

## 10. Millet for Food Security

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### **Abstract:**

*Millets, known as coarse cereals, belong to the grass family (Gramineae/Panicaceae) and encompass a range of 13 diverse varieties. These include Job's tears, fonio, pearl millet, finger millet, sorghum, little millet, proso millet, barnyard millet, brown top millet, foxtail millet, Guinea millet, and Kodo millet. These millet varieties originate from semi-arid tropical regions in Asia and Africa and offer various medicinal and nutritional benefits. Despite their rich content of vitamins, fiber, minerals, and phytochemicals, millets remain underutilized in many developed countries. However, their cultivation is relatively uncomplicated, and they have a short growth cycle, allowing farmers to obtain multiple harvests within a year.*

### **Keywords:**

*Millets, food security, farmers, nutrition*

### **10.1 Introduction:**

Millets, commonly known as minor millets, belong to a category of cereal crops cultivated for their small-sized grains obtained from grassy plants in the Poaceae family. These millets hold great significance owing to their nutritional value, medicinal benefits, and utilization as animal feed, despite being categorized as minor crops. Moreover, they have historically served as crucial food sources during periods of food scarcity. (Kumar *et al.*, 2021).

Millets encompass a wide range of varieties originating from Asia and Africa, making them suitable for the challenging semi-arid tropical climates of these regions. In these areas, where other crops struggle to thrive, millets have historically served as a primary food source for the local populations. With approximately 6,000 different millet varieties currently cultivated worldwide, these crops have been domesticated since ancient times. Despite their nutritional advantages and adaptability, millets remain underutilized in many developed countries, failing to reach their full potential. (Karupphasamy 2015).

Millet holds a significant position among cereal grains, with over a third of the global population including it in their diets. It stands as the sixth most important cereal crop worldwide in terms of production. The millet family includes several varieties such as Jowar (sorghum), Sama (little millet), Ragi (finger millet), Korra (foxtail millet), and Variga (proso millet). Among them, Ragi has the lowest fat content, while Bajra and Sama contain higher-than-average amounts. Millets are predominantly consumed as food in rural areas and primarily cultivated for that purpose. (Kimeera Ambati and Sucharitha K.V.V, 2019).

Millets have gained the reputation of being "super grains" owing to their remarkable nutritional profile, making them highly beneficial for individuals dealing with obesity, diabetes, and cardiovascular diseases. These crops are not only considered intelligent due to their photo-insensitivity, drought tolerance, and resilience to various climates but are also regarded as intelligent foods due to their rich content of vitamins, fiber, and minerals.

Recognizing their importance, the FAO designated 2023 as the International Year of Millets, while India declared 2018 as the National Year of Millets. Despite their significance, millet production currently represents only 2 percent of the global cereal production, with Asia accounting for 40 percent of it. (Gutha *et al.*, 2021).

Millets offer not only fiber, minerals, and vitamin B complex but also serve as a rich source of phytochemicals. These organic compounds possess antioxidant and detoxifying properties, adding to the nutritional value of millets. For instance, finger millet (ragi) stands out for its high calcium content, a vital mineral for maintaining strong bones and teeth. With their diverse phytochemical composition, millets make an excellent inclusion in a well-rounded diet, providing additional health benefits beyond their basic nutritional components. (Raju *et al.*, 2018).

Millets play a significant role as a prominent source of essential nutrients and rank as the sixth-largest producer of cereal grains globally. They continue to be a staple in many regions, offering the added advantage of addressing nutrient deficiencies in developing nations. As a health food, millets boast several desirable qualities.

They feature gluten-free proteins, a substantial amount of fiber, a low glycemic index, and bioactive compounds that match or even surpass those found in major cereal grains in terms of nutritional value. Carbohydrate content in millets typically ranges from 56.88 to 72.97 g per 100 g, with barnyard millet displaying the lowest levels. Except for finger millet, which varies between 4.76 and 11.70 g/100 g across different studies, the protein contents of millets are generally comparable, averaging around 10 to 11%. (Ashwani *et al.*, 2018).

## **10.2 Types of millets:**

Millets, a diverse group of small-seeded grasses, are cultivated and consumed worldwide. There are 13 known types of millets, including sorghum, finger millet, kodo millet, barnyard millet, brown top millet, foxtail millet, Guinea millet, Job's tears, fonio, and teff.

Among these, only Job's tears, fonio, and teff are not commonly grown in India. The remaining ten varieties of millets are widely available and consumed throughout India.

