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Review Article

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Finger Millet- A Possible Source of Human Nourishment and Health

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Abstract
Accessible for a significantly lower cost than other items, finger millet, the primary crop in human nutrition is regarded as a healthful diet for low-income populations. In Africa's West, East, and Great Lakes Regions, it is a reliable source of food. Furthermore, native to Ethiopia, it can withstand drought well. The chemical makeup of various finger millet types is crucial in determining which has a high nutritional value. Ethiopian research on the crop's chemical makeup is, however, lacking. This analysis evaluates the nutritional benefits, overall health, and application of finger millet in value-added foods. Its product is one of the most significant and is widely grown in several locations in Ethiopia and Eritrea. This little millet provides an essential amino acid in the form of foodstuffs lacking in leucine, isoleucine, methionine, and phenylalanine. The polyphenol and fiber content are also useful for various health advantages, including antioxidant, anti-diabetic, anti-atheroclerogenic, and anti-tumorigenic actions. Generally speaking, these millets are crucial for many items and are also utilized as a healthful food for newborns when fermented. They are also recognized as a significant source of fiber for diabetes patients.

Keywords: Chemical Composition, Finger Millet, Nutritional Quality, Antioxidant

1. Introduction

Finger millet is an important annual cereal crop of the world belonging to the family Poaceae. It is a main source for health and development and an incrementation of human genetic potential. The nutritional level of society has been considered an applicable show of national development and growth. In another way, malnutrition impedes national development and hence assumes the status of a national challenge. For solving the problem and challenge of deep-rooted food insecurity and malnutrition, dietary quality should be taken into consideration. Different food production should be encouraged at the national and household levels in Ethiopia within chancing yields. Growing traditional food crops suitable for the area is one of the possible potential successful approaches for improving household health diet. Finger millet is one of the most important drought-resistant crops and the 6th cereal crop in terms of world agriculture production. Also, it has a resistance to pests and diseases, a short growing season, and productivity under drought conditions, compared to major cereals [1]. It is required specific attention from developing countries in terms of utilization as food as well as from some developed countries in terms of its good potential in the manufacturing of bioethanol and biofilms [2]. It is also substantially cultivated in diverse areas of Ethiopia. Internationally, the 30 million finger millet produced about 90% of the growing international and was used in advance in the previous Soviet Union.

It is also produced in West, East, and Great Lakes Regions of Africa and is nevertheless the primary reasserts of energy, proximate composition, nutrients, and minerals for tens of thousands and thousands of useful resources terrible people China, Japan, Ethiopia, Egypt, Manchuria, India, Niger, Nigeria, and the previous Soviet Union are envisioned to account for approximately 80% of worldwide millet utilization [3,4]. It is an indigenous foods crop to Ethiopia and occupies a common 5% of the overall place dedicated to cereal manufacturing and debts for 4% of general cereal yield annually. It is a crucial crop in regions of Wollega, Eastern Hararghe, Gojjam, Iluababora Gonder, Gamo-Gofa, and Tigray. This additionally turns into a very crucial crop withinside the significant rift valley of the country including such as Arsi Negele, Shashemene, and Siraro Woredas [5]. Although finger millet does now no longer input the global markets as an object of trade, however, it's far a crucial crop withinside the regions of adaptation and is a higher supply of protein, lipid and micronutrient, and micronutrients. It is a small cereal with mild brown to brick red-colored seed coat wealthy in phytochemicals, like nutritional fiber and polyphenols in comparison to different cereals along with barley, rice, maize, and wheat. It is used withinside the guidance of geriatric, toddler meals, and fitness ingredients each in herbal and malted forms. It is milled into flour for the guidance of meal merchandise along with Injera, porridge, puddings, pancakes, biscuits, bread, and different snacks. It is likewise used as a nourishing meal for toddlers and is appeared as a healthful meal for diabetic patients.

1.1. History of Finger Millet

Finger millet is a grain crop that does not appear to be given due credit in today's globe. Because of its suitability for semi-arid and dry regions, it became a very important staple diet for many Asian and African populations before wheat and rice. It's critical in developing countries, where millet is still regarded as a staple food, and statistics show that developing countries account for over half of global millet production [6]. Millet is now the world's sixth most important grain. India is the world's largest millet producer, with eight African countries and China rounding out the top ten producers. Millets can grow anywhere from one to fifteen feet tall, depending on the variety, and have an indigestible hull that must be removed before the grain can be consumed. Millets include finger millet, foxtail millet, pearl millet, barnyard grass, panic grass, and other podded plant life that are mostly used as food for humans and animals in developed nations.

