Bioscene

Bioscene
Volume- 21 Number- 02
ISSN: 1539-2422 (P) 2055-1583 (O)
www.explorebioscene.com

Unlocking Prosperity; A Comprehensive Review of the Economic Potential of Millet Farming, Production with a Focus on Seven Diverse Millet Varieties

Shifna Thesni. K
Lovely Professional University, Punjab

Abstract: This comprehensive review explores the economic potential of millet farming, focusing on the production of seven distinct millet varieties in both India and worldwide. Millets, renowned for their adaptability and resilience, have historically played a vital role in global food security. Despite this, their economic significance, particularly for specific varieties, has been underexplored. This study aims to address this gap by analyzing the economic dimensions of cultivating seven diverse millet types and their overall impact on agricultural prosperity. Millet production, a significant aspect of global agriculture, involves diverse varieties cultivated across various regions. In India, different states contribute to the production of millets, showcasing the country's agricultural diversity. Millet cultivation not only supports domestic dietary needs but also plays a crucial role in international trade. Additionally, processing techniques and the development of value-added products contribute to the versatility of millets in various food products. Understanding the dynamics of millet production requires consideration of regional variations, processing methods, and evolving international market trends for these nutritious grains.

Key words: Millet, Finger millet, kodo millet, proso millet, foxtail millet, barnyard millet

Introduction

Millets are abundantly used worldwide; it is an excellent source of protein, carbohydrate, fat, minerals and vitamins. Millets often considered a humble and resilient cereal grain, has been a staple in the diets of diverse communities around the world for centuries(Gowda et al., 2022). While it might not have garnered the same attention as major crops like wheat, rice, or maize, millet possesses unique qualities that make it a valuable and versatile resource(Saha et al., 2016). In recent years, there has been a growing interest in exploring the economic potential of millet farming, recognizing its ability to contribute significantly to global food security, agricultural sustainability, and economic prosperity(Muthamilarasan& Prasad, 2021).It is rich in nutrients and other components like health beneficial phenolic compounds making it as suitable for food and feed(Hassan et al., 2021). Approximately 97% of millets are cultivated and utilized in developing nations, primarily in Africa and Asia. India stands as the world's leading millet producer, contributing to 26.6% of global production and encompassing 83% of Asia's millet farming regions. Within India, millets have traditionally formed a crucial component of the diets among tribal communities in states such as Jharkhand, Rajasthan, Odisha, Karnataka, Madhya Pradesh, Uttarakhand and Jharkhand (Sood et al. 2019).

Millets hold substantial importance as a global food crop and exert a significant economic influence, particularly on developing nations (Nithiyanantham et al., 2019). Millets are in the group of cereals from the Poaceae grass family and are considered one of the traditional cultivated crops(A. Singh et al., 2020). Several varieties of millets are being produced all over the world and seven important millets cultivated globally are proso millet (Panicum miliaceum), pearl millet (Pennisetum glaucum), kodo millet (Paspalum scrobiculatum), finger millet (Eleusine coracana), barnyard millet(Echinochloe species), little millet (Panicum sumatrense) and foxtail millet (Setaria italic) (Sarita & Singh, 2016). Each variety is assessed for its adaptability to different climates, nutritional content, market potential, and overall impact on economic sustainability in agricultural practices. Millets have earned the nickname "nutri-cereals" due to their exceptional nutritional content, particularly their rich reserves of essential micronutrients such as iron (Fe), calcium (Ca) and zinc (Zn)(A. Singh et al., 2020). These grains play a crucial role in fulfilling over 50% of the micronutrient needs in low-income communities, making them the top choice among crops. Millets are important foods in many underdeveloped countries because of their ability to grow under adverse weatherconditions like limited rainfall (Das & Rakshit, 2016). Millet is one of the most important drought-resistant crops and the 6th cereal crop in terms of world agriculture production. Also, millet has resistance to pests and diseases, short growing season, and productivity under drought conditions, compared to major cereals (Numan et al., 2021). As the global community strives to address pressing issues like food security, malnutrition, and environmental sustainability, millets have emerged as a potential solution. Their resilience in the face of climate variability, their capacity to improve soil health, and their role in diversifying diets make them a compelling subject of study and a crucial component of the sustainable agriculture agenda.

Millet varieties and cultivation practices

Millet farming refers to the cultivation and agricultural practices involved in the production of millet, a group of small-seeded grasses that are widely grown for their nutritious grains(Meena et al., 2021). Millets are staple crops in many regions around the world, particularly in arid and semi-arid areas where they demonstrate resilience to harsh environmental conditions. Millet cultivation is valued for its ability to thrive in diverse climates, its relatively short growing season, and its nutritional benefits, making it an important source of food and fodder for many communities worldwide(Wilson & VanBuren, 2022). The farming methods employed for millets aim to optimize yield, ensure crop health, and sustainably manage agricultural resources. Mainly there are 7 types of millet varieties including pearl millet, finger millet, kodo millet, barnyard millet, foxtail millet, little millet and proso millet(Sarita & Singh, 2016).

1. Pearl millet

Pearl millet is primarily grown for grain production in Asia and Sub-Saharan Africa, but its stover is also highly valued as a source of dry fodder. In some other regions, it is predominantly cultivated for use as a forage crop(Pattanashetti et al., 2016). This versatile cereal crop known for its ability to withstand drought and high temperatures consistently delivers good grain and forage yields even in challenging conditions characterized by poor, sandy soils, and arid climate(Jukanti et al., 2016). Despite the various obstacles faced in such harsh environments, farmers cultivate pearl millet either as a sole crop or in mixed and intercropping systems. These latter two cultivation methods offer smallholder farmers increased food and financial security. Pearl millet thrives in hot, arid, and semi-arid regions with minimal rainfall (Bussmann et al., 2016). It is well-suited to areas with temperatures ranging from 25°C to 35°C (77°F to 95°F) (Rani et al., 2018). It can grow in a variety of soil types, including poor, sandy soils. However, well-drained soils with good organic matter content are ideal. Pearl millet is known for its ability to tolerate drought and heat stress, making it a valuable crop in regions with irregular rainfall patterns(Serba et al., 2020)

2. Finger millet

Finger millet is a minor millet grown in the arid and semiarid tropics and subtropics of Asia and Africa. It is cultivated for food, as well as fodder and medicinal purposes(Maharajan et al., 2022). Finger millet exhibits remarkable genetic diversity, with different varieties suited to specific regions and climates. Understanding the local variety and its characteristics is crucial before commencing cultivation. Finger millet thrives in well-drained soils with a slightly acidic to neutral pH,the ideal soil for finger millet is well-drained loamy soil with a pH range of 5.8 to 6.8(Motshekga, 2021). Finger millet thrives in a variety of agro-climatic conditions but is primarily grown in tropical and subtropical regions. It is well-suited for both high and low rainfall areas and can tolerate drought conditions. It can grow in both arid and semi-arid regions, making it a valuable crop for areas with erratic rainfall(Ceasar et al., 2023). Select high-quality finger millet seeds free from diseases or pests. Pre-sowing treatments like seed soaking can enhance germination rates and crop establishment. Prepare the land by plowing and leveling to create a suitable seedbed. Finger millet is traditionally sown in rows, and the recommended planting depth is 2-3 cm, 20 to 35 cm in a row(Korir, 2019).

The grain is easily digestible, rich in nutrients, and adaptable, serving various culinary purposes such as cooking like rice, grinding for porridge or flour, and making cakes. Sprouted grains are suggested for infants and the elderly (Rao et al., 2017). Additionally, finger millet is utilized in the production of liquor (known as arake or areki in Ethiopia) and beer, with by-products being utilized for livestock feed(Hassan et al., 2021).

3.Kodo millet

Kodo millet, scientifically known as Paspalum scrobiculatum, is a type of small-seeded, drought-resistant cereal grain that belongs to the millet family (Poaceae). It is primarily grown in parts of India, Africa, and Southeast Asia(P. Kumari et al., 2024). Kodo millet has been cultivated for thousands of years and is considered an important food crop in many regions due to its nutritional value and adaptability to harsh environmental conditions. Kodo millet largely developed in the states of Chattisgarh,Maharashtra,Karnataka and Tamil Nadu (Pundir et al., 2024).The composition of Kodo grains includes 8.35% protein, 1.45% fat, 65.65% carbohydrates, and 2.95% ash(Bunkar et al 2021).It is primarily cultivated in warm and arid climates and is exceptionally resilient to drought conditions. As a result, it can be successfully grown in regions with limited and irregular rainfall, even in areas receiving as little as 40 to 50 centimeters of annual precipitation. Kodo millet can thrive in a range of soil types, including rocky and gravelly upland soils as well as loamy soils, but it tends to perform best in deep, fertile soils that are rich in organic matter. To support its continuous growth, well-drained soils with adequate moisture supply are essential(Vetriventhan & Upadhyaya, 2019).Kodo grains pose a toxic risk to both livestock and humans as a result of fungal contamination. The presence of the fungus Paspalum ergot induces symptoms including nervousness, impaired coordination, stumbling, spasms, feelings of despondency, and, in severe instances, fatality in animals. In humans, ingestion of contaminated kodo grains leads to symptoms such as nausea, vomiting, disorientation, mood disturbances, intoxication, and loss of consciousness(Deshpande et al., 2015).