### **A. Sorghum or Jowar:**

Sorghum (*Sorghum bicolor*) holds the position of being the fifth-most important cereal crop globally. It is primarily cultivated as a rain-fed crop across more than 42 million hectares of land by subsistence farmers in the semi-arid tropics (SAT) of Africa, Asia, and Latin America.

Sorghum serves as an excellent alternative for individuals with celiac disease, as it is a gluten-free ancient cereal grain that serves as a staple food in India and Africa, offering excellent gastrointestinal safety. India, in particular, witnessed a significant cultivation area dedicated to sorghum, exceeding 16 million hectares in 1981. However, this area gradually decreased to 7.8 million hectares by 2007-2008. Nonetheless, it still accounted for approximately 20% of the global sorghum cultivation area in recent years (Pragya *et al.*, 2021).

### **B. Finger Millet:**

As highlighted by Pragya Singh and Rita Singh (2011), millets, known as coarse cereals, constitute a diverse group of small edible grasses belonging to the grass family (Gramineae/Paniceae). Among the various millet varieties, finger millet stands out as a highly nutritious cereal. It is rich in essential nutrients such as iron, calcium, fiber, protein, and the amino acid methionine. Finger millet proves particularly beneficial for individuals who have experienced multi-generational deficiencies in these crucial nutrients due to heavy reliance on starchy staples. Recent research emphasizes the significance of finger millet in combating malnutrition and addressing food insecurity in several regions worldwide.

### **C. Pearl millet:**

Pearl millet (*Pennisetum glaucum*) is a versatile cereal crop widely cultivated in African and Asian countries for various purposes, including food, feed, and forages. It possesses remarkable resilience to drought and high temperatures, making it well-suited for regions where other cereal crops like wheat and maize face challenges. With a cultivation area exceeding 29 million hectares globally, pearl millet holds the largest share among millet varieties. While it is primarily concentrated in Africa, covering around 15 million hectares, it also holds significant cultivation area in Asia, accounting for approximately 11 million hectares. (Savita *et al.*, 2017).

### **D. Foxtail millet:**

Foxtail millet (*S. italica*) serves as a significant crop in various regions worldwide. It is a staple food in arid and semi-arid areas of China, certain parts of India, and Japan. Additionally, foxtail millet is cultivated in North and South America for purposes such as hay and silage production. Foxtail millet is rich in essential nutrients including iron, calcium, potassium, zinc, magnesium, and vitamins. It also contains raw edible fibers. Notably, foxtail millet has a low glycemic index (GI) and is gluten-free, making it an excellent dietary choice for individuals with specific nutritional requirements or health conditions. (Roshan *et al.*, 2017).

### **E. Kodo millet:**

Kodo millet, known for its origins in India, is believed to have been domesticated around 3000 years ago. It is scientifically known as *Paspalum scrobiculatum* L. and is extensively found in arid and semi-arid regions of India and various African countries. One of the notable characteristics of Kodo millet is its ability to thrive in less fertile soils, making it suitable for cultivation in subpar agricultural conditions. (Durga *et al.*, 2021).

### **F. Barnyard Millet:**

Barnyard millet, scientifically known as *Echinochloa crusgalli* (L.) P. Beauvois, is a versatile crop cultivated for both food and fodder purposes. It is referred to by various names, including Japanese barnyard millet, ooda, oodalu, sawan, sanwa, and sanwank. Nutritionally, barnyard millet is a valuable source of highly digestible protein and dietary fiber, offering a balanced combination of soluble and insoluble fractions. Its low and slow digestible carbohydrate content makes it particularly beneficial for modern individuals leading sedentary lifestyles. Barnyard millet is thus considered a valuable natural resource in terms of its nutritional composition. (Dayakar *et al.*, 2017).

### **G. Proso millet:**

Proso millet, scientifically known as *Panicum miliaceum* L., is believed to have been domesticated approximately 10,000 years ago in China. The domestication of proso millet is associated with the beginning of the Holocene period, a time characterized by rising temperatures and the interaction of hunter-gatherers with new plant species and environments, as suggested by current archaeological theories (Cedric *et al.*, 2017). Over time, proso millet has become a vital source of nutrition for populations worldwide.

