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Mighty Millets: Bespoke for Multi Nutrients

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Small-grained millets are warm-weather, annual cereals in the grass family. The three most significant millets grown in India are ragi (finger millet), bajra (pearl millet), and jowar (sorghum). Proso (Cheena), Kodo (Kodra, Arikelu), Fox tail (Kangni/Korra), Barnyard (Varai, Sawa), and little millet (Kutki) are only a few of the small millets that are grown in our nation. Millets have grown to be significant crops in Asia, and their global output has sharply increased. Less biotic and abiotic stress can affect them. In comparison to other major cereals, millet grains provide a particularly noteworthy source of minerals (iron and zinc), fibre, and carbohydrates. To promote millets' production and consumption, the Indian government declared them Nutri-Cereals in April 2018. Millets included are Sorghum (Jowar), Pearl Millet (Bajra), Finger Millet (Ragi/Mandua) & Minor Millets namely; Foxtail Millet (Kangani/Kakun), Proso Millet (Cheena), Kodo Millet (Kodo), Barnyard Millet (Sawa/Sanwa/ Jhangora), Little Millet (Kutki) and two Pseudo -millets viz Buckwheat (Kuttu) and Amaranthus (Chaulai). The UN declared 2023 the International Year of Millets (IYoM-2023) in order to increase domestic and international demand and to supply people with nutrient-rich meals. The significance

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of millets in the current environment is emphasised in this overview, along with the nutritional advantages and other health advantages of the main millet crops grown in India. Millets may show to be a crop with the ability to contribute to the security of food and nutrition.

Keywords: Millets; micronutrients; small millets; value addition; nutritional security.

1. INTRODUCTION

The challenge of micronutrient malnutrition cannot be resolved by staple crops like rice, wheat, and maize. Different millets are eaten. Ragi, the most common millet, is nutrient-rich. High in fibre, calcium, phosphorus, and iron. Pearl millet makes dosa, cereal, laddus, and more. Millets are good for diabetic weight loss and wheat allergies/intolerance. Millet-based products increase rural and urban acceptance. This helps producers and processors create a sustainable ecosystem.

Sorghum and other millets including pearl millets, finger millets, kodo, proso, foxtail millets, tiny, and barnyard millets are significant for health (Fig. 1). Millets flourish in low-rainfall areas where agriculture and food security are important. Most developing countries utilise millets for human food, although some use them for animal feed. Millets provide protein, phytochemicals, and minerals. Pearl millets have 5-8% protein, 65-75% carbohydrate, 15-20% fibre, and 2.5-3.5% minerals [1]. Whole millet and its products have been found to reduce the risk of diabetes, cardiovascular disease, and gastrointestinal disorders [2]. Millets contain minerals, phenolic compounds, dietary fiber, and vitamins in their outer layer [3].

Noodles were ancient staples in many countries. Nearly 4000 years old. China introduced a pot of thin noodles comparable to la-Mian, Chinese noodles developed through stretching and hand-pulling the dough [4]. Technological advances, eating habits, health consciousness, regional diversity of raw material, and flavour preferences have changed the formulation of noodles, over the time making them the world's most popular snack. Noodles can be produced from wheat, rice, potato-starch, pulses, millets, and other grains. Raw noodle quality is determined by colour, appearance, and processing. Sheeting and cutting machines make noodles from wheat flour, millets, pulses, water, and salt. Noodles must taste, feel, and look excellent. Noodles need gluten and wheat flour with strong starch swelling and pasting capabilities [5].

1.1 Ready to Eat (RTE) Foods

Ready-to-eat meals are common in developed nations because of their adaptability, nutritional value, and simplicity of preparation. Foods that are ready to eat are quite profitable. Small and medium-sized businesses produce fast noodles. Additionally common in quick food outlets are noodles. India enjoys spaghetti and noodles. Most urban households were exposed to simple-to-prepare items by Maggie.

1.2 Current Trends

Millets include sorghum, finger millet, pearl millet, and others. Millets can be grown on more than 32 million hectares of dry, semi-arid, and subhumid land. Most millet is produced in India. The FAO estimated that the world would produce 28.33 MMT of millet in 2019 and 30.08 MMT of millet in 2021. In 2023, millet production will be 6-7 lakh tonnes.

Fig. 1. Millets grown in India

1.3 Healthy Food Market Trend

The oats market is predicted to expand 3.85% from 2023 to 2028 to 34.69 million tonnes by 2028. This industry will benefit from global health awareness and lifestyle changes. Due to its high fibre, vitamin, and mineral content and portability, "oatmeal cookies" are the most popular healthy snack. Low-fat oatmeal cookies are predicted to expand due to growing awareness of healthy snacking.