4.Barnyard millet

Barnyard millet also known as samasanwamillet, shamula,sama,shama,shamul,kudiraivalu, bontachamalu,samvathkechawal have similar texture to that of the broken rice (Lohani et al., 2014).The nutritional benefit of barnyard millet is the main reason for using it as the food ingredient in several foods which will further help in achieving good health and well-being. Barnyard millet (Echinochloa species) is an ancient millet crop cultivated in warm and temperate regions of the world. It is abundantly harvested in Asia, notably in India, China, Japanand Korea (Bhatt et al., 2022). Barnyard millet belongs to the genus Echinochloa, the family Poaceae, and the sub-family Panicoideae (Renganathan et al., 2020).Echinochloa esculenta and Echinochloa frumentacea are the two main species of Barnyard millet, billion-dollar grass is another name for Indian barnyard millet (H. Kaur & Sharma, 2020). It is a tiny white grain that happens to be bigger in size than semolina but is smaller than sabudana (sago), and are generally sticky. Barnyard millets generally comprise of two different species, Japanese barnyard millet, and Indian barnyard millet. They are usually rainfed crop, but also happen to be very drought resistant and has the potential of withstanding waterlogging(Mohanapriya et al., 2024).

They are at times used for making kheer, at times it is also used for brewing beer. Moreover, they are also used as feed for cage birds, and its straw is used as a fodder for cattle. Apart from that, it is also used in many food products like porridge, cookies, cakes, etc(Maithani et al., 2022). They happen to be a common staple in the Uttaranchal region, as it is best grown in the hilly region, and as for that matter, they have a nutty flavor with a hint of sweetness. It is generally sown in the Kharif season, ie June - July and in the rabi season September – October (Choudhary, 2024). Barnyard millet draws a reference in the ancient literature of India, supposedly has drawn history of cultivation in China. It's been postulated that barnyard millet probably had been originated somewhere in Central Asia, and thereby spread from Central Asia to Europe and America(Joshi et al., 2021). Barnyard millet flour is also available in market. Due to the importance of health promotion and the presence of bioactive phytochemicals in plant foods, the phrase "functional foods" has become frequently used in relation to diseases like diabetes, cancer, Parkinson's disease, cataract, and others (Banerjee & Maitra, 2020). Like medicines, the term "nutraceuticals" refers to bioactive substances like vitamins, minerals, and essential fatty acids that have a preventative effect against degenerative diseases(Panwar et al., 2016). Millets have received attention for their potential as functional foods because they contain phytochemicals that are health-promoting. Millets are beneficial for people who have celiac disease or a gluten sensitivity. They are not acidic and do not cause allergies, making them simple to digest (Asrani et al., 2022). Dehulled varieties of barnyard millet, particularly after heat treatment, have been identified as beneficial for individuals with type 2 diabetes with a reported glycaemic index of 41.7 compared to 50.0 for dehulled millet(A. Singh et al., 2022).

5. Foxtail millet

Foxtail millet (Setaria italica) is an ancient grain crop that has gained renewed attention due to its nutritional value, adaptability to various agro-climatic conditions, and its resilience to adverse environmental factors(T. Liu et al., 2020). The origin of foxtail millet is thought to be in China. Cultivating foxtail millet involves selecting appropriate varieties and implementing specific cultivation practices. Foxtail millet produces more than 170 lakh tones of millet annually(Lokur et al., 2023). This cultivation takes place in regions such as Karnataka, Andhra Pradesh, Rajasthan,Telangana, Tamil Nadu,Maharashtra and the northeastern states of India (Hariprasanna,2016).Foxtail millet is rich in essential nutritional components, including starch, protein, vitamins, and minerals (T. Yang et al., 2022). The digestible portion of foxtail millet grains accounts for approximately 79%, while the remaining indigestible part contains elevated levels of fiber along with certain anti-nutritional components, owing to the coarse nature of the grains (Sharma & Niranjan, 2017).

6.Little millet

Little millet, scientifically known as Panicum sumatrense, is a small-grained cereal that belongs to the Poaceae family. It is one of the many millet varieties cultivated for its edible seeds. Little millet is known for its ability to thrive in adverse environmental conditions, such as low rainfall and poor soil quality(Das & Rakshit, 2016). This resilience makes it an excellent choice for sustainable agriculture and food security, especially in regions prone to drought or with limited resources(Fischer et al., 2016).Little millet is a rich source of nutrients, including carbohydrates, proteins, dietary fiber, vitamins, and minerals. It is particularly high in iron, calcium, and phosphorus, making it a valuable addition to diets, especially in regions where malnutrition is a concern. Additionally, little millet is gluten-free, making it suitable for individuals with gluten intolerance or celiac disease(S. Kaur et al., 2022).

7.Proso millet

Proso millet, also referred to as common millet or white millet, is cultivated across diverse regions worldwide, encompassing Europe and North America (Q. Yang et al., 2018). Characterized by its brief growing season, this millet variety finds applications in bird feed, human consumption, and serves as fodder for livestock. In the basis of nutritional value,it have high amount of zinc and protein(Karkannavar et al., 2021). Proso millet thrives in areas with limited resources and water, making it well-suited for cultivation on marginal lands with minimal inputs (Ravikesavan et al., 2023). Proso millet has demonstrated the ability to enhance glycemic responses and insulin levels in genetically obese mice with type 2 diabetes, particularly under conditions of high-fat feeding (Deng et al., 2023).

All India Millet Production

Table.2. Millet production in India state wise and world

Sl.no	Millet	States	Production in india(million tonnes)	area(million ha)	Production in world(million tones)
1	Foxtail millet	Meghalaya Karnataka	0.052	0.072	2.29
		Uttarakhand Maharashtra	1.27 0.93	0.86 0.74	3.42

2	Finger millet	Odisha West bangal Andhra Pradesh Tamilnadu karnataka	0.44 0.06 0.30 2.21 11.33	0.55 0.05 0.30 0.74 8.49	
3	Barnyard millet	Uttarakhand Madhya pradhesh	0.146	0.14	0.15
4	Pearl millet	Tamilnadu Karnataka Telangana Maharashtra Madhya Pradesh Rajasthan Haryana Uttar pradhesh	1.57 1.71 4.57 0.03 8.69 37.51 11.20 19.49	0.60 1.71 0.03 5.26 3.43 37.36 4.83 9.04	23.09
5	Proso millet	Tamilnadu Andhra Pradesh Karnataka	0.002	0.003	1.45
6	Kodo millet	Tamilnadu Karnataka Odisha Madhya Pradesh Maharashtra	0.082	0.19	0.084
7	Sorghum	Karnataka Telangana Andhra Pradesh Rajasthan Maharashtra	9.04 1.56 4.11 5.90 3.67	6.23 0.67 0.77	
8	Little millet	Karnataka Tamilnadu Odisha Maharashtra Madhya pradesh	0.20 0.27 0.20 0.17 0.77	0.26 0.23 0.38 0.44 0.89	0.12

Reference; (Paschapur et al. 2021),(Gowdaa et al 2019), Agricultural and Processed Food Products Export Development Authority(APEDA)

Table3 .Millet production in India year wise(FAOSTAT2018)