### **H. Little millet:**

Little millet, scientifically known as *Panicum sumatrense*, originated in India as a domesticated cereal crop. It is primarily cultivated in specific regions of India up to an altitude of 2100 meters and holds lesser significance in other parts of the world. Little millet is characterized by its smaller seeds compared to common millet and shares visual similarities with proso millet. This annual herbaceous plant grows upright or with folded blades, reaching heights ranging from 30 cm to 1 m. The linear leaves of little millet occasionally feature hairy lamina and membranous hairy ligules. The panicles of the plant bear awns measuring 2 to 3.5 mm in length and range from 4 to 15 cm in size. The grain of little millet is round and smooth, typically measuring 1.8 to 1.9 mm in length. (Dayakar *et al.*, 2017).

## **10.3 Millets Production and Consumption:**

According to FAOSTAT (2021), global millet production in 2019-20 reached 84.17 million metric tonnes, cultivated on an area of 70.75 million hectares. India contributed approximately 20.50% of the total production. Millet consumption is significant in Africa and Asia, with around 90 million people in these regions relying on millet as a staple food.

Africa holds the majority share, producing over 55% of the world's millet, while Asia accounts for nearly 40%. Europe, on the other hand, constitutes only about 3% of the global millet market. (Alam and Reddy, 2023).

The primary producers of millet crops in India were the southern states of Karnataka, Maharashtra, Gujarat, and Tamil Nadu. Among these states, Karnataka was the leading producer, followed by Maharashtra, Gujarat, and Tamil Nadu. In terms of consumption, Karnataka and Maharashtra had relatively higher consumption rates, with urban consumers typically consuming millet crops "once or twice a week." In Gujarat, despite being the largest producer of pearl millet, the consumption of these crops was comparatively lower, suggesting that the high production had limited impact on urban consumption patterns. In Delhi, where production levels were modest, millet crops were consumed moderately, typically once a month. (Joanna *et al.*, 2021).

The production and consumption of millets are predominantly concentrated in developing countries, accounting for over 97% of the global total. However, the global area dedicated to millet cultivation has decreased by approximately 25.71% between 1961 and 2018 across all continents. Despite this, the overall productivity of millets has increased worldwide, with yields rising from 575 kg/ha in 1961 to 900 kg/ha in 2018.

While millet production has significantly increased in Africa, experiencing substantial growth, most other regions have witnessed a decline over the past 58 years. West Africa, in particular, has observed the largest increase, with production nearly doubling in the 1960s. In Asia, although the land area allocated for millet cultivation has reduced, productivity has steadily improved, leading to increased production.

India, with a significant share of 37.5% in global millet production, holds the top position, followed by Sudan and Nigeria. However, millet production in India reached its peak in the 1980s and has gradually declined as cultivated land has diminished. (Meena *et al.*, 2021).

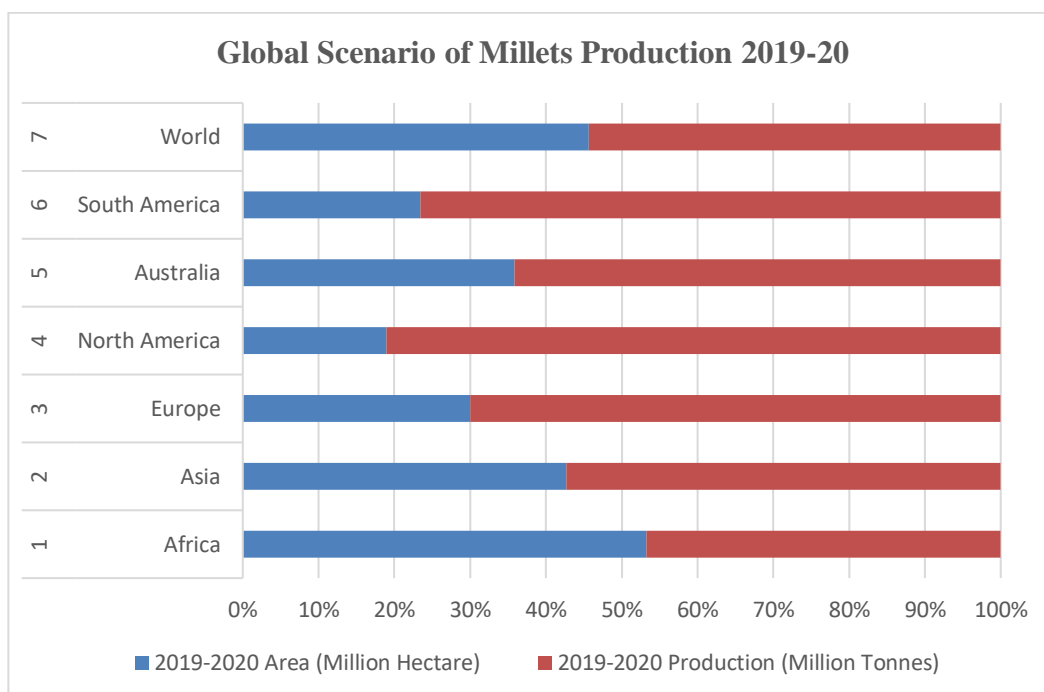
Minor millets, also known as coarse grains, are crucial sources of nutrition for tribal communities in areas with low yields of primary cereals. They contain high concentrations of micronutrients like vitamin B complex, calcium, iron, and sulfur, offering higher nutritional value than cereals. Despite being less expensive sources of dietary calories, their consumption has declined. Promoting the inclusion of minor millets in diets can address nutritional needs and improve overall health. (Junaid *et al.*, 2022).

