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Modern Processing of Millets: An Analysis of Nutritional Properties Changes

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Due to their rich nutrient profile, ability to withstand severe temperatures, and sustainable farming methods, millets, once thought of as a poor man's food are becoming more and more popular as nutri-cereals. However, the presence of antinutritional ingredients and conventional processing hurdles frequently limit their use. This article examines the impact of contemporary mechanical processing methods on the nutritious and antinutritional components of Indian millets as well as the ways in which cutting-edge food technology are making millet-based foods more widely available health goods. The review emphasizes how sophisticated processing can improve shelf life, texture, and flavor while maintaining nutritional quality (Saleh et al., 2013; Mishra & Gupta, 2023).

Keywords: Millets, Nutritional Profile, Antinutritional Factors, Mechanical Processing, Value Addition, Nutraceuticals, Food Technology, India

Introduction

India is the world's greatest producer of millet (National Institute of Nutrition, 2020) with types including finger millet, pearl millet, sorghum, foxtail millet, little millet, kodo millet, barnyard millet, and proso millet. These cereals are great substitutes for refined grains since they are high in dietary fiber, protein, micronutrients (iron, calcium, and magnesium), and bioactive substances. Because of their hard husk, tiny grain size, and antinutritional elements such tannins and phytates, millets present processing difficulties despite their health advantages (Srivastava & Rai, 2021). These obstacles are being addressed by recent technological developments in milling, puffing, malting, extrusion, and fermentation, which are increasing millet consumption and marketability. Despite being the world's top producer of nutrient-rich millet and the second-largest producer of rice and pulses, India is regrettably the country with the second-highest rate of child malnutrition. Over one-third of the world's undernourished youngsters reside in India. On the other hand, the nation has also become a center for people with diabetes and obesity, placing a double burden of hunger on the entire nation. Millets have a better fatty acid profile than cereals and are an excellent source of amino acids (methionine and cysteine) that contain protein and sulfur. Millets are high in minerals like calcium, phosphorus, magnesium, manganese, potassium, iron, and vitamins E and B. Millets' rich nutritional content has several advantages, including lowering the risk of cancer, diabetes, obesity, cardiovascular disease, gastrointestinal issues, migraines, and asthma

Nutritional Profile of Millets

Table-1 Nutritional Profile of millets in comparison with Cereals (per 100g)

Grains	Energy (Kcal)	Protein (g)	Carbo hydrate (g)	Starch (g)	Fat (g)	Dietary fibre (g)	Minerals (g)	Ca (mg)	P (mg)
Sorghum	334	10.4	67.6	59	1.9	10.2	1.6	27	222

Grains	Energy (Kcal)	Protein (g)	Carbo hydrate (g)	Starch (g)	Fat (g)	Dietary fibre (g)	Minerals (g)	Ca (mg)	P (mg)
Pearl millet	363	11.6	61.7	55	5	11.4	2.3	27	296
Finger Millet	320	7.3	66.8	62	1.3	11.1	2.7	364	283
Proso Millet	341	12.5	70.0	-	1.1	-	1.9	14	206
Foxtail Millet	331	12.3	60.0	-	4.3	-	3.3	31	290
Kodo Millet	353	8.3	66.1	64	1.4	6.3	2.6	15	188
Little millet	329	8.7	65.5	56	5.3	6.3	1.7	17	220
Barnyard millet	307	11.6	63.5	-	5.8	-	4.7	14	121
Maize	334	11.5	64.7	59	3.6	2.2	1.5	8.9	348
Wheat	321	11.8	64.7	56	1.5	11.2	1.5	39	306
Rice	353	6.8	74.8	71	0.5	4.4	0.6	10	160

Source: Indian Food Composition Tables and nutritive value of Indian foods [30,31]

Modern Processing Methods

The efficient use of existing millet crops to create reasonably priced, tasty, and nutrient-rich products is urgently needed because world food security is in jeopardy. In order to transform millet grains into cooked, edible form, inedible sections must be removed by processing. Therefore, processing is essential because it improves nutrient bioavailability and reduces antinutrients. Dehusking/decortication, milling, soaking, germination, fermentation, malting, heating, and roasting are some of the methods used. Food's physiological characteristics are altered by these processes.

Processing is of 2 types.

- **Primary Processing :**

1. Cleaning and Grading: Removal of dirt, stones, and damaged grains.
2. Dehulling: Modern dehullers like abrasive dehullers remove the outer layer efficiently while retaining the endosperm (Mishra & Gupta, 2023).
3. Milling: Producing millet flour using hammer mills, roller mills, or stone grinders (Mishra & Gupta, 2023).