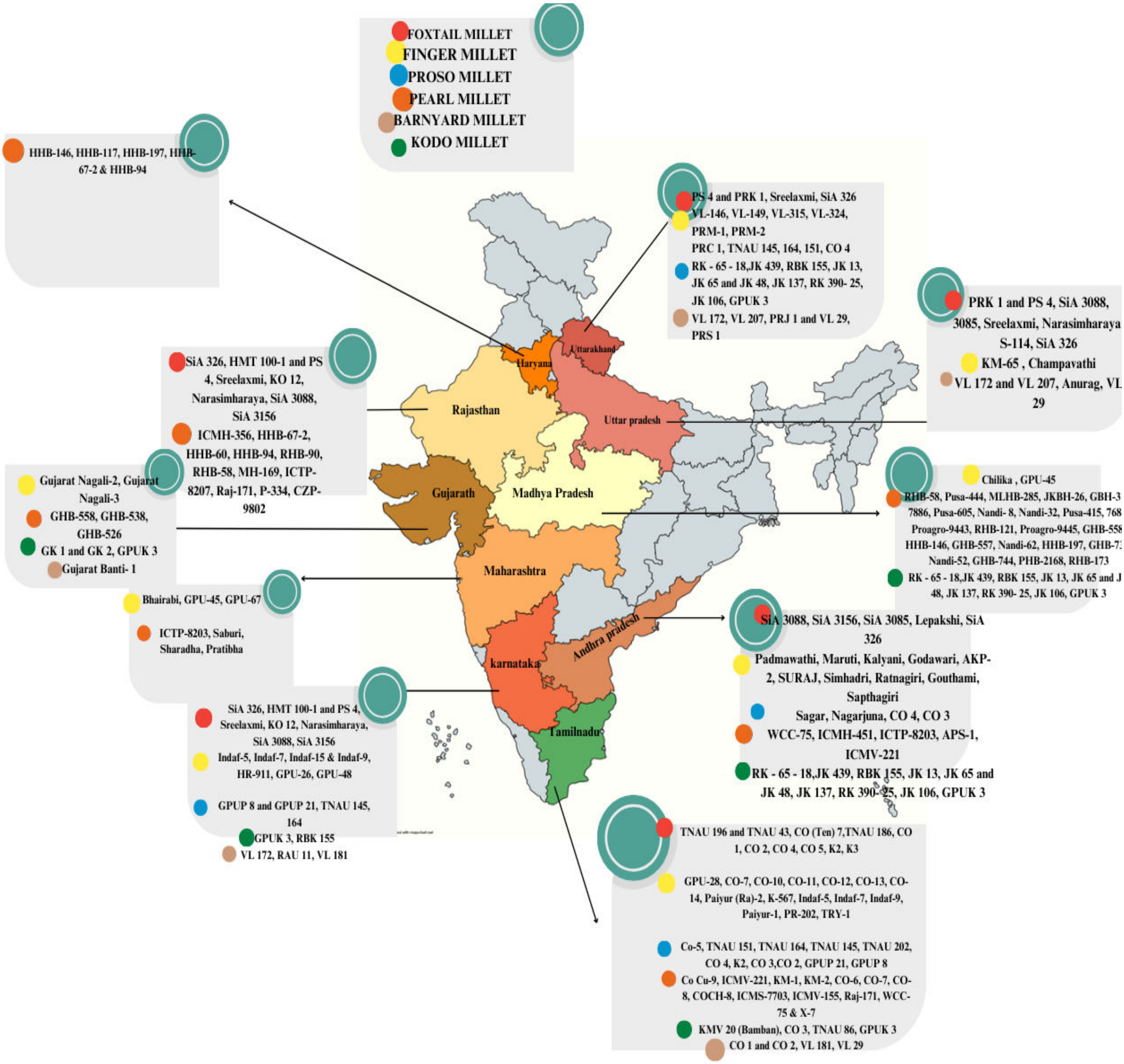
Year	Jowar (production in lakh tonnes)	Bajra /pearl millet (production in lakh tonnes)	Finger millet/ragi (production in lakh tonnes)	Small millet (production in lakh tonnnes)
2017-2018	48.3	92.09	19.87	4.39
2018-2019	34.7	86.64	12.39	3.33
2019-2020	47.72	103.63	17.55	3.71
2020-2021	48.12	108.63	19.98	3.47
2021-2022	48.12	96.24	16.96	3.75

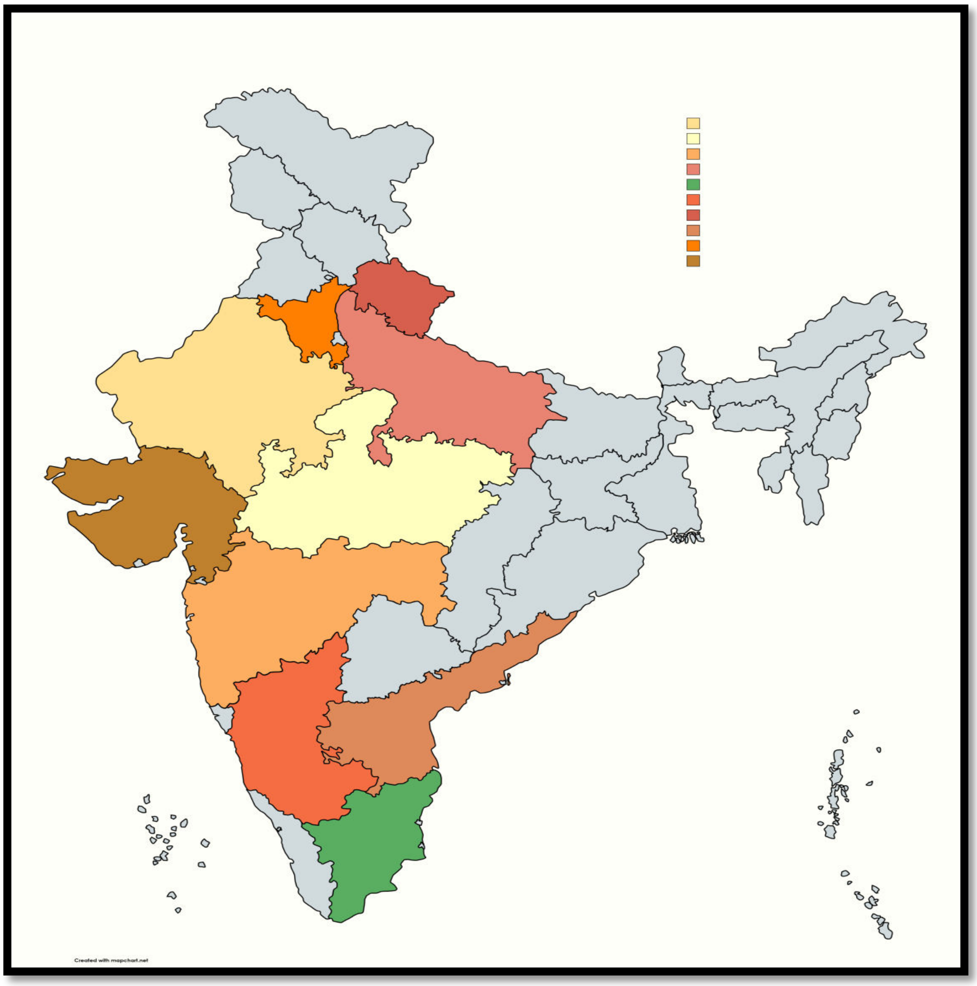
Table .4.World millet production

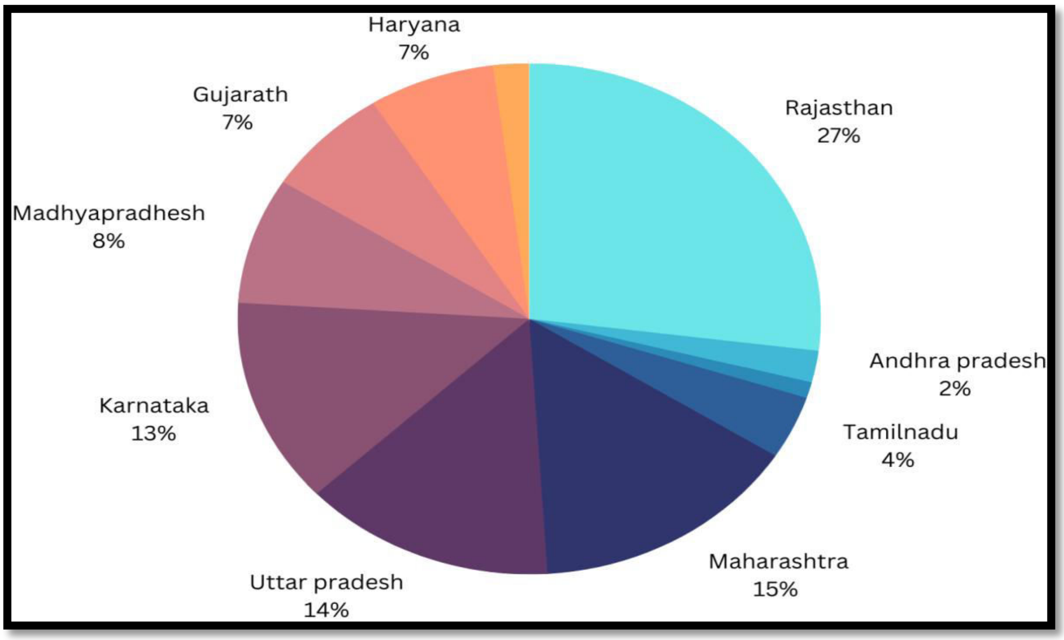
country	World Millet production (%)	Millet production (1000MT)
India	39.33	13200
Niger	11.14	3400
China	8.85	2700
Nigeria	6.55	2000
Mali	5.90	1800
Sudan	4.92	1600
Ethiopia	3.61	1100
Burkina faso	3.28	1000
Senegal	3.28	1000
Other countries	13.14	4013

Millet Production State Wise (2021-2022)