Millet crops are predominantly cultivated in semi-arid regions of Asia and Africa, covering approximately 32.12 million hectares and yielding 28.76 million tonnes in 2013. These crops possess a short growth cycle of 60 to 90 days, making them well-suited to thrive in environments with limited moisture, high temperatures, and nutrient-depleted soils. Millets play a vital role in subsistence farming, particularly in areas with unpredictable rainfall and poor soil fertility, as they exhibit adaptability to such challenging environmental conditions.

Moreover, millets are cost-effective for small-scale farmers as they require minimal inputs. Additionally, millets offer excellent nutritional value due to their high protein, mineral, and dietary fiber content. (Umanath *et al.*, 2018).

Studies have revealed that the consumption of millet protein, particularly UCE and UCEE FM protein, can have beneficial effects on weight loss and liver health. Furthermore, research indicates that the inclusion of millet protein, specifically UCE and UCEE millet protein, can mitigate the increased impact of D-galactosamine on certain liver enzymes in the bloodstream, such as AST, ALT, and LDH.

Additionally, the intake of UCE and UCEE millet protein has been associated with reduced levels of plasma TC, TG, and LDL-C, as well as TC and TG in the liver. Interestingly, it also leads to increased levels of HDL-C, which may contribute to improved cardiovascular well-being. (Ashfak *et al.*, 2023).



(Source: FAOSTAT, 2021)

## 10.4 Nutritional Importance and Health Benefits of Millets:

### A. Sorghum:

Sorghum, a nutrient-rich cereal crop, offers a wide range of vitamins and minerals, predominantly present in the aleurone layer and germ. It is notably abundant in various B vitamins, except for B12. Yellow sorghum grain, in particular, exhibits high levels of beta-carotene, lutein, and zeaxanthin, although this can vary based on genetics and environmental factors. While sorghum is not a significant source of vitamin C, it can be produced through soaking and germination. Sorghum grain also contains detectable amounts of vitamins E, K, and D. Research suggests that sorghum may have potential health benefits for conditions such as celiac disease, obesity, diabetes, and coronary heart disease, as indicated by a study conducted by Dayakar *et al.* in 2017.

### **B. Finger Millet:**

Finger millet is a highly nutritious cereal grain with a protein content ranging from 5-8%, ether extractives of 1-2%, carbohydrates of 65-75%, dietary fiber of 15-20%, and minerals of 2.5-3.5%. It stands out with its exceptional calcium content of 344 mg per 100 grams, surpassing other cereals. Previously labeled as "anti-nutrients," finger millet contains substances like phytates (0.48%), polyphenols, tannins (0.61%), and trypsin inhibitory factors, which possess metal-chelating and enzyme-inhibiting properties, as reported in a study by Palanisamy et al. in 2011.

Finger millet has shown potential health benefits due to its anti-mutagenic, anti-estrogenic, anti-carcinogenic, anti-inflammatory, and antiviral properties. These findings, derived from various studies, establish finger millet as a beneficial addition to a nutritious diet, as highlighted by (Palanisamy *et al.*, 2011).

### **C. Pearl millet:**

According to a study conducted by Ragaei et al. in 2006, pearl millet is a highly nutritious grain with abundant resistant starch, soluble and insoluble dietary fibers, minerals, and antioxidants. It contains approximately 2.1% ash, 2.8% crude fiber, 7.8% crude fat, 13.6% crude protein, and 63.2% starch, making up about 92.5% of its dry matter content. The energy value of pearl millet is reported to be 361 Kcal per 100g, as stated by (Patni and Agrawal 2017).