Millet has been cultivated for hundreds of years, but the numerous types of finger millet and pearl millet that are now prevalent were unknown until relatively recently. Barnyard grass has various species of simple grasses, and panicum is a large genus of roughly 450 grasses native to the tropical regions of the world, with some species expanding into the northern temperate quarter. They are typically large, annual, or perennial grasses that grow to be 1.3 m tall, and they all can flourish in extremely dry regions [7]. According to Lu H, et al., the ancient reach can be traced back to around 10,000bp in Neolithic China, which could be a point in time when plant domestication was taking place and extensively grown within the same location that became unearthed, but it became not unusual for millet that became dated the oldest pattern the usage of husk phytoliths & biomolecular additives from newly excavated garage pits on the Neolithic Cishan, China, relation [8]. According to the evidence discovered by Lu et al, foxtail and common millet was the first domesticated vegetation in the area. This was most likely due to millet's exceptional ability to grow with little water, which was a major reason why wheat and rice weren't blossoming at the same time. Lu et al comment on their claims by stating that unusual millet appeared as a staple crop in northern China around 10,000 years ago, implying that unusual millet could have been domesticated independently in this location and later spread to Russia, India, the Middle East, and Europe [8]. Millet domestication and hybridization have resulted in several distinct species over the millennia. Pearl millet is the most widely farmed type of millet. It has been cultivated for hundreds of years in Africa and India.

The millet discovered by Lu et al was common and foxtail millet, while pearl millet is thought to have been domesticated later in the Sahel region of West Africa between 2500 and 2000 BC [9]. It is a tall plant that can reach 4 meters in height and produces the most important millet grains that range in length from 3 to 4 millimetres [6]. It wasn't until 2000 BC that pearl millet spread to India, which is currently the world's largest producer of all millet, with pearl being the most numerous plants. Around 10,000 years ago, the foxtail became one of the first millet species to be domesticated. Due to its significant impact on Chinese culture, it is the world's second-most farmed millet. Foxtail millet is by far China's single most important millet. Nonetheless, China produced more than 90% of the world's foxtail millet output in the 1980s [10]. Nonetheless, owing to its ease of growth and low water requirement, it is now considered a staple food for China's negative [6]. Pros and foxtail millet have similar symptoms and growth patterns. They grow to be one to two meters tall and have seeds that are only a few millimetres long. Proso millet, also known as uncommon millet, can be found in parts of Asia and India, but not as widely as other species. It is widely used in Slavic countries and America, mostly for feed and compost. Farmers in America employ it as an intercrop, taking advantage of its low call for disease. Proso millet helps to avoid summertime fallow and allows for continuous crop rotation. The millet can grow from runoff and does not affect the soil, allowing it to replenish its vitamins in time for the next crop cycle [11]. Millet, like a cereal crop, is frequently starchy. When compared to wheat, its protein content is equivalent throughout the majority of the distinct species. Pearl millets have a high iron and phosphorus content. A 100 g serving of millet throughout the day [12]. which isn't unusual within China's unfavourable regions, India and Africa account for over 100% of the World Health Organization's recommended daily iron consumption. Avoiding anaemia is a tremendous benefit in the fight for survival, and wheat and rice simply cannot compete. The fibre produced by the bran layers is the disadvantage of consuming pearl millet.

Although the layers contain a good number of B-complicated vitamins, they also have a low digestibility, which means that not all of the vitamins make their way into the human system [12]. It's nearly a catch-22, because increased water consumption aids in the digestion of excessive fibre fabric, yet millet is grown owing to a lack of water in a location. Some African countries rely heavily on millet for existence. Sorghum and pearl millet are both low-cost options for preventing malnutrition due to vitamin deficiencies. Because of their higher levels of insoluble dietary fibre and more balanced amino acid profile, sorghum and pearl millet provide additional health benefits. Although the layers contain a good number of B-complicated vitamins, they also have a low digestibility, which means that not all of the vitamins make their way into the human system [12].

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deficiencies. Because of their higher levels of insoluble dietary fibre and more balanced amino acid profile, sorghum and pearl millet provide additional health benefits. Finger millet is planted as a nutritional staple food crop in Ethiopia's Tigray, Amhara, Oromia, Benishangul-Gumuz, Southern Nation and Nationalities Peoples, and Gambela local states [13,14].

