essential amino acids, especially methionine and cysteine, which are relatively low in other cereals. These amino acids are important for various biological processes in the body, including protein synthesis and immune function. Furthermore, finger millet protein is more digestible compared to protein from other cereals, making it a valuable dietary component, particularly for individuals with limited protein sources.

Carbohydrate content: Finger millet is predominantly composed of carbohydrates, which account for approximately 65 % to 75 % of its composition. This carbohydrate content primarily consists of starch, which provides a major source of energy. The high starch content, coupled with its relatively low glycaemic index, makes finger millet a favourable option for individuals seeking sustained energy release and better blood sugar control.

Processing of millets

The processing of finger millet involves several steps to make it suitable for consumption. Initially, the grains are cleaned to remove impurities like dust and stones. Following this, dehusking is performed to remove the outer husk, leaving the edible portion. The dehusked grains are then milled into flour, which can be adjusted for fineness based on the desired end product. This flour can be cooked in various ways, such as boiling to make porridge or used to prepare flatbreads. In some traditional recipes, the flour is fermented before cooking to enhance its nutritional value and digestibility. Overall, the processing of finger millet involves cleaning, dehusking, milling, and cooking, with variations based on regional practices and intended use.

Milling

The milling of finger millet involves grinding the dehusked grains into flour. This process can be performed using various types of milling equipment, such as stone mills, hammer mills, or roller mills. Stone mills are traditional and utilize two round stones to crush the grains, resulting in a coarse flour. Hammer mills use rotating hammers to pulverize the grains, producing a finer flour. Roller mills crush the grains between rotating rollers to create a uniform flour texture. The choice of milling equipment depends on factors such as the desired flour fineness and production scale. After milling, the finger millet flour can be further processed or used directly in various culinary applications, such as making porridge, flatbreads, or baked goods.

Roasting

Roasting is a common method used to process finger millet, enhancing its flavor and aroma. The process involves heating the grains in a dry pan or oven until they turn golden brown and emit a nutty fragrance. Roasting also helps improve the digestibility of finger millet by breaking down antinutritional factors. Roasted finger millet can be

ground into flour and used to make porridge, baked goods, or snacks. The roasting process can vary depending on the desired level of roasting and the intended use of the millet. Roasting finger millet is typically achieved by heating the grains in a dry pan or skillet over medium heat. The grains are spread evenly in the pan and stirred frequently to ensure even roasting and prevent burning. Alternatively, finger millet can be roasted in an oven by spreading the grains on a baking sheet and baking them at a moderate temperature until they turn golden brown and emit a nutty aroma. The roasting time can vary depending on the quantity of millet being roasted and the desired level of roasting. Once roasted, the millet can be allowed to cool before grinding into flour or incorporating into various dishes.

Popping

Popping is another method of processing finger millet, which involves heating the grains rapidly in a dry environment until they burst open. This process causes the millet to puff up and become light and crunchy. Popping can be achieved by placing the grains in a hot, dry skillet or pan and stirring constantly until they start to pop. It is important to use high heat and keep the grains moving to prevent them from burning. Popped finger millet can be eaten as a snack or used as a topping for salads, soups, or breakfast cereals.

Malting

Malting is a process that involves soaking the finger millet grains in water, allowing them to germinate, and then drying them. This process activates enzymes in the grains, which break down starches into sugars, making the grains sweeter and more digestible. Malting can be achieved by soaking the grains in water for a specified period, draining them, and then allowing them to germinate in a warm, humid environment. Once the grains have germinated, they are dried using low heat to stop the germination process. The dried, malted grains can be ground into flour and used to make a variety of foods, including malted beverages, bread, and porridge.

Value added food products using finger millet

Finger millet can be utilized to create a variety of value-added food products. The grains can be ground into flour, offering a gluten-free alternative for baking bread, biscuits, cakes, and other baked goods. The flour can also be used to make porridge, which can be flavored and sweetened to taste. Finger millet can be malted to produce beverages rich in nutrients, and the popped grains can be seasoned for a healthy snack. Additionally, finger millet flour can be fermented to make foods like idli and dosa, enhancing their digestibility and nutritional value. Finger millet porridge is a nutritious option for infants and young children, providing essential vitamins and minerals for growth and development. Finally, finger millet flour can be used to create instant mixes for convenient meal preparation, offering a versatile and nutritious ingredient for a range of food products.

Roti/ Chapati: A blend of wheat and finger millet in a 7:3 ratio (wheat:finger millet) is recommended for making chapattis. This blend reduces gluten content but does not compromise the ability to make well-textured chapattis. The resulting chapattis may have a slightly darker color due to the finger millet. Adding finger millet to chapattis enhances flavor and effectively controls glucose levels in diabetic patients. The slow digestion rate and high fibre content of finger millet create a feeling of fullness with fewer calories, potentially preventing overeating. Additionally, finger millet's fibre content can help alleviate constipation, offering additional health benefits.

Papad: Papad, a staple in South Indian cuisine, features a blend of ingredients including finger millet flour (15-20 %), combined with black gram, rice, and spices. During its preparation, the finger millet flour undergoes cooking in water until it reaches a gelatinized consistency. The dough is then rolled out and cut into various shapes before being dried to achieve a moisture content of 7 %. The inclusion of the pericarp of the finger millet grain, which is not separated from the starch, imparts a slightly darker hue to the papad. However, this color transforms to a lighter shade upon frying, enhancing the visual appeal of the final product.

