



Millets Based Fermented Products: A Review

Avishakar A Ajagekar¹, Siddhartha D Sali¹, Om D Borse¹, Amit B Patil¹,
Shweta Suri² and Anirudh G Patil^{1*}

¹Department of Food Technology, Annasaheb Dange College of Engineering and
Technology, Ashta, Maharashtra, India

²Amity Institute of food technology, Amity University, Noida, Uttar Pradesh, India

***Corresponding Author:** Anirudh G Patil, Department of Food Technology,
Annasaheb Dange College of Engineering and Technology, Ashta, Maharashtra,
India.

DOI: 10.31080/ASNH.2023.07.1251

Received: May 05, 2023

Published: May 28, 2023

© All rights are reserved by **Anirudh G Patil,
et al.**

Abstract

Millets are a group of cereal grains that belong to the Poaceae family, commonly known as the grass family. It's widely consumed in developing countries throughout Africa and Asia. In the entire world varieties of millets are cultivated by humans. From ancient times millets-based food products played an important role in the meal of people mostly in Asian and African countries. As millet has great nutritional value and beneficial effects on human health, consumed by persons performing heavy exercise or athletes. Millets are rich in protein, fibers, vitamins, and minerals which has many benefits for health. As millets are gluten-free and have a low GI (glycemic index) it does not harm our body but it plays an important role as an ingredient in a meal for people having gluten intolerance. Millet gets digested easily in our body and it helps with weight loss. All over the world, around 131 countries grow varieties of millets, and about 60 crores of peoples in Asia and Africa eats millets as their traditional food. India is the largest producer and exporter of millet. Pearl millet is mostly cultivated in India and exported to many countries. Nowadays, fermented millets-based food products are playing an extraordinary role in the diet. Fermented millet-based food products play an important role in good digestive health. As it contains probiotic organisms which help our gut for proper digestion of food products and provides many advantages to the body. In the world, millets-based fermented probiotic food products are consumed by people from ancient times. In many countries, different traditional food products are prepared by specific methods like Koko, idli, dosa, Mangisi, etc.

Keywords: Probiotic; Africa; Asia; Benefits; Glycemic Index; Fermented; Traditional

Introduction

Millets are one of the most important diets in human meals from ancient times. Probably millets were first cultivated in Asia more than 4,000 years ago. Millets were major grains in Europe during the Middle Ages [1]. There is much evidence that people in Korea were consuming millet-based food products from the middle pottery period (around 3500-2000 BC). Even until 50 years ago millets were the major grain grown in India [2]. India is the largest producer of millet in the world. India's two varieties of millet namely Pearl Millet (Bajra) and Sorghum (Jowar) together contribute approx 19 percent to world production in 2020 [3]. Millets are annual, warm-weather grasses that comprise several cereals belonging to different genera and species. Millets are grown primarily for grain and their straw makes valuable cattle fodder. Among the world millets are the most important food crop for the inhabitants of the semi-arid tropics, and are the main source of protein and energy. Millets form a major portion of the subsistence

system in India today and constitute 45% of all land planted to food plants. Today, various kinds of millets are grown in southern Uttar Pradesh, central Madhya Pradesh, Rajasthan, Haryana, western Andhra Pradesh, western Tamil Nadu, eastern Maharashtra, and parts of Karnataka [4]. The commonest varieties are jowar (sorghum), bajra (pearl millet), ragi (finger millet), and kodon millet. In the following pages, an attempt has been made to present the data about the cultivation of millet as available in the archaeological record to date and trace the history of their cultivation through the ages. Various types of millets have been reported from Neolithic levels in Karnataka (Hallur); from pre-Harappan and Harappan sites in Punjab; Haryana and Gujarat and from Chalcolithic levels of several sites in the Deccan and southeastern Rajasthan [5]. There are many varieties of millets grown in the world sorghum millet (jowar), proso millet (chena/Barri), pearl millet (bajra), foxtail millet (kakum/kangni), finger millet (ragi), browntop millet (korle), barnyard millet (sanwa), little millet (moraiyo), buckwheat millet (kuttu), amaranth millet (rajgira), kodo millet.

Production statistics: Global and national level

The majority of millet is produced in Africa, followed by Asia. India is the largest producer of millet. Other major millet-producing countries include Burkina Faso, Mali, and Senegal. Globally millets are cultivated in 93 countries and only seven countries have more than 1 ha acreage of Millet. In general point, more than 97% of millets production and consumption is by developing Nations. In the world, there are many varieties of millet produced [6]. Pearl millet (*Pennisetum glaucum*, *P. typhoides*, *P. typhipideum*, *P. americanum*) is the most widely grown of all millets. It is also known as bulrush millet, babala, bajra, cumbu, dukhn, gero, saje, sanio, or souna. Pearl millet is a traditional crop in Western Africa, particularly in the Sahel; in Central, Eastern, and Southern Africa; and Asia, in India and Pakistan, and along the southern coast of the Arabian Peninsula. Pearl millet has been recently introduced as a grain crop in the south eastern coastal plain of the United States, where it has been used as a summer forage. Pearl millet can be grown on poor, sandy soils in dry areas that are unsuitable for maize, sorghum, or finger millet [7]. It is a summer cereal grass with large stems, leaves, and heads. It is more efficient in its utilization of moisture than maize. The grain grows on condensed panicles (spiked) 10 to 150 cm in length. Pearl millet has the highest yield potential of all millets under drought and heat stress [8]. Finger millet (*Eleusine coracana*), known as Ragi in India, is another important staple food in Eastern Africa and in Asia (India, Nepal). It has a slightly higher water requirement than most other millets and is found in cooler, elevated regions up to 2000 metres above sea level. The plant carries several spikes or "fingers" at the top of the stem. The grain is small (1-2 mm in diameter). Proso or Common millet (*Panicum miliatum*) is grown in temperate climates. It is widely cultivated in the Russian Federation, Ukraine, Kazakhstan, the United States and Argentina, and Australia. The plant has open, branching, drooping panicles and is tolerant of a wide range of temperatures. Foxtail Millet (*Setaria italica*) requires moderate climate and temperature conditions. China is the largest producer of foxtail millet in the world. This millet is grown for both food and feed. The crop is also grown in India, Indonesia, the Korean peninsula, and some parts of southern Europe [9]. Teff (*Eragrostis tef*) is a very small-seeded grass that is cultivated for grain in the Ethiopian highlands. It can tolerate higher soil with poor drainage characteristics. In the world, many varieties of different millets like barnyard millets, little millets, kodo millets, and many types are produced. The United Nations General Assembly adopted a resolution declaring 2023 as the International Year of Millets. The main goal of this initiative is to raise public awareness of the health benefits of millets and their suitability for cultivation under challenging conditions brought by climate change. The International Year of Millet provides an excellent chance to improve the millet's contribution to food security, increase millet output globally, making sure that the processing, transport, storage, and consumptions are efficient and sustainable millet production and quality with stakeholder participation [9].