Fig.2

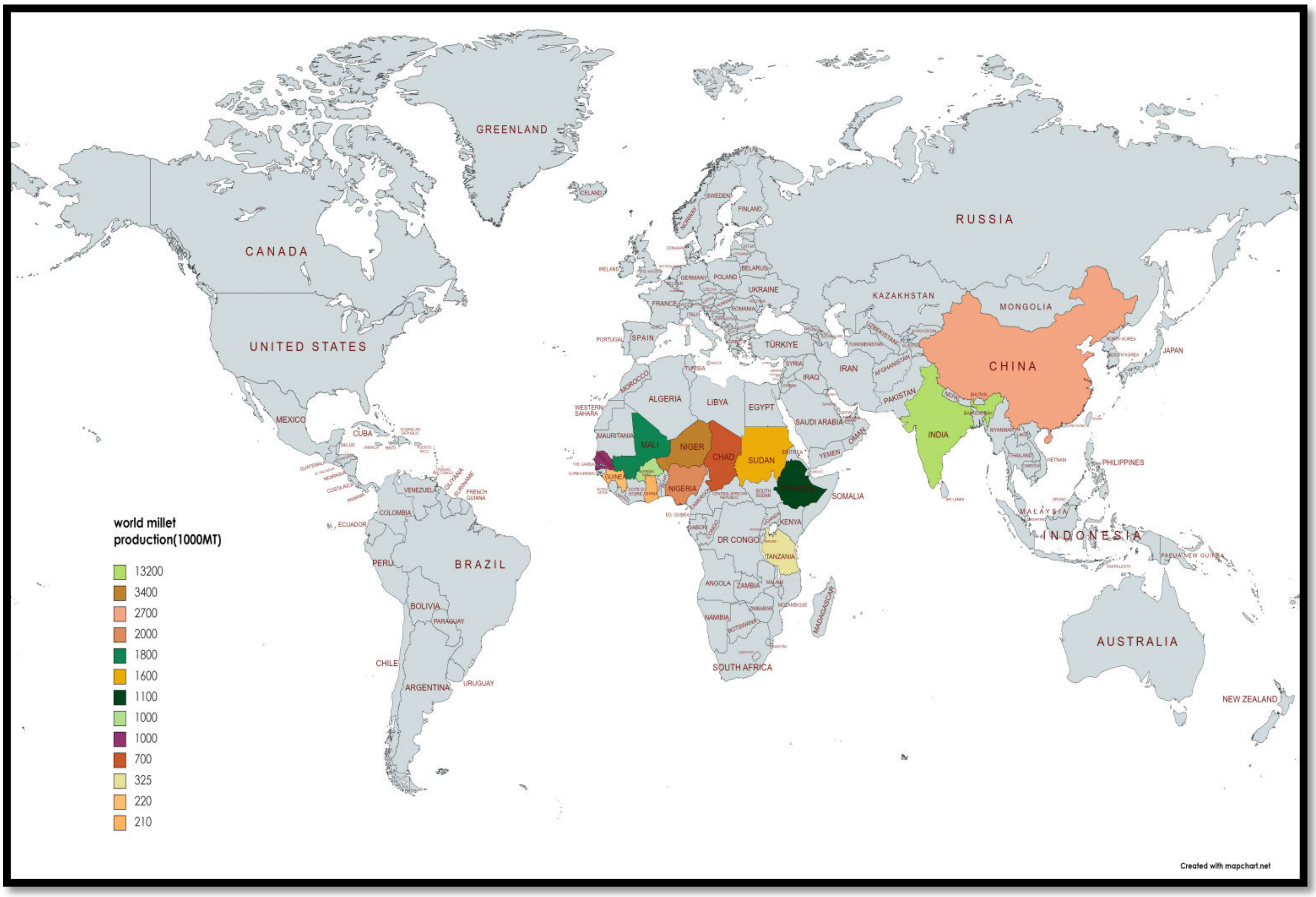





Haryana
7%
Gujarath
7%
Rajasthan
27%
Madhyapradhesh
8%
Andhra pradesh
2%
Karnataka
13%
Tamilnadu
4%
Maharashtra
15%
Uttar pradesh
14%

Top World Millet Producers

Fig.3



Value chain and processing

Millet grains have a tough outer layer called husk or hull, which is not very palatable. Processing, such as milling or dehulling, removes this outer layer, making the grains edible and easier to cook and consume. processing can improve the digestibility of the grains(Yousaf et al., 2021). Removing the outer layer and, in some cases, cooking or milling can break down complex carbohydrates and make the grain easier to digest, increasing the bioavailability of nutrients. Removing the hull from millets is not ideal due to their small grain sizes, and the process of dehulling results in the loss of nutrients(Goudar&Gj, 2016). Millets can be milled either through manual grinding at the household level or machine milling at the cottage, small-to-medium scale service, and large-scale industrial levels(Rao et al., 2017). Processing can alter the texture and taste of millet, making it more suitable for certain dishes. For example, millet flour is often used in baking to create a light and fluffy texture and some millet varieties may contain substances that are toxic if consumed in large quantities(Baban, 2022). Processing can help reduce or eliminate these substances, making millet

safer to eat. The nutritional richness of millets compared to other cereals makes the development of millet-based products a promising opportunity for enhancing health benefits, nutrition, and overall product quality (Birania et al., 2020).
Various conventional methods for processing and preparing household foods can be employed to improve the bioavailability of micronutrients in plant-based diets. These methods encompass soaking, germination/malting, thermal processing, mechanical processing, fermentation(Mishra & Mishra, 2024). The objective is to enhance the physicochemical accessibility of micronutrients, reduce the presence of antinutrients like phytates, or augment the levels of compounds that enhance bioavailability(Yousaf et al., 2021). Various techniques can be utilized in the production of different food items, including germination, malting, cooking, fermentation, roasting, flaking, and puffing of millet products (Yousaf et al., 2021).

1. Fermentation

Millet fermentation, an ancient method, is economically viable, enhancing nutrient levels, rendering proteins more accessible, decreasing antinutritional factors, aiding preservation, and enhancing texture and shelf life via diverse microorganisms (Balli et al., 2020) and offering prebiotic benefits like cholesterol reduction, immunity enhancement, and lactose intolerance alleviation (Yang et al., 2022).Lactic acid bacteria (LAB) and yeast are frequently employed for fermenting millet.Lactic acid bacteria (LAB) are widely found and diverse, producing lactic acid from sugar metabolism, resulting in acidic conditions (pH around 3.5). Yeast fermentation is also common in millet processing, yielding alcohol (ethanol) and carbon dioxide from sugar utilization, typically used in products like wine, beer, and bread(Semwal et al., 2021).Extended fermentation duration not only enhances the correlation between increased mineral availability and reduced non-nutritional components like tannins and phytic acid(Rathore, 2016) but also boosts microbial metabolism, yielding elevated levels of essential nutrients such as thiamine, folate, riboflavin, vitamin C, and vitamin E, which are vital for human health(Semwal et al., 2021). Given these advantageous outcomes, fermentation has been recognized as an efficient strategy for mitigating the risk of mineral deficiencies, particularly in developing nations where unprocessed cereals and pulses are staple foods (Nkhata et al., 2018).

2. Germination/sprouting

Germination, a controllable and efficient method and frequently used method in households, produces lighter and finer flours, enhancing the quality of infant and boosts the nutritional value of grains (Yousaf et al., 2021b). After soaking, grains are germinated in a humidity chamber at specific temperatures, increasing hydrolytic enzyme activity and breaking down major compounds like starch, fibers, and protein, which enhances cooking and texture(Cheng et al., 2020). Germination led to decreased levels of anti-nutrients like phytic acid, tannins, and polyphenols while increasing the bio-accessibility of minerals such as calcium, iron, and zinc. Additionally, they significantly enhanced the levels of thiamine, niacin, total lysine, protein fractions, sugars, and soluble dietary fiber (Sarita& Singh, 2016).It causes an increase in the titratable acidity and a decrease in pH of coarse cereals, likely due to starch hydrolysis into sugars, promptly metabolized into lactic acid by organisms, whereas ungerminated samples exhibit lower acidity and higher pH(Budhwar et al., 2020).Furthermore, numerous African cultures historically employed malting as a processing technique for the production of alcoholic beverages (Nkhata et al., 2018).