Bakery Products: There is a concerted effort to integrate finger millet flour into a range of bakery products, including biscuits, nankhatai, muffins, and bread. This initiative seeks to establish standardized recipes and maintain consistent product quality.

Incorporating millets into bakery goods not only boosts their fibre content and micronutrient profile but also paves the way for an array of premium millet-based products to enter and thrive in the bakery market.

Fermented products: Finger millet is used in the preparation of various fermented foods, adding a unique flavor and nutritional value to these traditional dishes. One such fermented food is "Ragi Mudde" or finger millet balls, a popular dish in southern India, especially in Karnataka. To make Ragi Mudde, finger millet flour is mixed with water and cooked until it forms a thick, dough-like consistency. The mixture is then shaped into balls and served with sambar or other curries. Another popular fermented dish is "Ragi Ambli," a fermented finger millet drink. Finger millet flour is mixed with water and allowed to ferment for a few hours or overnight. The fermented mixture is then strained, and the liquid is flavored with spices like cumin and pepper before serving. These fermented finger millet foods not only have a unique taste but also offer numerous health benefits due to the fermentation process, which enhances nutrient availability and digestibility.

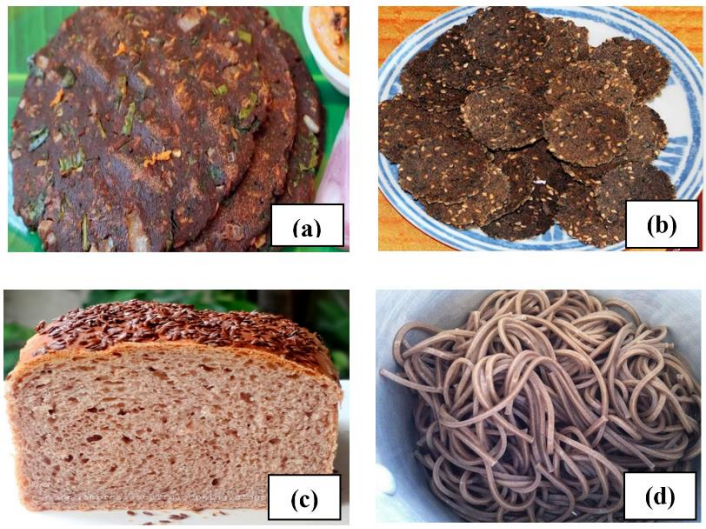

Figure 2: Finger millet-based value-added products (a) Roti (b) Papad (c) Bread and (d) Noodles

Noodles: The evolving dietary preferences of children and teenagers have spurred a thriving market for noodles, both in India and internationally. There is a growing demand for millet noodles, particularly those crafted from finger millet, driven by an increased awareness of their nutritional advantages. Noodles, a form of pasta and a convenient food, are typically created through a cold extrusion process, resulting in a firm and brittle texture post-drying. Cooking these noodles is swift and straightforward, requiring only a few minutes. Various noodle combinations are prepared, including those exclusively crafted from finger millet, a 1:1 blend of finger millet and wheat, and a 5:4:1 blend of finger millet, wheat, and soy flour. For exclusive millet-based noodles, pretreatment of the millet flour is essential to facilitate extrusion and achieve a smooth texture that endures through drying and cooking. Wheat flour is commonly integrated into noodle formulations due to its gluten content, which aids in extrusion and contributes to a smooth, blemish-free texture.

Conclusions

Finger millet, holds significant importance due to its nutritional profile and health benefits. It is rich in calcium, iron, fibre, and other essential nutrients, making it a valuable addition to the diet, especially in regions where malnutrition is prevalent. Incorporating finger millet into various products adds diversity to the diet and helps address nutritional deficiencies, particularly among children and pregnant women. Additionally, finger millet is gluten-free, making it suitable for individuals with gluten intolerance or celiac disease. By incorporating finger millet into value-added products, India can promote sustainable agriculture practices, support local farmers, and enhance food security while offering nutritious options to consumers.

References

Abioye, V. F., Babarinde, G. O., Ogunlakin, G. O., Adejuyitan, J. A., Olatunde, S. J., & Abioye, A. O. (2022). Varietal and processing influence on nutritional and phytochemical properties of finger millet: A review. Heliyon, 8(12).

Gebreyohannes, A., Shimelis, H., Laing, M., Mathew, I., Odeny, D. A., & Ojulong, H. (2021). Finger millet production in Ethiopia: Opportunities, problem diagnosis, key challenges and recommendations for breeding. Sustainability, 13(23), 13463.

Maharajan, T., Ceasar, S. A., & Ajeesh Krishna, T. P. (2022). Finger millet (Eleusine coracana (L.) Gaertn): Nutritional importance and nutrient

transporters. Critical Reviews in Plant Sciences, 41(1), 1-31.

Mitharwal, S., Kumar, S., & Chauhan, K. (2021). Nutritional, polyphenolic composition and in vitro digestibility of finger millet (Eleusine coracana L.) with its potential food applications: A review. Food Bioscience, 44, 101382.

Navyashree, N., Sengar, A. S., Sunil, C. K., & Venkatachalapathy, N. (2022). White Finger Millet (KMR-340): A comparative study to determine the effect of processing and their characterisation. Food Chemistry, 374, 131665.

* * * * * * * *