India is the largest producer and second largest exporter of millet in the world. According to the data from the US Department of Agriculture's Foreign Agricultural Service, as of February 2023, India produced 39% of the millets worldwide for the year 2022. India produced about 120 lakh tonnes of millets of the total 304.8 lakh tonnes produced globally in 2022. After India, Niger is the second highest producer accounting for about 11% followed by China accounting for 9%. The 3 countries together were responsible for almost half of the millet produced globally. The top 10 millet-producing countries contributed to 89% of the millet produced. Except for India and China, the remaining 8 countries are in Africa. Rajasthan is the largest pearl millet-producing state in India, accounting for more than 50% of the country's total production. In 2020-21, the total production of pearl millet in India was 11.41 million tonnes. While discussing statistics on proso millet in India, Production in 2020-21, the total production of proso millet in India was 2.02 million tonnes. The area under proso millet cultivation in India was 1.76 million hectares in 2020-21. In the case of statistics of sorghum in India, in 2020-21, the total production of sorghum in India was 10.35 million tonnes. The area under sorghum cultivation in India was 7.08 million hectares in 2020-21. While discussing statistics on foxtail millet in India, in 2020-21, the total production of foxtail millet in India was 0.73 million tonnes. The area under foxtail millet cultivation in India was 0.53 million hectares in 2020-21. In the case of statistics on finger millet in India, in 2020-21, the total production of finger millet in India was 3.82 million tonnes. The area under finger millet cultivation in India was 1.62 million hectares in 2020-21. Millet is an important crop in India and is grown in various regions of the country. The following are some statistics related to millet production in India, based on data from 2020-21.

India is the largest producer of millet in the world. Millet is grown on approximately 11 million hectares of land in India. The total production of millet in India in 2020-21 was 33.77 million tonnes. The major millet-producing states in India are Rajasthan, Maharashtra, Karnataka, and Uttar Pradesh. Pearl millet (Bajra) is the most widely cultivated millet in India, followed by finger millet (Ragi), foxtail millet, and little millet. Millet is an important source of food and nutrition in India, especially in regions with limited access to other food grains. Millet is also gaining popularity in urban areas as a healthier alternative to rice and wheat due to its high nutritional value and lower glycemic index [15].

Every millet in India has its nutritional characterization as follows: -

Pearl millet also known as Bajra, is one of the most important millets grown in India. Here are some statistics related to pearl millet production in India, based on data from 2020-21. Pearl millet is an important crop for small and marginal farmers in India, as it is relatively drought-tolerant and can be grown in low-fertility soils [11]. Pearl millet is an important source of food and nutrition for

millions of people in India, especially in arid and semi-arid regions where other crops may not thrive. Pearl millet is also used as animal feed and for making alcoholic beverages such as beer and spirits [11]. Proso millet is an important cereal crop in India, also known as hog millet, broom corn millet, or white millet throughout the world. Proso millet is grown in several states in India, including Andhra Pradesh, Telangana, Karnataka, Tamil Nadu, Maharashtra, Gujarat, Rajasthan, and Uttar Pradesh. Proso millet is an important crop for food security in India, especially in the arid and semi-arid regions, where it is grown as a rainfed crop. Nutritional value for proso millet is a rich source of protein, dietary fiber, vitamins, and minerals, and is considered a healthy food option. India exports proso millet to several countries, including the USA, UK, Canada, and Australia. The Indian government has launched several initiatives to promote the cultivation of proso millet and increase its productivity, including the National Food Security Mission, which provides financial assistance to farmers for proso millet cultivation [12]. Sorghum, also known as jowar, is an important cereal crop in India. Sorghum is grown in several states in India, including Maharashtra, Karnataka, Telangana, Madhya Pradesh, Andhra Pradesh, and Rajasthan. Sorghum is an important crop for food security in India, especially in the arid and semi-arid regions, where it is grown as a rainfed crop. Sorghum is a rich source of protein, dietary fiber, vitamins, and minerals, and is considered a healthy food option [12]. India exports sorghum to several countries, including the USA, China, and Nigeria. The Indian government has launched several initiatives to promote the cultivation of sorghum and increase its productivity, including the National Food Security Mission, which provides financial assistance to farmers for sorghum cultivation. Additionally, the government has set up Sorghum Research Institutes in several states to conduct research and development activities for sorghum crop improvement [12]. Foxtail millet is an important cereal crop in India. Foxtail millet is grown in several states in India, including Andhra Pradesh, Karnataka, Tamil Nadu, Telangana, Maharashtra, Odisha, and Madhya Pradesh. Foxtail millet is an important crop for food security in India, especially in the rainfed regions of southern and central India. Foxtail millet is a rich source of protein, dietary fiber, vitamins, and minerals, and is considered a healthy food option. India exports foxtail millet to several countries, including the USA, UK, and Australia [13]. The Indian government has launched several initiatives to promote the cultivation of foxtail millet and increase its productivity, including the National Food Security Mission, which provides financial assistance to farmers for foxtail millet cultivation. Additionally, the government has set up the Indian Institute of Millets Research in Hyderabad to conduct research and development activities for foxtail millet and other millets [13]. Finger millet, also known as ragi, is an important cereal crop in India. Finger millet is grown in several states in India, including Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Odisha, and Uttarakhand. Finger millet is an important crop for food

security in India, especially in the drought-prone areas of southern India, where it is grown as a rainfed crop [14]. Finger millet is a rich source of protein, dietary fiber, vitamins, and minerals, and is considered a healthy food option. India exports finger millet to several countries, including the USA, UK, Australia, and Canada. The Indian government has launched several initiatives to promote the cultivation of finger millet and increase its productivity, including the National Food Security Mission, which provides financial assistance to farmers for finger millet cultivation. Additionally, the government has set up the Indian Institute of Millets Research in Hyderabad to conduct research and development activities for finger millet and other millets [11].

Current scenario

India is one of the top 5 nations in the world for millets exports. According to the ITC trade map, millet exports climbed from \$400 million in 2020 to \$470 million in 2021. Compared to the previous year (\$59.75 million), India exported millets worth \$64.28 million in 2021–2022 [2].

Indian millets are a category of drought-tolerant, nutrient-rich grains that are mostly grown in arid and semi-arid areas of India. They are tiny-seeded grasses from the *Poaceae* botanical family. They are a crucial component of India's ecological and economic security and provide millions of resource-poor farmers with a significant supply of food and fodder. The terms "coarse cereals" and "cereals of the poor" are other names for these millets. Given their high protein, vitamin, and mineral content, Indian millets are nutritionally superior to wheat and rice. They are also gluten-free and have a low glycaemic index, making them ideal for people with celiac disease or diabetes.

India is both the world's top producer and exporter of cereal-related goods. In the fiscal years 2021–2022, India exported 12,872.64 USD million worth of cereals, or Rs. 96,011.42 crore. With a 75% (in value terms) share of India's total cereal exports during the same time, rice (including Basmati and Non-Basmati) takes the lead. While just 25% of all the cereals shipped from India during this time were different types, including wheat. Millets International Year Initiatives taken and suggested actions for 2023. The 2023 year had been proposed as the International Year of Millets (IYOM) by the Indian government to the United Nations. The United Nations General Assembly (UNGA) officially proclaimed 2023 as the International Year of Millets on March 5, 2021, with the backing of 72 additional nations, including India. The initiative of the Indian government is of celebrating IYOM 2023, it is done by making the population aware of the millet benefits and increasing the acceptability of the value added of millet across the country and world [15].