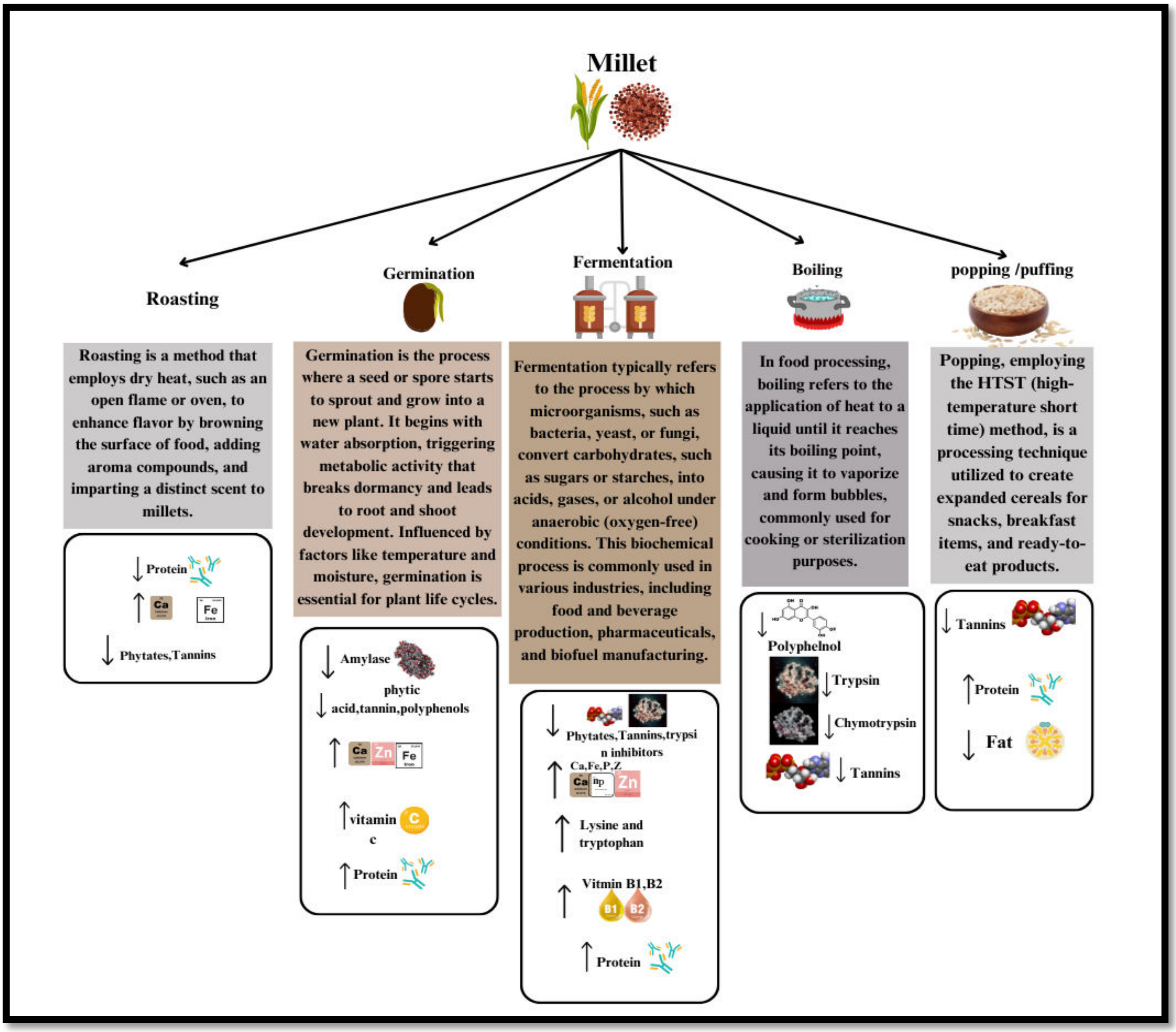


Table.1. Opportunities for Value addition

Millet	Value addition	Value added products	Reference
1.Kodo millet	Bakery products Extruded products	• Biscuit -prepared by addition of soy flour and 70% kodo flour increased the protein content of the biscuit. • Leavened bread - prepared from gluten kodo flour with addition of hydrocolloids, which imitate the gluten characteristics • Pasta -prepared using kodo flour and refine wheat flour of different proportions. • cold extruded Vermicelli and pasta using kodo flour, refined wheat flour and soy flour having a ratio of 50:40:10.(Geetha et al., 2014) .	Deshpande et al 2023

2.Finger millet	Traditional products Fermented Beverages Extruded products	• Papad- it is a conventional product, made by mixing the finger millet flour up to 15-20% with other ingredients such as spice, rice and black gram. • Porridge- • Multy grain flour-Multi-grain flour by combining wheat and finger millet in the ratio of 7:3(wheat:finger millet) is one of the simple semi-finished products suitable for making chapatti (roti) • Kodokojand, raksi-traditional mild-alcoholic beverage consumed in Eastern Himalayan areas of the Darjeeling hills and Sikkim in India. • Noodles/vermicelli	Thagunnaet al 2022 Singh et al 2023 Prasad et al 2010
3.Pearl millet	Ready to eat foods	• Kheer mix- After removing the hulls, pearl millet grains were exposed to 105 minutes of sun-drying and then autoclaved at 121°C for 15 minutes to make them soft. Following a 30-minute drying period at 35°C, the millets were blended with additional ingredients, including 0.25% cardamom powder, to infuse flavor.	Kaushik et al 2021
4.Proso millet		• Porridge –for the preparation boiled with water or milk(Russia)/by boiling millet in water and adding honey an	Das et al 2019

	Fermented products	eggs(korea) • Dosa – it is an Indian breakfast/pancake made from fermented batter using 2:1 millet and black grams. • Noti - Korean pancake	
5.Barnyard millet	Traditional food Extruded products Bakery products	• Porridge/madirakikheer- popular sweet dish in Uttarakhand • idli, dosa-a south indian breakfast dish. • Noodles and pasta • Biscuits/cookies/muffins	Sood et al 2017 Rasane et al 2022
6.foxtail millet	extruded products	• Pasta -Foxtail millet flour can be used to make gluten-free pasta, catering to individuals with dietary restrictions. • Breakfast cereals-Foxtail millet flakes or puffs can be used to create breakfast cereals similar to cornflakes. These cereals can be fortified with additional nutrients and flavors.	

International trade (export and import) of millet

The process of millet farming includes activities such as selecting suitable varieties of millet, preparing the soil, planting the seeds, managing crop growth through proper irrigation and fertilization, controlling pests and diseases, and harvesting the mature grains. Millet farming practices may vary depending on the specific type of millet being cultivated(Handschuch&Wollni, 2016).Millet cultivation is characterized by its adaptability to diverse climates and soil conditions, contributing to its widespread cultivation across the 93 countries where it is grown globally. International trading of millet export and import gradually increased from 1960 to 2022(FAO2022).Global import and export value of millets also increased and highest value (155.26 and 127.60 million US$, respectively)(Meena et al., 2021).From the available data of FAOSTAT 2018 the average data spanning from 2010 to 2017 indicates that Asia stands as the primary recipient of millet grains, accounting for over 65% of the total global imports. In parallel, the United States emerges as the leading contributor to millet exports, commanding more than 83% of the worldwide export market. When examining specific nations, the collective contributions of India, the United States, Argentina, and China constitute over 33% of the total millet export share(Meena et al., 2021). Country wise share of export of millets based on the study of P. Singh et al., (2023)the average from 2000 to 2010 and the average from 2011 to 2020. In the first period, Sudan had the highest share at 32.0%, followed by Benin at 12.1%, and Iran at 11.9%. Saudi Arabia, Japan, Netherlands, Italy, and Other Asia also contributed significantly. However, in the second period, Pakistan emerged with the highest share at 13.5%, overtaking Sudan, followed by Saudi Arabia at 12.3% and Viet Nam at 11.8%. Notably, the suicide rates in Nepal, Yemen, and Tunisia increased, while those in Japan, Netherlands, Italy, and Other Asia declined(P. Singh et al., 2023).

Efforts by the Indian government and non-governmental organizations to encourage millet cultivation in India

1. M. S. Swaminathan Research Foundation (MSSRF) - Encouraging traditional millet cultivation in Kolli Hills involves partnering with women's groups to promote collaborative farming initiatives. Provided support for over 35 Self Help Groups (SHGs) in the area, totaling more than 386 members, of which the majority, specifically 214, are women. As a result of this effort, the Self-Help Groups (SHGs) have united to establish the Kolli Hills Agrobiodiversity Conservers' Federation (KHABCoFED), a network of skilled groups adept in the milling, processing, packaging, and labelling of millet products(Swaminathan & Swaminathan, 2018).

2. Initiative for Nutritional Security through Intensive Millets Promotion (INSIMP) - program or project focused on promoting the cultivation and consumption of millets with the overarching goal of enhancing nutritional security. The initiative likely involves strategies to increase awareness, production, and utilization of millets, considering their nutritional benefits and resilience in diverse agro-climatic conditions. This type of program may include measures to support farmers, facilitate research, and encourage the integration of millets into dietary practices for improved nutrition and food security(Pandey & Bolia, 2023).

3. Rashtriya Krishi Vikas Yojana (RKVY) - Designed to achieve a 4% annual growth in the agricultural sector. The primary objectives of the program include

encouraging states to increase public investment in agriculture and related sectors, providing states with flexibility and autonomy in planning and implementing agricultural schemes, ensuring district and state plans are tailored to agro-climatic conditions, technology availability, and natural resources, reflecting local needs and priorities. Additionally, RKVY aims to reduce yield gaps in key crops through targeted interventions, ultimately maximizing returns for farmers (Vijayan et al., 2023).

4. Production Linked Incentive Scheme for Food Processing Industry (PLISMBP) - The Ministry of Food Processing Industries has granted approval for a centrally sponsored scheme, namely the "Production Linked Incentive Scheme for Food Processing Industry." This scheme, with an approximate budget of Rs. 10,900 crores, is designed to bolster Indian food brands in the international market. The primary focus of the initiative is on supporting the marketing of processed food products, particularly those falling into four main segments: Ready to cook or ready to eat products from Millets, Fruits & Vegetables based products, Marine products, and Mozzarella Cheese (S. Pandey et al., 2023).

5. The Agriculture Department in Kerala is spearheading an extensive millet cultivation initiative in the economically disadvantaged area of Attappady, actively engaging the local community. With an initial budget of Rs 1.8 crore, the programs aim to encompass all 192 tribal settlements in the region(Behera, 2017).

6. Nutri Cereals under National Food Security Mission (NFSM) - The main goal of this initiative was to improve the cultivation area, overall production, and productivity of all seven millets and two Pseudo Millets, namely Buckwheat (Kuttu) and Amaranthus (Chaulai). The mission aimed to enhance the Nutri-Cereals system by boosting seed supply, improving post-harvest processes, and connecting farmers to efficient markets, ultimately leading to better price outcomes for farmers (B. D. Rao et al., 2021).

7. Millet Network of India (MINI) - It is a nationwide collaboration comprising over 65 institutions advocating for various millet varieties. The alliance, which includes over 50,000 farmers, has expanded its initiatives to regions such as Uttarakhand, Nagaland, and Odisha(Chandrasekaran, 2023).

8. Nirman(Odisha) - The voluntary organization in collaboration with the Kutia Kandha community, has successfully revived twelve nearly extinct traditional millet varieties. These millets, including the small-sized Guruji, were conserved with the involvement of tribal people in seven villages of the Kandhamal district(Behera, 2017).