Nutritional content of different millets compared to that of paddy rice, wheat, and quinoa. Nutrient content in small millets compared to other common grains, source: NIN, Hyderabad In India, eight millet species are cultivated commonly under rain-fed conditions

1. Sorghum
2. Pearl millet
3. Finger millet
4. Foxtail millet
5. Kodo millet
6. Proso millet
7. Barnyard millet
8. Little millet

The pearl millet is most farmed. This crop, known locally as 'Bajra,' is widely grown throughout India. Sorghum and most millets have 10% protein and 3.5% lipids, but finger millet has 12-16% protein and 2-5% lipids. Vitamins and minerals abound in sorghum and millets. Millets have fewer cross-linked prolamins, making their proteins more digestible. The bajra nutritional value per 100g is

Energy: 361 Kcal
Carbohydrates: 67gms
Protein: 12gms
Fat: 5gms
Iron: 8mg (Source)

In some parts of India, foxtail millet is staple. Research found that millet reduced blood glucose by 70% in diabetic rats. Diabetes rats fed millet had decreased triglycerides, total/LDL/VLDL cholesterol, and higher HDL cholesterol (Source). Millets' magnesium content boosts insulin and glucose receptor function, preventing diabetes. Alpha-amylase inhibition and fibre content in finger millet diets diminish starch digestion and absorption, lowering glycemic response.

1.4 Elevated Bioavailability of Some Minerals

Sprouting grains were used to wean infants or make aged diets digestible. The Central Food Technological Research Institute in Mysore, India, found that malting millet increased iron, manganese, and calcium bioavailability while decreasing zinc and maintaining copper bioavailability.

Table 1. Nutritional content in 100 gms of dry grain

Nutritional content in 100 gms of dry Grain	Protein (in gms)	Carbohydrates (in gms)	Fat (in gms)	Minerals (in gms)	Fiber (in gms)	Calcium (in mgs)	Phosphorous (in mgs)	Iron (in mgs)	Energy (in kCals)	Thaimin (in mgs)	Niacin (in mgs)
Foxtail	12.3	60.2	4.3	4	6.7	31	290	2.8	351	0.59	3.2
Little	7.7	67	4.7	1.7	7.6	17	220	9.3	329	0.3	3.2
Kodo	8.3	65.9	1.4	2.6	5.2	35	188	1.7	353	0.15	2
Proso	12.5	70.4	1.1	1.9	5.2	8	206	2.9	354	0.41	4.5
Barnyard	6.2	65.5	4.8	3.7	13.6	22	280	18.6	300	0.33	4.2
Sorghum	10.4	70.7	3.1	1.2	2	25	222	5.4	329	0.38	4.3
Pearl	11.8	67	4.8	2.2	2.3	42	240	11	363	0.38	2.8
Finger	7.3	72	1.3	2.7	3.6	344	283	3.9	336	0.42	1.1
Paddy Rice	6.8	78.2	0.5	0.6	1	33	160	1.8	362	0.41	4.3
Wheat	11.8	71.2	1.5	1.5	2	30	306	3.5	348	0.41	5.1
Quinoa	14	64	6	*	7	36	457	4.6	368	0.36	*

Compiled from a study published by the National Institute for Nutrition, Hyderabad and other sources for Quinoa.