The international year of millet and opportunities

An increase in the contribution of millet to food security, increase in the global production of millet, ensuring the efficient processing, transport, storage, and consumption. Sustainable production and quality of millet with the involvement of the stakeholder. Production of Millet in India: Millet is a type of grain that is well-liked around the world, particularly in Africa and Asia. It is a common dish throughout the world, but especially in Africa and Asia. Around 1.2 billion people are thought to eat millet regularly, according to the World Food Programme. In recent years, millet production has been largely steady, with an anticipated 28 million metric tonnes of millet production in 2020. Africa produces the majority of millet, followed by Asia. China, Niger, and India are the top three millet-producing countries in the world. Burkina Faso, Mali, and Senegal are a few more significant millet-producing nations. Although millet is not a common food crop in developed nations, it is a crucial component of many people's meals there. Where other crops might fail in dry, arid settings, millet thrives under these conditions. Additionally, it is a wholesome grain that India is one of the top 5 nations in the world for millet exports. According to the ITC trade map, millet exports climbed from \$400 million in 2020 to \$470 million in 2021. Compared to the previous year (\$59.75 million), India exported millets worth \$64.28 million in 2021 [16].

Indian millets are a category of drought-tolerant, nutrient-rich grains that are mostly grown in arid and semi-arid areas of India. They are tiny-seeded grasses from the *Poaceae* botanical family. They are a crucial component of India's ecological and economic security and provide millions of resource-poor farmers with a significant supply of food and fodder. The terms "coarse cereals" and "cereals of the poor" are other names for these millets. Given their high protein, vitamin, and mineral content, Indian millets are nutritionally superior to wheat and rice. They are also gluten-free and have a low glycaemic index, making them ideal for people with celiac disease or diabetes.

India is both the world's top producer and exporter of cereal-related goods. In the fiscal years 2021–2022, India exported 12,872.64 USD million worth of cereals or Rs. 96,011.42 crores. With a 75% (in value terms) share of India's total cereal exports during the same time, rice (including Basmati and Non-Basmati) takes the lead. While just 25% of all the cereals shipped from India during this time were different types, including wheat [16]. Millets International Year Initiatives are taken and suggested actions for 2023. The 2023 year had been proposed as the International Year of Millets (IYOM) by the Indian government to the United Nations. The United Nations General Assembly (UNGA) officially proclaimed 2023 as the International Year of Millets on March 5, 2021, with the backing of 72 additional nations, including India.

The initiative of the Indian government is of celebrating IYOM 2023, it is done by making the population aware of the millet benefits and increasing the acceptability of the value added of millet across the country and world.

The international year of Millet gives a thriving opportunity to; increase the contribution of millet to food security, increase the global production of millet, ensuring efficient processing, transport, storage, and consumption and sustainable production and quality of millet with the involvement of the stakeholder. Production of Millet in India: Millet is a type of grain that is well-liked around the world, particularly in Africa and Asia. It is a common dish throughout the world, but especially in Africa and Asia. Around 1.2 billion people are thought to eat millet regularly, according to the World Food Programme.

In recent years, millet production has been largely steady, with an anticipated 28 million metric tonnes of millet production in 2020. Africa produces the majority of millet, followed by Asia. China, Niger, and India are the top three millet-producing countries in the world. Burkina Faso, Mali, and Senegal are a few more significant millet-producing nations. Although millet is not a common food crop in developed nations, it is a crucial component of many people's meals there. Where other crops might fail in dry, arid settings, millet thrives under these conditions [10].

Millets: types, nutritional composition and health benefits

Pearl millet

Pearl millet (*Pennisetum glaucum*, *P. typhoides*, *P. typhipideum*, *P. americanum*) is the most widely grown of all millets. It is also known as bulrush millet, babala, bajra, cumbu, dukhn, gero, saje, sanio, or souna. Pearl millet is a traditional crop in Western Africa, particularly in the Sahel; in Central, Eastern, and Southern Africa; and Asia, in India and Pakistan, and along the southern coast of the Arabian Peninsula. Pearl millet has been recently introduced as a grain crop in the southeastern coastal plain of the United States, where it has been used as a summer forage. Pearl millet can be grown on poor, sandy soils in dry areas that are unsuitable for maize, sorghum, or finger millet [17]. It is a summer cereal grass with large stems, leaves, and heads. It is more efficient in its utilization of moisture than maize. The grain grows on condensed panicles (spiked) 10 to 150 cm in length. Pearl millet has the highest yield potential of all millets under drought and heat stress [17]. About 70% of the dry grain is predominantly carbohydrates, consisting of 56–65% starch, of which 20–22% is amylose. It is a rich source of iron, zinc, magnesium, copper, manganese, potassium, and phosphorous. Mature kernels are rich in vitamin A but deficient in vitamins B, and C. Pearl millets are beneficial for heart health, a good diabetes diet, gluten intolerance, prevent constipation, and help the body in many ways [18].

Finger millet

Finger millet (*Eleusine coracana*), known as Ragi in India, is another important staple food in Eastern Africa and in Asia (India, Nepal). It has a slightly higher water requirement than most other millets and is found in cooler, elevated regions up to 2000 meters above sea level. The plant carries several spikes or “fingers” at the top of the stem. The grain is small (1-2 mm in diameter). In India, finger millet occupies the largest area under cultivation among the small millets. Finger millet stands unique among the cereals such as barley, rye, and oats with higher nutritional contents and has outstanding properties as a subsistence food crop. It is rich in calcium (0.34%), dietary fiber (18%), phytates (0.48%), protein (6%–13%) minerals (2.5%–3.5%), and phenolics (0.3%–3%). Moreover, it is also a rich source of thiamine, riboflavin, iron, methionine, isoleucine, leucine, phenylalanine, and other essential amino acids. The abundance of these phytochemicals enhances the nutraceutical potential of finger millet, making it a powerhouse of health-benefiting nutrients. It has distinguished health-beneficial properties, such as anti-diabetic (type 2 diabetes mellitus), anti-diarrheal, anti-ulcer, anti-inflammatory, antitumorogenic (K562 chronic myeloid leukemia), atherosclerogenic effects, antimicrobial and antioxidant properties [19].

Proso or common millet

Proso or Common millet (*Panicum miliaum*) is grown in temperate climates. It is widely cultivated in the Russian Federation, Ukraine, Kazakhstan, the United States and Argentina, and Australia. The plant has open, branching, drooping panicles and is tolerant of a wide range of temperatures. Proso millet has multiple benefits when consumed as human food. Proso millet is rich in minerals, dietary fiber, polyphenols, vitamins, and proteins. It is gluten-free and therefore, ideal for gluten intolerant people. Proso millet contains high lecithin which supports the neural health system. It is rich in vitamins (niacin, B-complex vitamins, folic acid), minerals (P, Ca, Zn, Fe), and essential amino acids (methionine and cysteine). It has a low glycemic index and reduces the risk of type-2 diabetes. Unfortunately, in the USA, it is mostly considered as bird feed, whereas it is mainly used as human food in many other countries. Besides human health benefits, proso millet has an impeccable environmental benefit. Proso millet possesses many unique characteristics (e.g., drought tolerance, short-growing season) which makes it a promising rotational crop for winter wheat-based dryland farming systems. Proso millet provides the most economical production system when used in a two years wheat/summer fallow cropping system in the semiarid High Plains of the USA [20].

Foxtail millet

Foxtail Millet (*Setaria italica*) requires moderate climate and temperature conditions. China is the largest producer of foxtail mil-

let in the world. This millet is grown for both food and feed. The crop is also grown in India, Indonesia, the Korean peninsula, and some parts of southern Europe [21]. Foxtail millet is one of the earliest cultivated crops, extensively grown in the arid and semi-arid regions of Asia and Africa. Foxtail millet contains significant levels of protein, fiber, minerals, and phytochemicals. Anti-nutrients such as phytic acid and tannin present in this millet can be reduced to negligible levels by using suitable processing methods. Foxtail Millet is rich in Vitamin B12 which is essential for maintaining a healthy heart, smooth functioning of the nervous system, and in general good for skin and hair growth. A diet including Foxtail Millet may improve glycaemic control and reduces insulin [22].