Challenges in millet farming

One of the main reasons for limited consumer awareness regarding millets stems from significant gaps existing between millet producers, manufacturers, suppliers, consumers, and researchers. There is a pressing need to educate consumers about the benefits of substituting millets for staple foods like rice and wheat, aiming to improve their nutritional and economic well-being by incorporating a diet rich in fiber, minerals, and gluten-free products(Shah et al., 2024). This shift towards millets aligns with sustainable development goals. The growing popularity of millets faces several challenges, including geographical disparities, variations in millet varieties, diverse processing methods, ecological advantages, sustainability labels, and the promotion of locally produced millets(Shah et al., 2023). To enhance both the quality of millet production and the financial stability of growers and processors, it is crucial to address challenges related to millet processing. These challenges encompass the provision of production support incentives or a Minimum Support Price (MSP), the lack of postharvest technologies, the need for improved production and technology methods, and the absence of government-backed procurement and marketing support(Hans &Govindaswamy, 2024).

Conclusion

The diverse landscape of millet cultivation encompasses seven distinct varieties, contributing significantly to India's agricultural output. While India is a major global player in millet production, the worldwide production of millet reflects its widespread importance. Each state in India contributes to the production of specific millet varieties, highlighting the regional diversity in cultivation millet.Foods are acknowledged as one of the healthiest dietary options, their consumption remains disproportionately low in developed nations grappling with a surge in diet-related chronic diseases. It is imperative to boost production and reduce costs by implementing ground-breaking advancements in production techniques. Additionally, there is a deficiency in processing techniques, machinery, and product standardization, emphasizing the need for comprehensive improvements in these areas.

Reference

- Verma, S., Srivastava, S., & Tiwari, N. (2015).Comparative study on nutritional and sensory quality of barnyard and foxtail millet food products with traditional rice products.Journal of food science and technology, 52(8), 5147-5155.
- Bhatt, D., Rasane, P., Singh, J., Kaur, S., Fairos, M., Kaur, J., ...& Sharma, N. (2022). Nutritional advantages of barnyard millet and opportunities for its processing as value-added foods. Journal of Food Science and Technology, 1-13.

- Nazni, P., & Shobana, D. R. (2016).Effect of processing on the characteristics changes in barnyard and foxtail millet. Journal of Food Processing and Technology, 7(3), 1-9.
- Lohani, U. C., Pandey, J. P., Singh, A., Shahi, N. C., & Chand, K. (2014).Effect of moisture content on selling characteristics of barnyard millet (Echinochloa frumentacea). International Journal of Basic and Applied Agricultural Research, 12(1), 99-103.
- Kaur, H., & Sharma, S. (2020). An overview of Barnyard millet (Echinochloa frumentacea). Journal of Pharmacognosy and Phytochemistry, 9(4), 819-822.
- Salunke, P. P., Chavan, U., Kotecha, P. M., & Lande, S. B. (2019).Studies on nutritional quality of barnyard millet cookies. Int J Chem Sci, 7(4), 651-657.
- Gomashe, S. S. (2017). Barnyard millet: present status and future thrust areas. Millets and sorghum: biology and genetic improvement, 184-198.
- Ravikesavan, R., Sivamurugan, A. P., Iyanar, K., Pramitha, J. L., & Nirmalakumari, A. (2022). Millet cultivation: An overview. Handbook of millets-processing, quality, and nutrition status, 23-47.
- Renganathan, V. G., Vanniarajan, C., Senthil, N., Nirmalakumari, A., Karthikeyan, A., Veni, K., & Ramalingam, J. (2021). Genetics and molecular markers for anthocyanin pigmentation in barnyard millet (Echinochloa frumentacea (Roxb.) Link). Plant Breeding, 140(2), 246–253.
- Pradhan, A., Panda, A. K., & Bhavani, R. V. (2019). Finger millet in tribal farming systems contributes to increased availability of nutritious food at household level: Insights from India. Agricultural Research, 8(4), 540-547.
- Sood, Salej, Rajesh K. Khulbe, Arun K. Gupta, Pawan K. Agrawal, Hari D. Upadhyaya, and Jagdish C. Bhatt. "Barnyard millet–a potential food and feed crop of future." Plant Breeding 134, no. 2 (2015): 135-147.

- Nazni, P., & Shobana, D. R. (2016).Effect of processing on the characteristics changes in barnyard and foxtail millet. Journal of Food Processing and Technology, 7(3), 1-9.

- Renganathan, V. G., Vanniarajan, C., Karthikeyan, A., & Ramalingam, J. (2020). Barnyard millet for food and nutritional security: current status and future research direction. Frontiers in genetics, 11, 500.
- Behera, M. K. (2017). Assessment of the state of millets farming in India. MOJ Eco Environ Sci, 2(1), 16-20.
- Shah, P., Dhir, A., Joshi, R., & Tripathy, N. (2023). Opportunities and challenges in food entrepreneurship: In-depth qualitative investigation of millet entrepreneurs. Journal of Business Research, 155, 113372.

- Pradhan, A., Panda, A. K., & Bhavani, R. V. (2019). Finger millet in tribal farming systems contributes to increased availability of nutritious food at household level: Insights from India. Agricultural Research, 8(4), 540-547.

- Khajuria, S., Rai, A., Khadda, B., Kumar, R., & Jadav, J. (2022). Pearl Millet (Bajra). Forage Crops of the World, 2-volume set: Volume I: Major Forage Crops; Volume II: Minor Forage Crops, 39.
- Rani, P., Charu, S., & Kumar, K. (2023). Growth trend of pearl millet and its impact on Indian economy: performance analysis. Int J Adv Multidiscip Res Stud, 3(3), 162-6.
- Sathish Kumar, M., Lad, Y. A., & Mahera, A. B. (2022).Trend analysis of area, production and productivity of minor millets in India.In Biological Forum–An International Journal (Vol. 14, No. 2, pp. 14-18).
- Sukumaran Sreekala, A. D., Anbukkani, P., Singh, A., Dayakar Rao, B., & Jha, G. K. (2023). Millet Production and Consumption in India: Where Do We Stand and Where Do We Go?. National Academy Science Letters, 46(1), 65-70.
- Rani, S., Singh, R., Sehrawat, R., Kaur, B. P., & Upadhyay, A. (2018). Pearl millet processing: a review. Nutrition & Food Science, 48(1), 30-44.
- Balkrishna, A., Arya, V., Joshi, R., Kumar, A., Sharma, G., & Dhyani, A. (2022). Doubling Farmers' Income in India: Progress, Gaps and Futuristic Approaches. Indian Journal of Ecology, 49(3), 1044-1050.
- Sarkar, M. S., & Lama, A. 14. Entrepreneurship Development Promotion Through Millet Processing.
- Ravikesavan, R., Sivamurugan, A. P., Iyanar, K., Pramitha, J. L., & Nirmalakumari, A. (2022). Millet cultivation: An overview. Handbook of millets-processing, quality, and nutrition status, 23-47.
- Mirza, N., & Marla, S. S. (2019). Finger millet (Eleusine coracana L. Gartn.) breeding. Advances in Plant Breeding Strategies: Cereals: Volume 5, 83-132.
- Maharajan, T., Ceasar, S. A., & Ajeesh Krishna, T. P. (2022).Finger millet (Eleusine coracana (L.) Gaertn): Nutritional importance and nutrient transporters. Critical Reviews in Plant Sciences, 41(1), 1-31.
- Pradhan, A., Panda, A. K., & Bhavani, R. V. (2019). Finger millet in tribal farming systems contributes to increased availability of nutritious food at household level: Insights from India. Agricultural Research, 8(4), 540-547.
- Thapliyal, V., & Singh, K. (2015). Finger millet: potential millet for food security and power house of nutrients. International or Research in Agriculture and Forestry, 2(2).
- Shobana, S., Krishnaswamy, K., Sudha, V., Malleshi, N. G., Anjana, R. M., Palaniappan, L., & Mohan, V. (2013). Finger millet (Ragi, Eleusine coracana L.): a review of its nutritional properties, processing, and plausible health benefits. Advances in food and nutrition research, 69, 1-39.
- Gull, A., Jan, R., Nayik, G. A., Prasad, K., & Kumar, P. (2014). Significance of finger millet in nutrition, health and value added products: a review. Magnesium (mg), 130(32), 120.