According to the most recent report of, during the 2017 more meh season, 1,765 personal peasant holders grew finger millet on roughly 456,057 acres of land, producing approximately 1,030,823 tons [15]. According to Tesfaye K, et al., Tesfaye K., Zewdu A, et al., the productivity of finger millet within the country is typically low due to a scarcity of advanced varieties, sickness, and pests, the negative utility of seed and fertilizer, moisture stress in dry regions, and a lack of research on the crop [14,16,17]. Between 2001 and 2017, the finger millet manufacturing area in Ethiopia increased by 33.8%, from 346,780 to 463,992 ha, while the overall manufacture increased by more than threefold, from 316,166 to 1,077,616 tons. Similarly, the yield of finger millet increased from 912 kg/ha in 2001 to 2,323 kg/ha in 2017. According to Ayalew B, the release of finger millet varieties throughout the country is the most critical issue for yield development in the 2000s [16].

According to the author, the output of finger millet in Ethiopia has increased by 66% over the last three decades. Between 1999 and 2015, fourteen different kinds of finger millet were introduced. Dissemination of new improved varieties, education, and demonstration of control applications are essential strategies advocated by unique writers to boost the productivity of finger millet in Ethiopia [17,18].

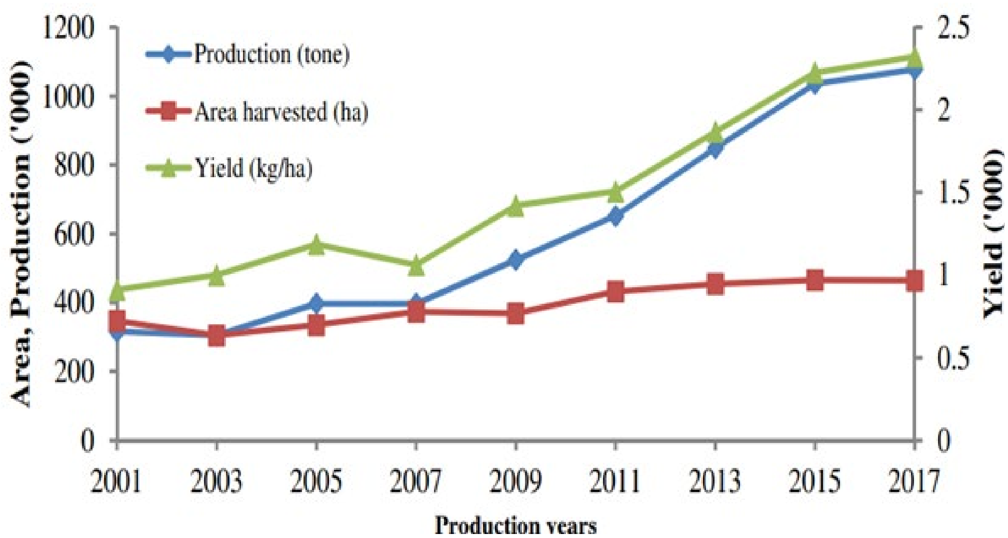

Figure: Production Trend and Yield of Finger Millet in Ethiopia

1.2. Nutritional Compositions

Nutritional well-being is a sustained force for health and development as well as the maximization of human genetic potential, it is important to maintain human total physical well-being. Dietary quality must therefore be taken into account to address the issues of pervasive food insecurity and malnutrition [20]. Similar to other cereals like rice, wheat, maize, and millet, it has a nutritional value in terms of carbohydrate content material of protein, rough fibre, and minerals. Because it contains more lysine, threonine, and valine than other millets, its protein profile is very well-balanced. It's crude fibre and mineral content are noticeably superior to those of wheat fibre and rice fibre. Because it contains more lysine, threonine, and valine than other millets, its protein profile is extraordinarily well-balanced. Its crude fibre and mineral content are noticeably superior to those of wheat fibre and rice fibre. It contains important amino acids, including isoleucine, leucine, methionine, and phenylalanine, which are deficient in other starchy foods. includes B vitamins as well, including niacin, B6, folic acid, calcium, iron, potassium, magnesium, and zinc. For the health and well-being of infants, breastfeeding mothers, the elderly, and convalescents, millets are highly nutritive, high-energy foods. However, due to the high-fat content in the millet flours, the dishes made from them both traditionally and industrially today have a poor shelf life. the typical components of the finger.