Barnyard millet

Barnyard millet is grown in the hilly areas widely in hilly regions of Uttarakhand. Also known as Shyama in Bengali, moraiyo in Gujarati, sanwa rice in Hindi, oodalu in Kannada, kuthiraivolly in Tamil, and udalu in Telugu, Barnyard millet tastes almost like broken rice when cooked. The barnyard millets give 75 calories and 1.5g of protein, 68 % carbohydrate, and less than 400 kcal/100 gms and are ideal for those who follow a diet. The Barnyard millet or Sanwa rice as it is popularly known has high levels of protein, calcium, iron, minerals, and vitamin B complex. It is also low in carbohydrates and gluten-free, making it a boon for those with gluten allergies, type II diabetes, and cardiovascular diseases [23].

Sorghum

In India, sorghum is known as jowar, cholam, or jonna, in West Africa as Guinea corn, and China as kaoliang. Sorghum is especially valued in hot and arid regions for its resistance to drought and heat. Sorghum is a cereal grain that's widely produced around the world. Its whole grain is commonly used in baking, while its syrup is used as a sweetener. Finally, it's used as a natural fuel source. One half-cup serves up 18% of the Daily Value (DV) of iron, 25% DV of vitamin B6, 37% DV of magnesium, and 30% DV of copper. It also contains significant amounts of phosphorus, potassium, zinc, and thiamine. The health benefits of Sorghum are such that it is a good source of vitamins and minerals, has a high content of dietary fibers, is a rich source of antioxidants, helps in inhibiting tumor growth, natural cure for patients of diabetes, is a staple food for celiac patients, lowers blood cholesterol, helps in weight control, provides strong bones, improves mood, boosts energy levels and promotes blood circulation [24].

The United Nations General Assembly adopted a resolution declaring 2023 as the International Year of Millets. The main goal of this initiative is to raise public awareness of the health benefits of millets and their suitability for cultivation under challenging conditions brought by climate change. The International Year of Millet provides an excellent chance to improve the millet's contribution

to food security and increase millet output globally, making sure that the processing, transport, storage, and consumption are efficient and sustainable millet production and quality with stakeholder participation [25].

Millet based fermented food products

Foods and drinks that have experienced microbial fermentation are referred to as fermented products. During this process, bacteria, yeasts, or fungi break down complex chemical components in the food to produce a variety of by-products, including organic acids, gases, and alcohol. For thousands of years, people have employed fermentation to preserve food and improve its flavor, texture, and nutritional content. Probiotics, which are healthy bacteria that can improve digestive health and strengthen the immune system, can be found in fermented goods. Probiotics aren't present in all fermented foods, and the advantages might vary depending on the type and effectiveness of the fermentation process. Depending on the kind of fermented product being produced, different bacteria are utilized in the fermentation process. Each of the several bacterial strains that may be employed in fermentation has unique qualities that can change the flavor, texture, and nutritional value of the finished product. Some common bacteria used in fermentation include; *Lactobacillus* is used for the fermentation of sorghum and millet-based foods like ogi, a traditional African porridge, *Lactobacillus fermentum* is a common bacterium. *Lactobacillus plantarum* is used in the fermentation of millet-based products like kaffir beer and idli, an iconic Indian breakfast dish, *Lactobacillus plantarum* is a common bacterium. *Pediococcus pentosaceus* is a type of bacteria that is frequently discovered during the fermentation of pearl millet-based products like Mahewu, a traditional fermented beverage from Zimbabwe. *Leuconostoc mesenteroides* is the bacterium that is frequently discovered in the fermentation of products made from finger millet, such as the Bhakari, a traditional Indian flatbread. Foods made from millet grains and fermented with yeast or bacteria are known as millet-fermented products. By the action of microorganisms like bacteria, yeast, or fungi, the process of fermentation involves converting the sugars and other carbohydrates in food into alcohol, organic acids, or gases [25].

Many different types of fermented millet products are consumed around the world, including:

- **Koko:** A key ingredient in West African cuisine, Koko is a tasty and wholesome fermented food. It is a well-liked option for breakfast, snacks, and other meals thanks to its distinctive flavor and adaptability. Many people in West Africa regularly eat koko, a millet porridge, for lunch or as a snack. Koko is made by wet milling pearl millet grains with spices (typically ginger, chili pepper, black pepper, and cloves), adding water to the milled materials to make

a thick slurry, and discarding the steep water. Later, the slurry is sieved, fermented, and sedimented for two to three hours. When the desired consistency is reached, the sedimented bottom layer is added after the liquid top layer has been decanted and boiled for 1–2 hours. The millet grain is typically steeped in the evening, and the process is complete when the product is ready for consumption at noon the following day. Koko is typically eaten with added sugar and is available for purchase as porridge in plastic bags or bowls. *Weissella confuse*, *Lactobacillus fermentum* and *L. salivarius* are the main microbes in Koko. Koko is a wholesome food that is high in fiber, protein, and complex carbohydrates. Additionally, it is a good source of vitamins and minerals like calcium, iron, and B vitamins. Koko has been fermented, making it easier to digest than unfermented grains. It also might have probiotic qualities that help to maintain gut health. Koko is thought to have medicinal properties in addition to its nutritional advantages. It is frequently employed as a treatment for digestive issues and is believed to have calming effects on the stomach [26].

- **Fura:** African countries commonly cultivate millet, a type of grain, to make fura, a traditional fermented food product. The gluten-free, high-fiber grain known as millet is a great source of iron, magnesium, and phosphorus. Fura is a staple food in many households and is widely consumed in West African nations like Nigeria, Ghana, and Burkina Faso. Millions of people living in the semi-arid tropics depend on pearl millet as a food source, and it is a significant source of calories in developing nations. North of the equator, the Sahel borders semi-arid and arid regions of Africa. Fura, a dish made from millet flour, is a common dish in the Sahel region. A step-by-step process for making pearl millet-based fura. In a disc attrition mill made locally, millet grain is slightly moistened with water before grinding. After the grain has dried in the sun, the hull is removed, and the grain is then sieved and ground in a hammer mill. Pearl millet flour is combined with powdered ginger, black pepper, and water (95°C) in a mortar, then thoroughly mixed with a pestle to form a smooth dough [25]. The dough is formed into balls by hand, put inside a pan of boiling water, and cooked at atmospheric pressure for 30 minutes. The balls are kneaded once more while they are still hot until they form a smooth, slightly elastic mass. The fura balls are then formed from the dough. The resulting stiff dough is reconstituted with sour milk to the consistency of porridge. Fura is now available in supermarkets thanks to a business in Abuja, Nigeria, that specializes in producing powdered (instant) fura. In addition to being a delicious and healthy food, fura is a significant source of income for many small-scale farmers and

women's organizations in West Africa [25]. These groups can make money, and support their families, and communities by making and selling fura. Fura is also a sustainable and environmentally friendly food because it is produced using conventional techniques that use little energy and ingredients that are sourced locally [25].