- Gull, A., Ahmad, N. G., Prasad, K., & Kumar, P. (2016).Technological, processing and nutritional approach of finger millet (Eleusine coracana)-a mini review.J Food Process Technol, 7(593), 2.
- Amadou, I., Gounga, M. E., & Le, G. W. (2013). Millets: Nutritional composition, some health benefits and processing-A review. Emirates Journal of Food and Agriculture, 501-508.
- Sharma, N., & Niranjan, K. (2018). Foxtail millet: Properties, processing, health benefits, and uses. Food reviews international, 34(4), 329-363.
- Sachdev, N., Goomer, S., & Singh, L. R. (2020). Foxtail millet: a potential crop to meet future demand scenario for alternative sustainable protein. Journal of the Science of Food and Agriculture, 101(3), 831–842.
- Kalsi, R., & Bhasin, J. K. (2023). Nutritional exploration of foxtail millet (Setaria italica) in addressing food security and its utilization trends in food system. eFood, 4(5), e111.
- Eduru, A., Kamboj, A., Reddy, P. M., & Pal, B. (2021). Nutritional and health benefits of millets, present status and future prospects: A review. The Pharma Innovation Journal, 10(5), 859-868.
- FAOSTAT, "Food and agriculture organization of the UnitedNations,2011, www.faostat.fao.org.
- Dey, S., Saxena, A., Kumar, Y., Maity, T., & Tarafdar, A. (2022).Understanding the antinutritional factors and bioactive compounds of kodo millet (Paspalum scrobiculatum) and little millet (Panicum sumatrense). Journal of Food Quality, 2022, 1-19.
- Bunkar, D. S., Goyal, S. K., Meena, K. K., & Kamalvanshi, V. (2021). Nutritional, functional role of kodo millet and its processing: a review. International Journal of Current Microbiology and Applied Sciences, 10(01), 1972-1985.
- Patni, D., & Agrawal, M. (2017). Wonder millet–pearl millet, nutrient composition and potential health benefits-a review. Int J Innov Res Rev, 5, 6-14.
- Amadou, I., Gounga, M. E., & Le, G. W. (2013). Millets: Nutritional composition, some health benefits and processing-A review. Emirates Journal of Food and Agriculture, 501-508.
- Dias-Martins, A. M., Pessanha, K. L. F., Pacheco, S., Rodrigues, J. A. S., & Carvalho, C. W. P. (2018).Potential use of pearl millet (Pennisetum glaucum (L.) R. Br.) in Brazil: Food security, processing, health benefits and nutritional products. Food research international, 109, 175-186.
- Gull, A., Ahmad, N. G., Prasad, K., & Kumar, P. (2016).Technological, processing and nutritional approach of finger millet (Eleusine coracana)-a mini review.J Food Process Technol, 7(593), 2.
- Mahajan, P., Bera, M. B., Panesar, P. S., & Chauhan, A. (2021). Millet starch: A review. International Journal of Biological Macromolecules, 180, 61–79.

- Sharma, N., & Niranjan, K. (2018). Foxtail millet: Properties, processing, health benefits, and uses. Food reviews international, 34(4), 329-363.
- Jukanti, A. K., Gowda, C. L., Rai, K. N., Manga, V. K., & Bhatt, R. K. (2016). Crops that feed the world 11. Pearl Millet (Pennisetum glaucum L.): an important source of food security, nutrition and health in the arid and semi-arid tropics. Food Security, 8, 307-329.
- Thagunna, B., Rimal, A., Kaur, J., Dhakal, Y., & Paudel, B. (2022). Finger Millet: A powerhouse of nutrients its amino acid, micronutrient profile, bioactive compounds, health benefits, and value-added products. J Res Agri Animal Sci, 9, 36-44.
- Kaushik, N., Yadav, P., Khandal, R. K., & Aggarwal, M. (2021). Review of ways to enhance the nutritional properties of millets for their value-addition. Journal of Food Processing and Preservation, 45(6).
- Birania, S., Rohilla, P., Kumar, R., & Kumar, N. (2020). Post harvest processing of millets: A review on value added products. International Journal of Chemical Studies, 8(1), 1824-1829.
- Singh, N., Kumari, P., & Bassi, J. G. N. (2023). Nutrient rich Kodo millet, importance and value addition: An overview.
- Das, S., Khound, R., Santra, M., & Santra, D. K. (2019). Beyond bird feed: Proso millet for human health and environment. Agriculture, 9(3), 64.
- Karkannavar, S. J., Shigihalli, S., Nayak, G., & Bharati, P. (2021). Physico-chemical and nutritional composition of proso millet varieties. Pharma Innovation Journal, 10, 136-140.
- Yang, Q., Zhang, P., Qu, Y., Gao, X., Liang, J., Yang, P., & Feng, B. (2018). Comparison of physicochemical properties and cooking edibility of waxy and non-waxy proso millet (Panicum miliaceum L.). Food Chemistry, 257, 271-278.
- Rajasekaran, R., Francis, N., Mani, V., & Ganesan, J. (2023).Proso millet (Panicum miliaceum L.).In Neglected and underutilized crops (pp. 247-278).Academic Press.
- Kumari, P., Thakur, A., Sankhyan, N. K., & Singh, U. (2023).Millet production and consumption in India and their nutritional aspects.Just Agriculture, 3(5), 46.
- Prasad, R. C., Upreti, R. P., Thapa, S., Jirel, L. B., Shakya, P. R., & Mandal, D. N. (2010). Food security and income generation of rural people through the cultivation of finger millet in Nepal.Minor millets in South Asia, 107-146.
- Singh, P. A. R. D. E. E. P., Arora, K. A. S. H. I. S. H., Kumar, S. U. N. N. Y., Gohain, N. A. M. A. M. I., & Sharma, R. K. (2023). Indian millets trade potential-cum-performance: Economic perspective. Indian Journal of Agricultural Sciences, 93(2), 200-204.

- Paschapur, A. U., Joshi, D., Mishra, K. K., Kant, L., Kumar, V., & Kumar, A. (2021). Millets for life: a brief introduction. Millets and Millet Technology, 1-32.
- Meena, R. P., Joshi, D., Bisht, J. K., & Kant, L. (2021).Global scenario of millets cultivation.Millets and millet technology, 33-50.
- Gowdaa, H. R. C., Amruthab, T., Raghavendraa, K. J., & Kumarc, S. (2019). Millets production and prospects in India: an economic overview. Green Farming, 10(3), 300-305.
- Sharma, N., & Niranjan, K. (2018). Foxtail millet: Properties, processing, health benefits, and uses. Food reviews international, 34(4), 329-363.
- Yang, T., Ma, S., Liu, J., Sun, B., & Wang, X. (2022). Influences of four processing methods on main nutritional components of foxtail millet: A review. Grain & Oil Science and Technology.
- Hariprasanna, K. (2016). Foxtail millet: Nutritional importance and cultivation aspects. Indian farming, 73(1), 47-49.
- Nithiyanantham, S., Kalaiselvi, P., Mahomoodally, M. F., Zengin, G., Abirami, A., & Srinivasan, G. (2019).Nutritional and functional roles of millets—A review.Journal of food biochemistry, 43(7), e12859.
- Dayakar Rao, B., Bhaskarachary, K., Arlene Christina, G. D., Sudha Devi, G., Vilas, A. T., & Tonapi, A. (2017). Nutritional and health benefits of millets.ICAR_Indian Institute of Millets Research (IIMR) Rajendranagar, Hyderabad, 2.
- Sarita, E. S., & Singh, E. (2016). Potential of millets: nutrients composition and health benefits. Journal of Scientific and Innovative Research, 5(2), 46-50.
- Vijayan, B., Nain, M. S., Singh, R., Kumbhare, N. V., & Kademani, S. B. (2023).Knowledge test for extension personnel on Rashtriya Krishi Vikas Yojana. Indian Journal of Extension Education, 59(1), 131-134.
- Pandey, S., Bharti, A., & Bharti, P. (2023). Central and State Government initiatives for mainstreaming millets and millets based products. Pharma Innovation, 12(9), 1415–1419.
- Kumar, A., Tomer, V., Kaur, A., Kumar, V., & Gupta, K. (2018). Millets: a solution to agrarian and nutritional challenges. Agriculture & food security, 7(1), 1-15.
- Rathore, S., Singh, K., & Kumar, V. (2016). Millet grain processing, utilization and its role in health promotion: A review. International Journal of Nutrition and Food Sciences, 5(5), 318-329.
- Gowda, N. N., Siliveru, K., Prasad, P. V., Bhatt, Y., Netravati, B. P., &Gurikar, C. (2022). Modern processing of Indian millets: A perspective on changes in nutritional properties. Foods, 11(4), 499.