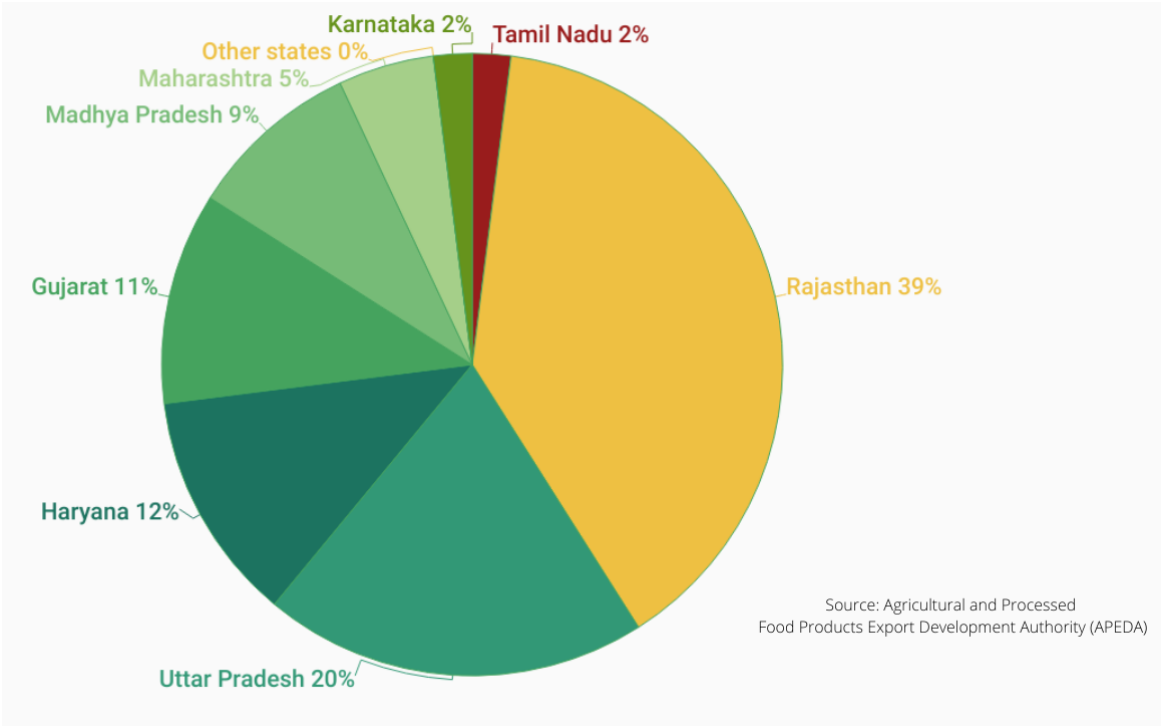

Chart 1. The state-wise millet production in 2021-22
Data sourced from APEDA. The United Nations (UN) General Assembly at its 75th session declared 2023 the International Year of Millets (IYM2023)

1.5 High Antioxidant Activity

After analysing Kodo, foxtail, finger, pearl, proso, and little millets, Kodo had the greatest phenolic content and proso the lowest. Millets contain several antioxidants that neutralise cancer-causing free radicals and remove toxins from the kidneys and liver. Quercetin, curcumin, ellagic acid, and other helpful catechins aid excretion and neutralise organ enzymatic activity to eliminate external chemicals and poisons.

1.6 Prevention of Cardiovascular Disease

Millets are high in magnesium, which lowers blood pressure and heart stroke risk, especially in atherosclerosis. Millets' potassium reduces cardiovascular risk by vasodilating blood pressure. Millets include plant lignans that can transform into animal lignans in the digestive system and prevent heart disease. Millets decrease cholesterol, eliminate LDL, and enhance HDL due to their high fibre content.

1.7 Sorghum Baby Food

Drum-dried sorghum/millet milk powder baby food contains safe protein for children over one month. Commercial sorghum/millet baby food makers can use this formulation and processing such as sorghum porridge (Fig. 2). Rising disposable income, demand for ready-to-eat products, health consciousness, product benefits, and the launch of diverse oat-containing producers drive the market [6,7,8] The change from dairy products to oat milk will define global growth.

2. MILLET IMPORTANCE

Millets, the first domesticated grain, are grown in 131 nations. Millets are grain crops grown mostly on marginal land in arid areas. Millets, high-energy nutri-cereals, were domesticated 10,000 years ago. They are grown in marginal, degraded ground with low rainfall and soil nutrients. Finger, pearl, foxtail, barnyard, proso, kodo, and small millets are grown worldwide.

Millets are the future crops that can address the issues like food, feed, fuel, malnutrition, health, and climate change because they are adapted to a wide range of ecological conditions, require less water, and input, and grow well even in infertile soil. They are rich in dietary fibre, antioxidants, minerals, phytochemicals,

polyphenols, and proteins that fight health-related disorders/diseases. Several private and government agencies have invested huge amounts in millet production and their utilization for the formulation of different food products. The low glycemic index of millet helps manage diabetes, while its high fibre content aids digestion and prevents constipation.

Fig. 2. Sorghum porridge

2.1 Millet Health Benefits

Millets are nutritionally comparable and even considered superior to main cereals in terms of providing protein, micronutrients, and phytochemicals. Their fewer cross-linked extended chains may help digest millet protein. Millets may reduce the risk of heart disease, diabetes, and some metabolic syndrome by detoxifying the body, boosting the immunity, enhancing the respiratory health, energy levels, and muscular and nervous system.