- Mangisi:** Families in rural Africa consume a lot of fermented drinks, which are also alcoholic beverages. In addition to their use in social gatherings and ceremonies, and weaning foods. Mangisi is a naturally fermented millet mash beverage that has a sweet-sour flavor. In different parts of sub-Saharan Africa, like Zimbabwe and Uganda, preparation varies. In one form, water is added to finger millet flour after it has been malted and milled. Slowly the mixture is added. Heated to almost boiling for 80 minutes. The result is a mash (masvusvu), which is then chilled, diluted, strained, and left to stand for several hours, during which spontaneous fermentation occurs and magic is produced. Another option calls for simmering the mixture for one to two hours after malting and milling the finger millet. The masvusvu is chilled, diluted, and let to stand for the whole of the next day. More malt flour is added on day two, and the mixture continues to ferment until day three when the coarse solids are strained out. After the mixture is put back into the fermentation vessel, the magic is prepared. According to Gadaga et al., the product has higher alcohol because of the longer fermentation period as well as the second day's addition of extra malt, which could act as an additional source of inoculum [26].
- Jandh:** Traditional fermented foods are typically unique to individual cultures and geographical regions. Jandh, a mildly sweet and acidic style of beer beverage is one of Nepal's main traditional alcoholic products. Jandh is a finger millet (koko or marua) fermentation product that is occasionally combined with a little amount of wheat or maize. Jandh has been outfitted as follows. Steam is used to soften the millet seeds, which are then placed over leaves (ideally banana leaves) [26]. The boiling and cooled seeds are then dusted with powdered much, the beginning culture. The seeds are thoroughly mixed, heaped high, and left at room temperature for 24 hours. They are then typically put in an earthen pot and covered in leaves and straw. The seeds are allowed to ferment in polyethylene bags in urban areas. Then, depending on the season, water (either cold or hot) is added to the grits in bamboo containers [27].
- Uji:** In East Africa (Kenya, Uganda, and Tanzania), Uji is a thin, lactic acid-fermented porridge that is popular. Is referred to as Iowa and Obusera, respectively, in Tanzania and Uganda. It is prepared through the lactic acid fermentation of cassava and grain (maize, finger millet, or sorghum) flours combined in various combinations and ratios. The fermentation inocula are produced through a process known as backslapping [26]. The fermentation inocula are produced through a process known as backslapping. The most widely used 1:1 Maize and sorghum, maize and finger millet, cassava and finger millet, and cassava and sorghum are examples of combinations. Uji is consumed by both adults and children as a pleasant beverage and as their primary weaning food. The predominant species of lactobacilli in ordinary uji fermentation is *Lactobacillus plantarum*, which is in charge of the large quantities of lactic acid and the resulting sour taste of uji. *Pediococcus acidilactici*, *P. pentocaceus*, *L. paracasei* subsp. *paracasei*, *L. fermentum*, *L. cellobiosus*, and *L. buchneri* are among the other species that are found [28].
- Burukutu and Pito:** Millet has been effectively employed as a barley substitute in numerous nations. For instance, cereals like finger millet have been a key component in the traditional production of malt in sub-Saharan Africa and India. African beers typically differ from Western beer varieties in various respects, including being frequently sour, having less carbonation, and lacking hops. Unrefined African beers, including unfermented sub-states and microbes, are drunk. Pito and buraku are brewed simultaneously by fermenting single or combined grains of malted or germinated cereal, such as millet, into a brownish suspension or liquor. A common alcoholic beverage among the inhabitants of sub-Saharan Africa is buraku [28].
- Kunu-Zaki:** A fermented, non-alcoholic beverage made from grains is called Kunlun-Zaki. It is a well-liked cold drink in several regions of the Sahel, including Tchad, northern Nigeria, and Niger. The output of kanun-zaki is primarily a domestic activity at the moment, with no significant factory output. In their study of the microbiology of the kanun-zaki fermentation process, Efiuvey and Akoma found that *Lactobacillus fermentum* and *Lactobacillus leichmanii* predominated at the end of the fermentation time. When millet or millet and other ingredients are combined, four different types of kanun-zaki can be produced, according to Akoma et al. Wheat fermented for 6 hours, either with or without the inclusion of ground malted rice. Using created starting cultures (controlled fermentation), natural (uncontrolled) fermentation, and various combinations of millet, wheat, malted rice, and starter cultures explained how kanun-zaki may be manufactured. For the control experiment, previously sterilized, raw cereal starch was completely combined with hydrolysed cereal starch before being added to gelatinized cereal starch. To determine whether fermentation

may occur, this mixture was incubated at room temperature for 6 hours without the addition of starting culture [25]. The authors asserted that starting culture was added to either millet and malted rice or kanun-Zaki to make kunun-zaki. In comparison to other products, millet, wheat, and malted rice have several advantages in terms of flavor, aroma, appearance, and general appeal. However, in the Sahel, the caliber of regional producers' expertise and the season in which a product is manufactured have always been determinants of the quality of traditional food items like kanun-Zaki. Braza and sargassum are two other fermented millet beverages that are produced in Romania and Mongolia, respectively [28].

- **Ogi:** In West Africa, ogi is a porridge made from fermented millet, sorghum, maize paste, or cake. Ogi is typically offered as a moist cake encased in polyethylene bags or leaves. Ogi that has been gelatinized is commonly used as a traditional baby food during weaning as well as a morning dish for many people. From 4 to 6 months of age, children in many African countries are offered mashed adult foods or gelatinized cereal flour slurries to supplement breast milk [29]. Either hot or cold water. Ogi has been made using both conventional and modern manufacturing techniques. & malting the starch level of the grains can be altered using fermentation procedures so they don't thicken and don't need dilutions. The prevention of infections throughout the fermentation process is another advantage of effective manufacturing procedures [25]. According to Akinrele's research, the main microorganisms responsible for the fermentation and nutritional improvement of ogi are *Lactobacillus plantarum*, *Corynebacterium spp.*, *Aerobacter spp.*, *Candida mycoderma*, *Saccharomyces cerevisiae*, *Rhodotorula spp.*, *Cephalosporium spp.*, *Fusarium spp.*, *Aspergillus spp.* Odunfa determined that the main bacterium involved in the fermentation of ogi was *Lactobacillus plantarum*. Responsible for the synthesis of lactic acid. Ogi's distinctive aroma and sour flavor are attributed to lactic, acetic, butyric, and formic acids. Consumers are said to like light-colored ogi with a mildly acidic flavor [29].
- **Ben-Saalga:** Ben-Saalga is a fermented gruel made from millet that is produced in a variety of traditional ways. Burkina Faso, is a country in West Africa. In Africa, traditional fermented foods made from cereal are regularly served as supplemental foods to young children and new borns. Around 7 kg of millet is typically processed each day in a traditional production facility to make ben-saalga. Cleaning and soaking of grain (pearl millet), grinding, kneading, sifting, settling, and cooking are the primary processes in the processing process. According to the producer's tradition, aromatic substances like ginger, black pepper, pepper, and mint are typically added in little amounts before grinding [26]. The supernatant remaining after the settling process is collected and cooked for 40 minutes until nearly boiling during the final cooking. Afterward. The paste is then added to the simmering mixture and allowed to cook for 7 minutes. According to the cooked version of the sour paste, known as sour ben-saalga, lacked sufficient nutritional qualities to meet the needs of newborns and young children [25].
- **Bushera:** The most popular traditional drink made in Uganda's western highlands, where sorghum is grown, is called bushera. And millet is a significant commercial and staple crop. Young children and adults both ingest the stuff. Bushera can be prepared in a variety of ways. Sorghum or millet grain that has been germinated is used to make the flour, which is combined with boiling water and allowed to cool to room temperature [24]. The mixture is then supplemented with germinated millet or sorghum flour, and let to ferment for one to six days at room temperature. The five genera of lactic acid bacteria that have been isolated from bushera, in general, are *Lactobacillus*, *Lactococcus*, *Leuconostoc*, *Enterococcus*, and *Streptococcus*. In comparison to other species, *Lactobacillus brevis* is isolated more frequently [30].
- **Togwa:** African traditional drink called togwa is fermented with lactic acid. Togwa is commonly spoken in southern Tanzania. Produced with finger millet malt and maize flour. It is utilized as a weaning food and a refreshment in this region, where it is taken by both adults and small children. The wheat or cassava flour is cooked in water to make togwa. After cooling, actual flour made from germinated grains and the starter culture (old togwa) is added. Fermentation occurs spontaneously and uncontrollably, producing a product of varying quality. The microorganisms that were extracted from togwa include *Lactobacillus brevis*, *Lactobacillus fermentum*, *Lactobacillus cellobiosus*, and *Weissella Pediococcus pentosaceus*, as well as confusion. They are all present during the entire fermentation process. The *L. plantarum* group is the pre-dominant organism after various natural lactic acid fermentations taken as either food or beverage. It is also the major bacterium at the end of togwa fermentation. Reduced sugars that have been released have a sweet flavor. Masvusvu is additionally used as an additive when producing opaque beers. Masvusvu is created differently from kunun-zaki, which is made from wet millet flour that hasn't been malted, and gowé, which is made from wet-milled malted sorghum flour [24].
- **Rabadi:** Native to India, the lactic fermented milk beverage known as "rabadi" is a favorite in the country's northwestern semiarid regions. Indian dairy dessert known as millet-based