Multiple epidemiological studies have indicated that diets rich in plant-based foods can contribute to the prevention of various degenerative diseases, including cancer, heart conditions, diabetes, metabolic syndrome, and Parkinson's disease. These findings were presented in the study conducted by Patni and Agrawal (2017) in their study.

### **D. Foxtail millet:**

Foxtail millet is a highly nutritious grain known for its low glycemic index (GI) and high fiber content. Compared to other cereals, it has a higher protein content and more fiber. A study has shown that foxtail millet contains glucans, which can enhance the metabolism of sugar and cholesterol. As a result, foxtail millet has hypoglycemic and hypocholesterolemic effects, making it beneficial for preventing diabetes and cardiovascular diseases. This research finding highlights the potential of foxtail millet as an ingredient for low-GI foods. (Hariprasanna 2016).

### **E. Kodo millet:**

Kodo millet is a nutritious grain known for its protein content of 8%. Glutelin is the predominant protein fraction in kodo millet. It is also an excellent source of dietary fiber, with a high content of 9%, surpassing wheat (1.2%) and rice (0.2%). The carbohydrate content in kodo millet is 66.6g per 100g, providing 353 kcal. It contains minerals at a level of 2.6% and fat at 1.4%. Kodo millet is also notable for its iron concentration, ranging from 25.86 to 39.60 ppm. (Deshpande *et al.*, 2015).

Scientific studies have suggested that incorporating millet into one's diet can provide several health benefits. These benefits include the prevention and management of conditions such as heart attacks, atherosclerosis, migraines, high blood pressure, and diabetic heart disease. Additionally, the high fiber content of millet has been associated with a reduced risk of gallstone formation. (Deshpande *et al.*, 2015).

#### **F. Barnyard Millet:**

Grains are recognized for their nutritional value due to their rich content of protein, carbohydrates, fiber, and essential micronutrients such as iron (Fe) and zinc (Zn). Compared to commonly consumed cereals like rice, wheat, and maize, grains are often more affordable, making them a cost-effective and beneficial option for meeting dietary needs. (Vellaichamy *et al.*, 2020).

Barnyard millet has been associated with various medicinal benefits, including its anti-inflammatory, anti-carcinogenic, antioxidant, and antimicrobial properties. It also possesses wound-healing properties and has shown effectiveness in managing biliousness and constipation-related ailments. (Vellaichamy *et al.*, 2020).

#### **G. Proso millet:**

Proso millet is rich in essential amino acids such as methionine, phenylalanine, tryptophan, and valine. However, it has a relatively lower content of lysine, which is considered a limiting amino acid. Despite this, Proso millet has a higher essential amino acid index (51%) compared to wheat (45%). It is a nutritious grain, similar to other popular cereals like rice and wheat, containing significant amounts of protein, carbohydrates, and energy. With approximately 11% protein content per 100g, Proso millet provides essential micronutrients like iron, zinc, and copper. Additionally, due to its lower glycemic index (GI), Proso millet is suitable for individuals with type-2 diabetes and cardiovascular disease. Products made entirely from Proso millet have a GI of 50-65, which is notably lower than refined corn- and wheat-based products (Saurav *et al.*, 2019).

#### **H. Little millet:**

Little millet is a nutritious grain known for its high fiber content and can be a healthy alternative to rice in various dishes such as pongal and kheer. It not only provides ample fiber but also contains significant amounts of phosphorus (220 mg/100g) and iron (9.3 mg/100g). Ankita *et al.* (2020) state that little millet can be particularly beneficial for individuals with low body mass and those dealing with conditions like cancer, diarrhea, and cardiovascular diseases. It is considered a wholesome grain with potential health advantages.

### **10.5 Millet and Food Security:**

Millet, a highly nutritious and drought-resistant crop, has been cultivated for centuries in various regions of the world. It belongs to the Poaceae family, which includes major food crops like wheat, rice, and maize. Millet serves as a vital source of food and livelihood for



millions of people in arid and semi-arid regions of Africa and Asia. This versatile crop has multiple uses, including ethanol production, animal feed, and as a staple food. It can be consumed as porridge, flatbread, or ground into flour for baking.