- Saha, D., Gowda, M. C., Arya, L., Verma, M., & Bansal, K. C. (2016). Genetic and genomic resources of small millets. Critical Reviews in Plant Sciences, 35(1), 56-79.
- Muthamilarasan, M., & Prasad, M. (2021).Small millets for enduring food security amidst pandemics. Trends in plant science, 26(1), 33-40.
- Hassan, Z. M., Sebola, N. A., &Mabelebele, M. (2021). The nutritional use of millet grain for food and feed: a review. Agriculture & food security, 10, 1-14.
- Singh, A., Kumar, M., & Shamim, M. (2020).Importance of minor millets (Nutri Cereals) for nutrition purpose in present scenario. International Journal of Chemical Studies, 8(1), 3109-3113.
- Das, I. K., & Rakshit, S. (2016). Millets, their importance, and production constraints. In Biotic stress resistance in millets (pp. 3-19). Academic Press.
- Meena, R. P., Joshi, D., Bisht, J. K., & Kant, L. (2021).Global scenario of millets cultivation. Millets and millet technology, 33-50.
- Wilson, M. L., & VanBuren, R. (2022).Leveraging millets for developing climate resilient agriculture. Current Opinion in Biotechnology, 75, 102683.
- Pattanashetti, S. K., Upadhyaya, H. D., Dwivedi, S. L., Vetriventhan, M., & Reddy, K. N. (2016). Pearl millet.In Genetic and genomic resources for grain cereals improvement (pp. 253-289).Academic Press.
- Bussmann, A., Elagib, N. A., Fayyad, M., & Ribbe, L. (2016).Sowing date determinants for Sahelian rainfed agriculture in the context of agricultural policies and water management. Land Use Policy, 52, 316-328.
- Serba, D. D., Yadav, R. S., Varshney, R. K., Gupta, S. K., Mahalingam, G., Srivastava, R. K., ... & Tesso, T. T. (2020). Genomic designing of pearl millet: a resilient crop for arid and semi-arid environments. Genomic designing of climate-smart cereal crops, 221-286.
- Maenetja, N. P. (2021). Evaluation of finger millet (Eleusine coracana) under irrigated and rainfed conditions as a fooder crop on the Pietersburg Plateau, South Africa (Doctoral dissertation).
- Ceasar, S. A., Maharajan, T., Krishna, T. A., &Ignacimuthu, S. (2023). Finger millet (Eleusine coracana (L.)Gaertn). In Neglected and Underutilized Crops (pp. 137-149). Academic Press.
- Korir, A. K. (2019). Effects of Fertilization and Spacing on Growth and Grain Yields of Finger Millet (Eleusine Coracana L.) in Ainamoi, Kericho County (Doctoral dissertation, KeMU).
- Kumari, P., Pareek, V., Kajla, P., & Khurana, S. (2024). Composition, structure and functionality of starch isolated from Kodo millet. In Non-Conventional Starch Sources (pp. 253-278).Academic Press.
- Pundir, M., Singh, G., Rather, M. F., & Parry, N. A. (2024). Comparison study of starch from Kodo millet and other millets: Comparison study of starch. Sustainability, Agri, Food and Environmental Research, 12(1).

- Vetriventhan, M., & Upadhyaya, H. D. (2019).Variability for productivity and nutritional traits in germplasm of kodo millet, an underutilized nutrient-rich climate smart crop. Crop Science, 59(3), 1095-1106.
- Bhatt, D., Rasane, P., Singh, J., Kaur, S., Fairos, M., Kaur, J., ...& Sharma, N. (2023). Nutritional advantages of barnyard millet and opportunities for its processing as value-added foods. Journal of Food Science and Technology, 60(11), 2748-2760.
- Mohanapriya, B., Shanmugam, A., Francis, N., Indhu, S. M., &Ravikesavan, R. (2024).Breeding Barnyard Millet for Abiotic Stress Tolerance.In Genetic improvement of Small Millets (pp. 493-511). Singapore: Springer Nature Singapore.
- Maithani, D., Sharma, A., Gangola, S., Bhatt, P., Bhandari, G., &Dasila, H. (2023). Barnyard millet (Echinochloa spp.): a climate resilient multipurpose crop. Vegetos, 36(2), 294-308.
- Choudhary, R., Chodhary, M., Rana, B. B., & Narwal, K. (2023). BARNYARD MILLET (Echinochloa species).
- Joshi, R. P., Jain, A. K., Malhotra, N., & Kumari, M. (2021).Origin, domestication, and spread. In Millets and Pseudo Cereals (pp. 33-38). Woodhead Publishing.
- Panwar, P., Dubey, A., & Verma, A. K. (2016).Evaluation of nutraceutical and antinutritional properties in barnyard and finger millet varieties grown in Himalayan region. Journal of food science and technology, 53, 2779-2787.
- Banerjee, P., Maitra, S., & Banerjee, P. (2020).The role of small millets as functional food to combat malnutrition in developing countries. Indian Journal of Natural Sciences, 10(60), 20412-20417.
- Singh, A., Bharath, M., Kotiyal, A., Rana, L., & Rajpal, D. (2022). Barnyard millet: the underutilized nutraceutical minor millet crop. J Pharm Innov, 11(6), 115-128.
- Lokur, A., Donde, K. J., & Pius, J. (Eds.). (2023). MILLETS–2023: A Transdisciplinary Approach to its Resurgence and Sustainability. Allied Publishers.
- Liu, T., Yang, X., Batchelor, W. D., Liu, Z., Zhang, Z., Wan, N., ...& Zhao, J. (2020). A case study of climate-smart management in foxtail millet (Setariaitalica) production under future climate change in Lishu county of Jilin, China. Agricultural and Forest Meteorology, 292, 108131.
- Fischer, H. W., Reddy, N. N., & Rao, M. L. (2016b). Can more drought resistant crops promote more climate secure agriculture? Prospects and challenges of millet cultivation in Ananthapur, Andhra Pradesh. World Development Perspectives, 2, 5–10.
- Kaur, S., Kumar, K., Singh, L., Sharanagat, V. S., Nema, P. K., Mishra, V., & Bhushan, B. (2022). Gluten-free grains: Importance, processing and its

effect on quality of gluten-free products. Critical Reviews in Food Science and Nutrition, 1–28.

- Deng, X., Liang, J., Wang, L., Niu, L., Xiao, J., Guo, Q., ...& Xiao, C. (2023). Whole grain proso millet (Panicummiliaceum L.) attenuates hyperglycemia in type 2 diabetic mice: involvement of miRNA profile. Journal of Agricultural and Food Chemistry, 71(24), 9324-9336.
- Yousaf, L., Hou, D., Liaqat, H., & Shen, Q. (2021). Millet: A review of its nutritional and functional changes during processing. Food Research International, 142, 110197.
- Goudar, G., &Sathisha, G. J. (2016).Effect of extrusion and flaking on the retention of nutrients and phenolic compounds in millet grains. International Journal of Food Science and Nutrition, 1(4), 08-11.
- Baban, S. (2022). Millet: A Review of its Nutritional Content, Processing and Machineries. International Journal of Food and Fermentation Technology, 12.
- Mishra, S., & Mishra, S. (2024).Food Processing Techniques to Conserve Millet-Based Ethnic Food Products of India. In Sustainable Food Systems (Volume I) SFS: Framework, Sustainable Diets, Traditional Food Culture & Food Production (pp. 363-380). Cham: Springer Nature Switzerland.
- Handschuch, C., &Wollni, M. (2016). Improved production systems for traditional food crops: the case of finger millet in western Kenya. Food security, 8, 783-797.
- Meena, R. P., Joshi, D., Bisht, J. K., & Kant, L. (2021).Global scenario of millets cultivation. Millets and millet technology, 33-50.
- Swaminathan, M., & Swaminathan, M. S. (2018).ICT and agriculture. CSI Transactions on ICT, 6, 227-229.
- Pandey, A., & Bolia, N. B. (2023). Millet value chain revolution for sustainability: A proposal for India. Socio-Economic Planning Sciences, 101592.
- Behera, M. K. (2017). Assessment of the state of millets farming in India. MOJ Ecology & Environmental Science, 2(1), 16-20.
- Chandrasekaran, P. R. (2023). "Millet" as a postcolonial-masculinist sign of difference: tracing the effects of ontological-epistemic erasure on a food grain. Food, Culture & Society, 26(4), 886-904.
- Rao, B. D., Dinesh, T. M., & Nune, S. D. (2021).Policy analysis and strategies.In Millets and pseudo cereals (pp. 185-201). Woodhead Publishing.
- Shah, P., Mehta, N., & Shah, S. (2024). Exploring the factors that drive millet consumption: Insights from regular and occasional consumers. Journal of Retailing and Consumer Services, 76, 103598.

- Shah, P., Dhir, A., Joshi, R., & Tripathy, N. (2023). Opportunities and challenges in food entrepreneurship: In-depth qualitative investigation of millet entrepreneurs. Journal of Business Research, 155, 113372.
- Hans, V. B., &Govindaswamy. (2024). Agricultural marketing in India: challenges, opportunities, and transformations. Social Science Research Network.
- Deshpande, S. S., Mohapatra, D., Tripathi, M. K., &Sadvatha, R. H. (2015).Kodo millet-nutritional value and utilization in Indian foods.Journal of grain processing and storage, 2(2), 16-23.
- Balli, D., Bellumori, M., Pucci, L., Gabriele, M., Longo, V., Paoli, P., ...&Innocenti, M. (2020). Does fermentation really increase the phenolic content in cereals? A study on millet. Foods, 9(3), 303.
- Yang, T., Ma, S., Liu, J., Sun, B., & Wang, X. (2022). Influences of four processing methods on main nutritional components of foxtail millet: A review. Grain & Oil Science and Technology, 5(3), 156-165.
- Semwal, J., Kamani, M. H., &Meera, M. S. (2021). Fermented Millet Technology and Products. Millets and Millet Technology, 255-271.
- Budhwar, S., Sethi, K., &Chakraborty, M. (2020). Efficacy of germination and probiotic fermentation on underutilized cereal and millet grains. Food Production, Processing and Nutrition, 2, 1-17.
- Li, C., Jeong, D., Lee, J. H., & Chung, H. J. (2020). Influence of germination on physicochemical properties of flours from brown rice, oat, sorghum, and millet. Food Science and Biotechnology, 29, 1223-1231.
- Nkhata, S. G., Ayua, E., Kamau, E. H., &Shingiro, J. B. (2018). Fermentation and germination improve nutritional value of cereals and legumes through activation of endogenous enzymes. Food science & nutrition, 6(8), 2446-2458.

.