fermented rabadi is made with millet, milk, and jaggery. In India, millet has been grown for many centuries and is a healthy, gluten-free grain. Milk is reduced to about one-third of its original volume by simmering it until it thickens, creating the sweet, and creamy dessert known as rabadi. To make millet-based fermented rabadi, the millet must first be soaked for an overnight period to soften it [31]. The millet is made into a coarse paste the following day and combined with water. The mixture is then allowed to ferment for the remainder of the night, which aids in breaking down the millet's complex carbohydrates and making it easier to digest. Rabadi is traditionally made by combining various amounts of sour buttermilk and cereal flour. The mixture is then boiled after continuing to ferment for an additional three to four hours in the sun. The product can either be consumed straight away or after being diluted with milk or buttermilk. Rabadi production is still largely a domestic art, which leads to wide variation and short shelf life. Even more so, large-scale production cannot be accomplished using the traditional method. There are excellent opportunities in India to combine milk and milk byproducts with traditional cereals and use cutting-edge technologies for processing and preservation, adding value to the products and improving their health benefits [29].

- **Dosa:** Many residents of the area regularly consume dosa, a traditional South Indian dish. It is a fermented pancake made from rice and lentil batter. Dosa can, however, be prepared in a variety of ways using a variety of grains, including millet. Those seeking a gluten-free and healthier alternative often turn to dosa made from fermented millet batter. In Africa and Asia, millet is a type of grain that is widely grown. It is renowned for its nutritional value and is a good source of fiber, iron, and magnesium. For those who are intolerant to gluten, millet is a great alternative because it is gluten-free [19]. The millet is first soaked in water for several hours before being used to make fermented millet batter for dosa. The soaked millet, lentils, and additional ingredients like fenugreek seeds are then blended into a smooth paste. The millet and lentil proteins and carbohydrates in the batter are broken down by the natural bacteria during the overnight fermentation process, improving the batter's nutritional value and making it easier to digest [29]. Then, the thinly spread fermented millet batter is cooked until crisp and golden brown on a hot griddle or pan. In contrast to conventional rice and lentil dosa, dosa made from fermented millet batter has a distinctive texture and flavor. Chutneys and sambar, which are customary dosa accompaniments, go well with their mildly tangy and nutty flavour [27].
- **Idli:** In various regions of India, pearl millet, sometimes referred to as bajra, is a widely consumed cereal grain. Making

idlis, a common breakfast food in South India, is one of the most popular methods to consume pearl millet. Pearl millet-based idlis, in contrast to conventional rice-based idlis, are becoming more and more well-liked because of their numerous health advantages. Idlis prepared from pearl millet are a fermented food created from the ingredients urad dal (split black gramme) and fenugreek seeds [29]. The mixture is prepared by soaking, grinding, and overnight fermentation. The complex carbohydrates and proteins in the batter are broken down by the fermentation process, making the batter easier to digest. The excellent nutritious content of pearl millet makes it one of the best options for idlis. Protein, fiber, and important minerals like iron, magnesium, and phosphorus are all abundant in pearl millet. It is a great option for those who are sensitive to gluten because it is low in fat and gluten-free. Pearl millet-based idlis are also more filling and gratifying than conventional rice-based idlis because of their distinctive nutty flavor and somewhat coarse texture. As pearl millet has a low glycemic index and aids in blood sugar regulation, they are also a fantastic choice for persons who are trying to reduce weight or manage their blood sugar levels [28].

Therapeutic benefits of millets

Millets are beneficial to our health as it is important for helping our digestive system. Millet contains fiber, which contributes to digestive health and helps to regulate bowel movements. Millet also has prebiotics, which stimulates the growth of probiotics within the microbiome. This is important for gut health and the immune system in general. Millet is a very helpful source for people with celiac disease or gluten intolerance because of its gluten-free structure. People with celiac disease can consume this grain, which is nutrient-rich and high in protein and fiber, it does not create any discomfort to consumers [1]. Millets are beneficial to our health as it supports our cardiovascular system in different ways. Millets contain many varieties of minerals like iron, zinc, manganese, and copper, magnesium which helps our circulatory system directly or indirectly. Consuming millet may also trust source elevated levels of the protein adiponectin, which can protect cardiovascular tissues. Millets are also a good source of vitamin B3 and niacin. All these factors help to reduce heart-related diseases and control the high level of cholesterol and triglycerides which are responsible for cardiovascular diseases. Another special feature of millet is it can be used to improve the mood of a person. As it has a high concentration of amino acid and tryptophan. So, from the study related to the amino acid and the tryptophan concentration we got the result that it can be used to decrease the chances of depression and anxiety in a person.

Millets are also helping in reducing the risk of diabetes. As we know there are 2 types of diabetes, millets are very useful to reduce type 2 diabetes. It helps to maintain the glucose concentration in the body. An increase trusted Source in adinopectin concentration may improve insulin sensitivity. Another health benefit of millet is related to managing obesity. From the study 2021 investigation of the effectiveness of millets, it was confident that millets can be used to maintain obesity and the cholesterol level in the body. It was observed that the type of millet base diet can reduce BMI which is reduced in the obesity or overweight. Millets are very beneficial in reducing oxidative stress. Oxidative stress can create different types of chronic conditions including neurodegenerative disorders, arthritis, and diabetes. A high-fat diet is also a risk factor for the development of dementia because it increases oxidative stress in the brain. Millets are rich in antioxidants which are responsible to reduce oxidative stress in the body. Antioxidants may help support the body's ability for resisting oxidative stress and factors in illness and aging. Consuming antioxidants could decrease the risk of chronic diseases. Different researchers also concluded that the intake of millet could alleviate oxidative stress in the hippocampus and downregulate the expression of Alzheimer's disease [33].

Pearl millet contains phytates, which make it harder for the body to absorb nutrients, and goitrogenic polyphenols. These may play trusted Source a role in the incidence of goiters in diets high in millet.