- **Secondary Processing :**

It involves techniques converting primary processed raw materials into “Ready-to cook” (RTC) or “Ready-to- eat” (RTE) products by flaking, popping, extrusion etc.

Extrusion: Used to make ready-to-eat products like puffed millets, snacks, and noodles (Saleh et al., 2013).

Malting (Germination): Enhances enzymatic activity, reducing antinutrients and improving digestibility (Devi et al., 2014).

Fermentation: Traditional and industrial fermentation increases probiotic value and reduces antinutrients (Srivastava & Rai, 2021).

Puffing and Roasting: Used for snack products with enhanced texture and taste (Mishra & Gupta, 2023).

Flaking: Mechanical flaking for breakfast cereals (Saleh et al., 2013).

How Processing affect the Nutritional Properties of Millets ?

Positive Effects :

Improved Mineral Bioavailability: Malting and fermentation reduce phytates (Devi et al., 2014; Srivastava & Rai, 2021).

Enhanced Protein Digestibility: Heat processing denatures anti-nutritional proteins (Saleh et al., 2013).

Better Shelf-life and Palatability: Modern processing creates appealing products with longer storage potential (Mishra & Gupta, 2023).

Negative Effects :

Loss of Heat-Sensitive Nutrients: Vitamins like thiamine (B1) and vitamin C may degrade (Saleh et al., 2013)

Fiber Reduction: Dehulling removes some bran, reducing total fiber content (Mishra & Gupta,2023)

Table-2 Inference on nutritional properties changes during different processing methods

	Energy	Carbohydrate	Protein	Minerals	Dietary fiber	Fat	Vitamins	Antioxidants
Dehulling	↓	↑	↓	↓	↓	↓	↓	—
Milling/Sieving	—	—	↓	↓	↓	↓	↓	—
Soaking	—	↓	—	↓↑	—	↓	—	↓
Germinating	↑	↓↑	↑	↑	↑	↓↑	↑	↑
Malting	—	—	—	—	↑	↓	—	—
Fermenting	—	↑	↑	↑	↑	↓	↑	—
Roasting	↓	—	↓	↓↑	↓↑	↓↑	—	—
Extrusion	↓	↓	↓	—	↓	—	—	—
Cooking	↓	↓	↓↑	—	↑	↓	—	—
Puffing/ Popping	—	—	↑	↓↑	↓	↓	—	—

Note: (↑):increases, (↓):decreases, (↓↑):decreases or increases, (—): data not available (Reference source: above manuscript)

Strategies to tackle Nutritional Loss in Millet Processing :

1. Minimal Processing :Use stone milling or light pounding to retain the bran layer.

2.Fortification : Add lost nutrients back into processed millet products, e.g. iron fortified millet flour

3. Pre-treatment Techniques : Apply germination, soaking, and fermentation before mechanical processing to reduce anti nutritional factors naturally.

4. Vacuum and Low-Temperature Drying : Use low temperature processing techniques like vacuum drying or freeze drying to

Preserve heat sensitive nutrients such as vitamins and anti-oxidants

Maintain functional properties of bio active compounds

5. Use Of Composite Flour Technology : Mix millet flours with legume or pulse flours to

- Improve protein quality and compensates for any nutrient deficit from processing
- Balance amino acid profiles

6. Paraboiling : Steaming millets before de hulling can

- Help retain nutrients in endosperm
- Reduce leaching of vitamins and minerals during cooking.
- Improve shelf life and texture.

7. Consumer and Industry Awareness :

- Promote the use of whole grain millet products in markets and food industries.
- Educate consumers on choosing unrefined millets and importance of proper cooking methods.

8. Development of Smart Processing Technologies: Invest in research for non thermal processing methods like –

- Ultrasound Processing
- High- pressure Processing (HPP) etc.

Conclusion

In the quest for wholesome, climate-resilient, and sustainable food systems, millet is essential. Millets are being transformed from coarse grains into value-added goods such as baby food, morning cereals, health drinks, and gluten-free snacks thanks to modern processing technology. In light of the fluctuating effects of processing on the nutritional qualities of millets, attention must still be paid to refining processing methods for small

millets in order to increase their acceptability without sacrificing their health advantages. It is essential to strike a balance between maintaining nutritional integrity and processing in a way that is consumer-friendly (Saleh et al., 2013). Their function in preventing malnutrition and fostering wellbeing would be further strengthened by ongoing research and technological advancements in millet processing (Mishra & Gupta, 2023)

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