The common constituents of the finger millet are seed testa, embryo, and endosperm. Pink is the most often grown hue among the several varieties of finger millets, which also come in white, tan, pink, brown, violet, and yellow. Finger millet is more accurate than other types of millet, such as foxtail millet, pearl millet, kodo millet, and proso millet, since it has five layers in its testae. This could be one of the opportunities for increased nutritious fibre content in finger millet [12]. When compared to other millet species, it possessed the highest amount of calcium and phosphorus, as well as a crucial mineral called calcium [21]. For it to be possible for children, pregnant women, and other groups to grow and develop properly, micronutrients, especially calcium, are essential. Diabetes, obesity, and malnutrition have an impact on the elderly and humans [21]. The lack of calcium in the food products made from finger millet in the daily diets of both young and old people [22]. Iron, which is present in finger millet grains in concentrations between 20 and 30 percent, and magnesium, which has been linked to high blood pressure, asthma severity, migraine frequency, and an increased risk of coronary heart attack [23,24]. Compared to other millet species, finger millet grains are more nutritious and have better mineral content and proximate composition, despite the grain's small size. Although finger millet is still incredibly neglected and underutilized, it is more nutrient-rich and has greater mineral content and proximate composition when compared to other millet species [25].

Nutrient	**(mg/100 g)**	**Literature**
Proximate composition		
Moisture	7.15-13.1	[26]
Protein	7.7	[27]
Lipid/Fat	1.8	[20]
Mineral	2.7	
Dietary fiber	15-22	[24]
Carbohydrate	75-83.3	[27]
Energy (kcal)		
Minerals		
Calcium	398.0	[28]
Iron	3.3-14.89	
Phosphorus	130-250	[29]
Copper	0.47	
Magnesium	78-201	
Zinc	2.3	[30]
Manganese	17.61-48.43	[31]
Potassium	430-490	
Sodium	49.0	

Table 1: Proximate Composition and Mineral Contents of Finger Millet Grains

Vitamins which might be different vitamins found in finger millet grains are vital micronutrients required via way of means of the human frame for ordinary increase and self-maintenance. Different vitamins that may be discovered in finger millet grains are essential micronutrients that the human body needs for regular growth and self-maintenance. Vitamins are divided into fat-soluble and water-soluble categories, and nutrient loss can result in food deficits and subsequent health issues [32,33]. The nutrients A and B complex are abundant in finger millet grains, which also contain lipids and water-soluble nutrients [34]. According to Muthamilarasan M, et, al., finger millet grains contain essential fatty acids like linolenic and palmitic acids, which may be beneficial for the development of brain and neural tissue [35]. Fat makes garage dwellings more expensive and helps you avoid weight-related risks. Fat makes garage homes higher, reduces weight-related risks to you, and/or allows you to alter frame weight [36]. (1-2%) of the grains of finger, millet contains it. On the other hand, certain millet grains contain higher levels of fat, ranging from 3.5 to 5.2% [37].

Nutrient	**mg/100g**	**Literature**
Vitamin	**6.0**	**[10,24,27]**
Retinol	0.2-0.48	[1,24,33]
Thiamine	0.12	[28,34]
Riboflavin	1.0-1.30	[38]
Niacin	0.0-1.0	[39]
Fatty acids g/100g of total fat		
Palmitic	21.1-1.24.7	[39]
Oleic acid	49.8	[38]
Linolenic acid	**24.2**	**[39]**
Linolenic	1.3-4.40	[33]

Table 2: The Major Vitamin Content and Fatty Acids of Finger Millet Grains

The modest release of glucose into the system during digestion and the ability to alleviate constipation are two of millet grains' health advantages [40]. Additionally, it has been linked to a lower chance of developing diabetes, lower blood pressure, and cardiovascular disorders [41]. Consuming millet grain has been linked to a lower risk of cancer and lower cholesterol levels, according to [42]. Its starch is beneficial for the development, and repair of body tissue, prevention of gallstones, protection against breast cancer, and protection against postmenopausal women and childhood cancer and is used in the pharmaceutical industries as a binder for the preparation of granules and capsule dosage forms [43]. It tastes delicious, is quickly digestible, and is also eaten as whole grains [43]. Due to their role as excellent suppliers of vitamins and fatty acids, one of the most advantageous cereal grains for low socioeconomic communities, particularly in Africa and some regions of Asia [44].

1.3. Polyphenolic Compounds

Polyphenols, secondary metabolites found in plants, play an important role in pathogen resistance. The potential health benefits of consuming plant polyphenols as antioxidants have received a lot of attention. Diets high in plant polyphenols can help prevent the beginnings of cancer, cardiovascular disease, diabetes, osteoporosis, and neurological diseases. The biological effects of plant polyphenols on human health. Polyphenols have lately gained prominence as life-span requirements due to their involvement in preserving physical capacities and fitness throughout the human and later phases of existence [45]. It is a diverse range of chemicals, many of which are probably found in numerous food plants. Polyphenols, in particular, are found in almost all plant diets ingested by both humans and animals. They are also one of the most commonly advertised nutritious dietary supplement classes [19]. While flavonoids are present in trace amounts, the majority of polyphenols in cereals are phenolic acids and tannins [46]. Many of these compounds' properties, such as antioxidant, anti-mutagenic, anti-osteogenic, anti-carcinogenic, and anti-inflammatory effects, as well as platelet aggregation inhibitory interest, may be useful in preventing or reducing disease prevalence, despite having no known direct role in nutrition [19].