Finger millet also has antinutritional factors that include tannins, protease inhibitors, oxalates, and phytate.

There are many other benefits of the consumption of millet: -

- Suppressing cancer cell growth
- Promoting wound healing
- Maintaining bone health
- Supporting antifungal and antimicrobial activity [30].

Market potential of millets

Millets were probably first cultivated in Asia more than 4,000 years ago and they were major grains in Europe during the middle ages. Today, though they are used chiefly to produce hay in the United States and Western Europe, they remain important food staples in less-developed countries worldwide. Millet grains have high carbohydrates, protein ranges from 6 to 11 percent, and fat varies from 1.5 to 5 percent [33]. Millets are typically annuals and range in height from 30 to 130 cm, except pearl millet, which has stalks 1.5 to 3 meters (5 to 10 feet) tall and about 2.5 cm thick. Pearl millet, called bajra in India, is suited to soils of low fertility and limited moisture and is a popular food crop in India. Proso millet—also called common, or broomcorn, millet ripens within 60–80 days after sowing and is commonly used in birdseed mixtures. It is also eaten as a cereal food in Asia [34]. The main problem in a

decrease in millet consumption is less availability of ready-to-eat millet-based products. As we know in the modern world, everyone is about to prefer food that can be easily prepared and delicious. Though millet-based ready-to-eat products are available in very less varieties. Therefore, consumption of wheat and rice-based ready-to-eat product gets increased and millet-based products gets decreased. While discussing the economic importance of millets, the advantages, and different challenges study is important. Advantages include composition like High nutrient content in millets. Millets are rich in fibers, vitamins, minerals, antioxidants, and other beneficial nutrients. Another important benefit is millets are Gluten-free. So, many people with gluten intolerance problems can enjoy food products that are millet based. Millets are useful in promoting weight loss in people. As millet has a low glycemic index, it gets slowly digested in our body and it is very beneficial for people following the diet for weight loss. The main advantage of millet is it Supports cardiovascular health. Millets are rich in magnesium and polyunsaturated fatty acids, which are responsible for reducing blood pressure and decreasing the chances of cardiovascular disease. It also helps to Increase energy levels faster than other food products. As millets are a good source of carbohydrates so it provides a steady source of energy. It also supports digestive health for proper digestion. Millets are rich in fiber which promotes digestion and avoids the risk of constipation. Millets are Suitable for multiple diets in athletes. Millets are suitable for various diets, including vegan, vegetarian, and gluten-free diets. Millets cultivation also supports farmers in many ways cultivation of millets is beneficial for small-scale farmers as they are relatively easy to grow and it has low input and high yield [35].

Challenges in cultivation, production, processing and marketing of millets

In this modern world, every person is about to prefer food that is easy to prepare and such types of food products are not nutritious as millet. So, millets are less popular than rice and wheat so in the entire world the consumption of rice and wheat is getting increased and millets get decreasing. Another challenge for the cultivation of millets is the Lack of processing facilities which is a very important factor for final product preparation. In the current situation, processing of the millets has very less facilities and therefore it affects the marketability and profitability of the product. Another challenge gets created because of inadequate storage and transportation infrastructure. Inadequate storage and transportation facilities lead to post-harvest losses and difficulty in reaching markets. It directly affects the marketing of the product. While discussing challenges in marketing, there is limited marketing and branding of the millets in the market. Millets has a Lack of marketing and branding facilities therefore it is not able to attract consumers who are diverting to other food products. The most important challenge in millets is the lack of awareness in people about the importance

of the millets. Because of limited awareness about the nutritional and health benefits of millets among consumers, farming millets is a challenge [36]. By taking all the conditions under consideration Government of India has decided to provide different types of funds and prizes for the initiative start-ups based on millets and its related products. Initiative for Nutritional Security through Intensive Millet Promotion (INSIMP) a part of 'Rashtriya Krishi Vikas Yojana' Rashtriya Krishi Vikas Yojana (RKVY) is the only comprehensive initiative to support millet production. 'Rainfed Area Development Programme (RADP)' a component of the 'Rashtriya Krishi Vikas Yojana (RKVY)' are playing a major role in such tasks. The Government of India had proposed to the United Nations for declaring 2023 as the International Year of Millets (IYOM). The proposal of India was supported by 72 countries and the United Nations General Assembly (UNGA) declared 2023 as the International Year of Millets on 5 th March 2021. Now, the next task for the celebration of IYOM 2023 is to make it a people's movement so that Indian millets, recipes, and value-added products are accepted globally. Millets are being promoted through technology dissemination, quality seeds through millet seed hubs, awareness generation, and minimum support price. In Karnataka and Telangana efforts are done for the cultivation of nutrients rich smaller millets. Millets awareness is getting increasing in Kolkata, Mumbai and Delhi, and other states. From all those efforts government of India finally got results as dozens of startups have successfully launched their millet-based food products in the market under the guidance of IIMR. Startups are provided grants of up to Rs 25 lakh under the Government's 'Rashtriya Krishi Vikas Yojana' [25]. Millet-based products face several challenges that include limited consumer awareness, processing and storage difficulties, texture and taste concerns, high cost, limited availability, and marketing difficulties. Firstly, millet is not widely known and lacks popularity compared to other grains like wheat or rice. This makes it challenging to promote millet-based products and educate consumers about their nutritional benefits and preparation methods. Secondly, millet is small, which makes its processing and storage more challenging than other grains. Millets require specialized equipment and techniques for cleaning, dehulling, and milling, which can be expensive for small-scale producers [37]. Thirdly, millet has a unique texture and taste that may not appeal to everyone. Moreover, millet is low in gluten, making it difficult to create products with an ideal texture. Fourthly, millet can be more expensive than other grains, particularly if it is not locally grown, and requires specialized processing. Because of limited consumer awareness production of millet-based products getting decreased. Millet is not as well-known or much popular as other grains like wheat or rice, etc. and many consumers are not aware of its nutritional benefits or how to cook and use it. Processing and storage of such products is also a very difficult task because of the less availability of equipment required during the processing. Millets are small grains, and their processing and storage can be

challenging which can cause many problems. They require specialized equipment and techniques for cleaning, dehulling, and milling, which can be expensive for small-scale producers [38]. Millets have a distinct taste and texture that may not appeal to everyone so it may vary from person to person. They are also relatively low in gluten, which makes it difficult to create products with a desirable texture. Another factor while purchasing any product from the market is the cost of the product. Compared to other grains, millets can be more expensive, particularly if they are not locally grown or if they require specialized processing. Millets are not as widely available as other grains, particularly in urban areas. This can make it difficult for producers to find a reliable supply of millet and for consumers to access millet-based products. Marketing is one of the difficult tasks for selling the product and because millet is not as well-known or popular as other grains, producers may struggle to market their products effectively and reach a wider audience. To overcome these challenges, education and awareness campaigns could be conducted to promote the nutritional benefits and versatility of millet-based products. Improving processing and storage techniques could also help to increase the availability and quality of millet-based products. Finally, efforts to reduce costs and increase the availability of millet could help to make these products more accessible to consumers [39].

Conclusion

From this review survey, we could study the information on millets, cultivation methods, varieties of millets, and the importance of millets in our daily diet. As we know, India has great varieties of soils according to states or regions. Every region has its specific varieties of millets. Because of many issues like lack of awareness about the importance of millets and many other reasons like commercial value, the millets are getting ignored by consumers. The people are shifting towards usage of wheat and rice-based food products that are not more nutritious than millets. Millets has very high nutritional value as it contains proteins, vitamins, minerals, bioactive compounds, dietary fibres, and one of the important substances that is inulin. Inulin has many benefits related to gut health and it acts as a prebiotic compound for probiotic organisms which are responsible for the fermentation of millets during processing. Millets-based products have many benefits on health in different ways. Studies involving new product development and exploring health benefitting components must be focused on by the people and scientific fraternity.