2.2 Pearl Millet

Bajra is pearl millet (*Pennisetum glaucum*). It is a tropical semi-arid cereal cultivated in Africa and Asia. Pearl millet is predominantly a food crop [9]. Pearl millet, the fourth most significant cereal after wheat, rice, and sorghum, provides the rural Indian population with 360 kcal/kg of dietary energy. Pearl millet provides ample amounts of protein, calcium, phosphorus, and iron. Pearl millet is rich in thiamine (B_1), riboflavin (B_2), and niacin (B_6). A lot of pearl millet grain is also utilized for livestock feed, poultry feed, and alcohol extraction [10]. Whole grain cereals have the most energy (784cal/kg) Pearl millet has more protein and fat than sorghum [11].

2.3 Pearl Millet Health Benefits

- Pearl millet flour controls glucose receptors due to its high magnesium content. Fiber-rich foods aid digestion.
- Pearl millet prevents flatulence, stomach pain, cramps, ulcer, acidity, inflammation, and colon cancer.
- Protein in pearl millet helps cells and muscles develop and regenerate. It also prevents ageing muscle deterioration

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2.4 Indian Millets Output and Consumption

About 50 years ago, India and many other countries consumed millets. According to the National Council of Applied Economic Research (NCAER), millets have lost their significance share of plates to wheat, rice, and other processed cereals. Due to increased land use for wheat and rice production, millet cultivation has decreased significantly by 58% for small millets, 64% for sorghum, 49% for finger millet, and 23% for pearl millet since 1956.

India produces the most millet and exports the fifth-most. Millet exports are booming as demand rises. Millet's demand is expanding business prospects. In 2021, the millet market was worth over USD 9 billion and is projected to rise by 4.5% to over USD 12 billion by 2025. Indian households are eating less millets. From 1970 to 2020, millets per capita dropped from 32.9 kg to 4.2 kg.

2.5 Haryana Pearl Millet

In the last three years, Haryana produced 11.77 lakh tonnes of millet, ranking fourth in the nation. With the increase in holding size, livestock consumption accounts for 54.15 and 51.63 percent of total consumption in Mahendragarh and Bhiwani districts, respectively, followed by family consumption at 30.68 and 30.69 percent.

2.6 Millet Need

Pearl millet is a food, and many rural food preparations, especially products, use it as a staple crop. Pearl millet (bajra in India) is one of the most widely grown tiny millets. Pearl millet outperforms rice and wheat in mineral and vitamin content, protein (6-8%) and fat (1-2%). Many people get their carbs from it.

Millets are too rudimentary to use. Millet's output and consumption have decreased. This depleted vital elements in our diets. India leads millet production and export. Rice and wheat flour have replaced millet, reducing production and export by 20%. Millets may prove an economical solution to the country's food and health problems in today's changing lifestyle and developing health challenges. Due to their high tryptophan and magnesium content, millets soothe our moods and lessen migraine and heart attack risk, according to the Indian Institute of Millet Research. They are gluten-free, nonallergic, abundant in protein, antioxidants, and cholesterol-lowering.

2.7 Pearl Millet

Bajra, or pearl millet, is a very nutritious and easy-to-digest cereal grain. It is gluten-free and healthy for people suffering from celiac disease. They are loaded with carbohydrates, minerals, and vitamins like folic acid, niacin, thiamine, riboflavin and beta-carotene.

2.8 Per 100 gm of Pearl Millet Contains-

- Energy – 348 kcal
- Protein – 10.96 gm
- Carbohydrate –61.78 gm
- Fat contents –5.43 gm
- Dietary fibers – 11.49 gm

2.9 Pearl Millet Health Benefits

1. Pearl millets are good for diabetics since their carbohydrate is slowly absorbed. This makes them diabetic-friendly.
2. These grains are high in fibre and cholesterol-lowering.
3. Perfect for celiac illness and gluten intolerance–pearl millet is gluten-free and readily tolerated by everyone.
4. Pearl millets are one of the few foods that reduce stomach acidity, preventing ulcers and discomfort from recurrent acidity.
5. Prevent constipation—Pearl millet promotes intestinal health. Pearl millets prevent constipation. Because pearl millet has insoluble fibre.
6. Vegetarians cannot acquire enough protein from meat and fish. Pearl millet provides vegetarians with protein and other health advantages. Pearl millet flour is complete with seeds like rajma, moong dal, chana dal, etc.
7. Pearl millet's potassium content lowers blood pressure. Potassium-rich meals wash out salt, lowering blood pressure.
8. Pearl millet's phosphorus content strengthens bones.
9. Dietary fibres bulk up and relieve constipation.
10. Pearl millet is beneficial for high cholesterol sufferers since it has enough healthy fat.