Millet stands out for its high protein, dietary fiber, vitamins (such as magnesium, phosphorus, and potassium), and essential amino acids like lysine and tryptophan, which are often deficient in other cereal grains like wheat and rice. It is also gluten-free, making it suitable for individuals with celiac disease or gluten intolerance. Millet plays a crucial role in food security, providing a reliable food source and income for farmers in regions prone to drought and challenging conditions. Despite its advantages, millet has often been overlooked due to the dominance of other crops and limited awareness of its nutritional value and versatility. However, there is a growing interest in promoting millet as a sustainable and nutritious food crop, with various initiatives underway to support its cultivation and consumption.

### **10.6 Challenges and Opportunities:**

Small millets, including finger millet, foxtail millet, proso millet, barnyard millet, kodo millet, little millet, teff, fonio, job's tears, guinea millet, and browntop millet, are coarse cereal grains that serve as staple foods in various regions. They belong to the Poaceae family, which also includes major cereals like rice, wheat, maize, and sorghum. However, small millets offer several advantages over large cereals.

One significant advantage is their agroecological adaptability. Small millets can thrive in diverse agroecological conditions, including drylands and low-fertility soils, where other crops may struggle to grow. They require less water and fertilizer, making them more environmentally friendly and sustainable compared to major cereals.

In terms of nutrition, small millets have a superior profile. They are rich in protein, fiber, and essential micronutrients such as calcium, iron, and zinc. This makes them a valuable dietary choice for individuals seeking a nutrient-dense food source. Moreover, small millets are gluten-free, making them suitable for individuals with gluten intolerance.

Overall, small millets offer a combination of adaptability, sustainability, and nutritional value, making them a promising option for food security and sustainable agriculture. Their cultivation and consumption can contribute to diverse and resilient food systems reduce the plagarism.

Small millets have additional benefits when it comes to addressing immediate food security needs. One advantage is their ability to provide multiple harvests within a single year. Due to their fast maturation and short growth cycles, small millets can be harvested more frequently compared to major cereals. This characteristic makes them a valuable resource for meeting immediate food requirements.

Furthermore, small millets exhibit resilience in challenging environmental conditions. They are well adapted to withstand drought, low-fertility soils, and other harsh conditions. This resilience ensures a stable food supply even during periods of environmental stress.

Their capacity to provide multiple harvests and withstand adverse conditions makes them valuable for ensuring food availability and resilience in communities. However, there are various challenges that affect millet food security.

These challenges include inadequate investment in research and development, limited market access, the impact of climate change, and insufficient awareness of millet's nutritional benefits. Insufficient investment in developing new millet varieties and protecting against pests, diseases, and extreme weather leads to low yields and crop failures in regions prone to drought and flooding. Additionally, small-scale farmers often face difficulties in obtaining fair prices and accessing markets, which discourages them from investing in millet production. Climate change further exacerbates these challenges by causing unpredictable weather patterns and crop failures. Furthermore, the underutilization of millet beyond traditional production regions limits its market potential, despite its high nutritional value. Addressing these challenges is crucial for promoting millet's role in food security (Source: Fetene et al., 2011).

There are various strategies that can be employed to enhance the food security of millet. One key aspect is the increasing demand for nutritious and sustainable food among health-conscious consumers, which provides farmers with new markets and income opportunities. Implementing new technologies and innovations, such as improved seeds, precision farming techniques, and efficient irrigation systems, can increase millet yields and mitigate the risks posed by climate change. Governments and non-governmental organizations (NGOs) can support millet farmers by implementing policy interventions such as facilitating access to credit, providing training, and disseminating market information.

Furthermore, there is potential to transform millet into high-value products like millet flour, which could drive demand and create additional income streams for farmers. By investing in research and development, expanding market access, and implementing supportive policies, it is possible to ensure that millet remains a significant source of food and nutrition for communities worldwide. These measures can contribute to improving the overall food security of millet and the well-being of millet farmers. (Source: Adapted from Fetene et al., 2011).

## **10.7 Conclusion:**

Millet continues to be a prevalent staple food in numerous regions, particularly in developing countries, and it holds great potential in combating malnutrition. The versatility of millet is noteworthy, as it can be utilized for various purposes such as ethanol production and animal feed. Its resilience to adverse conditions and ease of cultivation make it a reliable source of both food and income for farmers. Millet's nutritional value and sustainability further enhance its appeal as a crop.

Recognizing its significance, several initiatives have been established to support the cultivation and consumption of millet. These initiatives aim to capitalize on its nutritional benefits, sustainability, and ability to address immediate food security needs. The cultivation and consumption of millet are being promoted as a means to improve nutrition and enhance food security.

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