Acknowledgement

The authors would like to thank Dr. V.D.Talnikar, Ms. Snehal T. Yadav and all faculties of the Department of Food Technology, Anasaheb Dange College of Engineering and Technology, Ashta for their constant support.

Conflict of Interest

The author declares no conflict of interest.

Bibliography

- Ravikesavan R., et al. "Millet Cultivation: An Overview". *Handbook of Millets-Processing, Quality, and Nutrition Status* (2022): 23-47.
- Mathew Jasmine and M K Joseph. "International year of millets 2023: Millet promotion in India for food security". *Rajagiri Journal of Social Development* 14.2 (2022): 2-17.
- Khunt R S., et al. "Review on prospects and constraints of organic production in India: A new paradigm in agricultural production". *Indian Journal of Economics and Development* 18.4 (2022): 958-964.
- Malathi B., et al. "Growth pattern of millets in India". *Indian Journal of Agricultural Research* 50.4 (2016): 382-386.
- Anbukkani P., et al. "Production and consumption of minor millets in India-A structural break analysis". *Annals of Agricultural Research* 38.4 (2017): 1-8.
- Chandra Ajay Kumar., et al. "Global production, demand, and supply". *Millets and Pseudo Cereals*. Woodhead Publishing, (2021): 7-18.
- Kalamkar S S., et al. "An analysis of growth trends of principal crops in India". *Agricultural Science Digest* 22.3 (2002): 153-156.
- Ullah Asmat., et al. "Prediction of effective climate change indicators using statistical downscaling approach and impact assessment on pearl millet (*Pennisetum glaucum* L.) yield through Genetic Algorithm in Punjab, Pakistan". *Ecological Indicators* 90 (2018): 569-576.
- Poudel Shobha and Rajib Shaw. "The relationships between climate variability and crop yield in a mountainous environment: A case study in Lamjung District, Nepal". *Climate* 4.1 (2016): 13.
- Dayakar Rao B., et al. "Demand Creation Measures and Value Chain Model on Millets in India". *Millets and Millet Technology* (2021): 381-411.
- Bisht Anju., et al. "Small Millets: An Overview". *Small Millet Grains: The Superfoods in Human Diet* (2022): 1-13.
- Basavaraj, G., et al. "Availability and utilization of pearl millet in India". *SAT ejournal* 8 (2010).
- Bhagavatula Shraavya., et al. "Sorghum and millet economies in Asia-Facts, Trends and outlook". International Crops Research Institute for the Semi-Arid Tropics, (2013).
- Loganathan V and P Stanly Joseph. "Direction of Major Agriculture Commodities Export and its Implication for consumption Psychology of foreigners on Indian Commodities during Globalization Era". *Journal of Positive School Psychology* 6.2 (2022): 4502-4508.
- Wimalasiri Eranga M., et al. "Agro-climatic sensitivity analysis for sustainable crop diversification; the case of Proso millet (*Panicum miliaceum* L.)". *Plos one* 18.3 (2023): e0283298.
- Theuri Serah and Sarah Burkhart. "Calling on all SNEB Members to Engage in the "International Year of the Millets 2023". *Journal of Nutrition Education and Behavior* 55.1 (2023): 1.
- Amadou Issoufou., et al. "Millets: Nutritional composition, some health benefits and processing-A review". *Emirates Journal of Food and Agriculture* (2013): 501-508.
- Dias-Martins Amanda M., et al. "Potential use of pearl millet (*Pennisetum glaucum* (L.) R. Br.) in Brazil: Food security, processing, health benefits and nutritional products". *Food Research International* 109 (2018): 175-186.
- Devi Palanisamy Bruntha., et al. "Health benefits of finger millet (*Eleusine coracana* L.) polyphenols and dietary fiber: a review". *Journal of Food Science and Technology* 51 (2014): 1021-1040.
- Das Saurav., et al. "Beyond bird feed: Proso millet for human health and environment". *Agriculture* 9.3 (2019): 64.
- Sharma Nitya and Keshavan Niranjana. "Foxtail millet: Properties, processing, health benefits, and uses". *Food Reviews International* 34.4 (2018): 329-363.
- Hou Dianzhi., et al. "A whole foxtail millet diet reduces blood pressure in subjects with mild hypertension". *Journal of cereal science* 84 (2018): 13-19.
- Renganathan Vellaichamy Gandhimeyyan., et al. "Barnyard millet for food and nutritional security: current status and future research direction". *Frontiers in Genetics* 11 (2020): 500.
- Ambati Kimeera and KV Sucharitha. "Millets-review on nutritional profiles and health benefits". *International Journal of Recent Scientific Research* 10.7 (2019): 33943-33948.

25. Dayakar Rao B and Sri Devi Nune. "Role of Nutrihub Incubation for the Development of Business Opportunities in Millets: An Indian Scenario". *Millets and Millet Technology* (2021): 413-438.
26. Ilango Shankar and Usha Antony. "Probiotic microorganisms from non-dairy traditional fermented foods". *Trends in Food Science and Technology* 118 (2021): 617-638.
27. Amadou I., et al. "Millet-based traditional processed foods and beverages—A review". *Cereal Foods World* 56.3 (2011): 115.
28. Arora Sonia., et al. "Effect of germination and probiotic fermentation on nutrient profile of pearl millet based food blends". *British Food Journal* 113.4 (2011): 470-481.
29. Behera Sudhanshu S., et al. "Traditionally fermented pickles: How the microbial diversity associated with their nutritional and health benefits?". *Journal of Functional Foods* 70 (2020): 103971.
30. Arora Laghima, et al. "Assessment of sensory and nutritional attributes of foxtail millet-based food products". *Frontiers in Nutrition* 10 (2023).
31. Selladurai Manivannan., et al. "Considerations for gluten free foods-pearl and finger millet processing and market demand". *Grain and Oil Science and Technology* (2022).
32. Restar Arjee., et al. "Mapping community-engaged implementation strategies with transgender scientists, stakeholders, and trans-led community organizations". *Current HIV/AIDS Reports* (2023): 1-10.
33. Gulia S K., et al. "Progress in grain pearl millet research and market development". *Issues in New Crops and New Uses* (2007): 196-203.
34. Hall A., et al. "Sorghum and pearl millet as food-feed-crops in India". *Animal Nutrition and Feed Technology* 4.1 (2004): 1-15.
35. Dekka Srenuja., et al. "Potential processing technologies for utilization of millets: An updated comprehensive review". *Journal of Food Process Engineering* (2023): e14279.
36. Macauley Harold and Tabo Ramadjita. "Cereal crops: Rice, maize, millet, sorghum, wheat". (2015).
37. Amadou Issoufou. "Millet based fermented beverages processing". *Fermented beverages*. Woodhead Publishing, (2019): 433-472.
38. Gruère Guillaume., et al. "The role of collective action in the marketing of underutilized plant species: Lessons from a case study on minor millets in South India". *Food Policy* 34.1 (2009): 39-45.
39. Shah Priya., et al. "Opportunities and challenges in food entrepreneurship: In-depth qualitative investigation of millet entrepreneurs". *Journal of Business Research* 155 (2023): 113372.