3. MILLET-BASED PRODUCTS

3.1 Millet Bread/Bun

Bread is made by mixing flour, water, oil, salt, and yeast into dough and baking it into a loaf. IIMR (Indian Institute of Millets Research) makes millet pieces of bread by replacing 50% wheat flour with pearl millet flour, finger millet flour, or foxtail millet flour of and adding the yeast, trans-fat free oil, salt, and sugar. Bread was prepared from proofed dough. Buns were prepared from dough balls (Fig 3).

Fig. 3. Millet bread

3.2 Technology/product Advantages

Fiber-rich millet bread benefits all ages.
Breakfast meal.

- Magnesium, zinc, iron, protein, and fibre are abundant.
- It lasts 6 days in LDPE packets.

3.3 Millet Cake

Cake is made by blending flour, sugar, fat, eggs, and flavourings into dough and baking it. At IIMR (Indian Institute of Millets Research), millet cakes

are made with 100% pearl millet flour, finger millet flour, or foxtail millet flour, high-quality vegetable oil, sugar, eggs, and chocolate or vanilla essence. out of all, Finger millet cake was best (Fig. 4).

Fig. 4. Barnyard millet cake

3.4 Advantages and Uniqueness of Technology/Product

- Millet cake are rich in fibres and its beneficial for all age groups.
  it can be used as snack food or breakfast food
- Millet cake is rich in magnesium, zinc, iron, dietary fibre, and protein.
- It has a shelf life of 5 days when packed in packets.

3.5 Instant Millet Laddu Mix

- Indian laddu is a ball of flour/semolina, powdered low-calorie sugar, and shortening.
- Roasted sorghum, fine raw finger millet flour, pearl millet flour, powdered low-calorie sugar, dry fruits, and cardamon make millet laddu mix (Fig. 5).
- Combine this with ghee or milk to create balls before serving.
- The mix was packaged.

3.6 Technology/Product Benefits

1. Instantly flavour laddus.
2. Gluten-free and celiac-friendly.
3. High phenolic content and satiety reduce digestibility.
4. Reduce oxidative stress.
5. Dietary fibre and low-calorie sugar aid digestion.
6. Three months shelf life at ambient temperature.

Fig. 5. Finger millet laddus

3.7 Sorghum Energy Bars

Sorghum flakes and broken flakes add energy bars. Bran is carefully pulverised and dried to remove moisture. Honey syrup was added to bind and sweeten bran and flakes. It provides clean energy (Fig. 6).

Fig. 6. Sorghum energy bars

3.8 Millet's Health Benefits

Millet, a nutritious whole grain, has been eaten worldwide for millennia. A balanced diet with it has several health benefits.

3.9 Health Benefits of Millet-Based Foods

1. Millet contains carbs, protein, vitamins, and minerals. These nutrients support body function and wellness.
2. Millet is gluten-free, making it a good grain for celiacs. It can replace wheat, barley, and rye in recipes, providing gluten-free options.
3. Dietary fiber in millet promotes digestion and prevents constipation. Fibre bulks stool, promoting regular bowel movements and intestinal health.
4. Pearl millet has a low glycemic index which helps to manage blood sugar levels in diabetes patients and in those trying to control their blood sugar.
5. Bone health: Magnesium, phosphorus, and calcium are found in millet. These minerals help build bones and prevent osteoporosis.
6. Pearl millet strengthens muscles and memory.
7. Whole grains like bajra may prevent diabetes, heart disease, and cancer.
8. Pearl millet may provide further health benefits.
9. Bajra has 1.2 cal/g. Thus, low-calorie meals like bajra may help weight loss.
10. High-fiber foods, such as pearl millet, have also been linked to better type 2 diabetes and chronic illness management.

4. CONCLUSION

Sorghum is grown in Africa, Asia, and Central America to reduce food insecurity. The world's fifth greatest grain crop and Africa's second largest by tonnage. Millets reduce migraine and heart attack risk due to their high tryptophan and magnesium content, according to the Indian Institute of Millet Research. Millets relieve constipation, gas, cramps and bloating with their fibre. Millets protect against celiac, an immune-mediated enteropathic illness caused by gluten. Replacing wheat, barley and rye with gluten-free grains including rice, millet, corn, amaranth, sorghum, quinoa, buckwheat and wild rice can aid gluten-free dieters. Millets are gluten-free and can meet the growing demand for gluten-free foods and beverages. They are also suitable for celiac disease patients. The nutritional chart recommends eating millets in sufficient amounts to reap their many benefits. According to millet nutritional studies, millets are antioxidants, detoxifiers, immunological modulators, and more. Millets can fight age-related degenerative disorders as CVD, cancer, diabetes, and others.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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