In comparison to many other continental cereals, such as barley, rice, maize, and wheat, tiny millet a dark brown seed coat rich in polyphenols [47]. Phenolic substances were identified in distinct anatomical parts of the millet seed using the histochemical and chemical investigation of milling fractions. The aleurone layer, testa, and pericarp, which comprise the majority of the bran part, are the grain's outermost layers where it is not uniformly distributed. In grains, there are both free, soluble conjugates of phenolic compounds and insoluble bound forms. Millet contains the majority of phenolic compounds in the form of glycosides, according to Rao and Muralikrishna Subba, with protocatechuic acid being the main free phenolic acid and ferulic acid being the main bound phenolic acid [46]. They are physiologically active and, in sufficient quantities, can impair the biological availability and nutritional value of proteins and minerals [48]. The total phenolics and tannin content of various genotypes of finger millet grain varied. When compared to brick-red stained grains, lighter-colored grains have significantly lower total phenolic and tannin levels. The colored testa of the red-hued variations has a significant tannin content, which was discovered in the aforementioned grain tissue [27]. The presence of red pigments such as anthocyanins, which are often polymerized phenolics seen in brown cultivars, may explain the apparent difference in polyphenol content between white and brown kinds [49].

1.4. Antioxidant Properties

Antioxidant chemicals are gaining popularity as lipid stabilizers and as inhibitors of imbalanced oxidation, which causes most malignancies and aging [50]. Their solid radical intermediates protect you from the oxidation of many food ingredients, such as particular, fatty acids, and oils [51,52]. Millet seed coat phenolic acids and their subordinates, flavonoids, and tannins are multifunctional and may operate as reducing agents (detached radical eliminators), steel chelators, and singlet oxygen quenchers [37]. The ability of phenolic compounds to act as antioxidants stem from their ability to donate hydrogen atoms via hydroxyl structures on benzene jewelry to electron-poor loosened radicals, forming a resonance-stabilized and less reactive radical in the process. Herbal antioxidants suited for consuming flours of small millets have been studied. The total antioxidant potential of a finger, small, foxtail, and proso millets was discovered to be higher, with general carotenoid concentration ranging from 78-366 mg/100 g within the millet kinds. Total tocopherol content material was higher in finger and proso millet varieties (3.6-4.0 mg/100 g) than in foxtail and tiny millet varieties (1.3 mg/100 g). HPLC analysis of carotenoids for the presence of -carotene showed its absence within the millets, and nutrition E revealed a higher proportion of -and -tocopherols; nevertheless, it revealed lower tocotrienol levels inside the millets. Small millet edible flours are a real source of endogenous antioxidants [53]. Through electron spin resonance spectroscopic research, it was discovered that kodo millet extract quenched 70% of 1, 1, Diphenyl -2- picrylhydrazyl (DPPH), observed through exceptional millet, finger millet, little millet, foxtail millet, barnyard millet, exceptional millet, and their white types of millet, finger millet, and different extracts which confirmed 15–53%. Food preparation via roasting and boiling, germination, and/or fermentation reduced the unfastened radical quenching hobby, which is most likely due to tannin hydrolysis, and white millets demonstrated lower hobby than colored millets, indicating that phenolics within the seed coat are accountable for the antioxidant activities [54].

The reduced electricity of seed coat extracts becomes far superior to that of whole flour extract. The antioxidant capacity of phenolic acids changes throughout the malting of finger millet. According to Rao and Muralikrishna Subba, the antioxidant activity of a free phenolic acid aggregate was determined to be superior to that of a specific phenolic acid aggregate [46]. An increase in an antioxidant activity coefficient was discovered in the case of loosened phenolic acids, however, the same decreased in specific phenolic acids after 96 hours of malting. Soluble and insoluble-sure phenolic extracts of various whole grain millets (Kodo, finger, foxtail, proso, pearl, and little millets) were evaluated for their phenolic content and antioxidative efficacy utilizing Trolox equal antioxidant potential, decreasing electricity, and carotene-linoleate model machine, in addition to ferrous chelating hobby, which revealed high antioxidant activities, even though the order of their efficacy became assay. The ability of whole millets as herbal antioxidant reassessments is due to varietal variations in phenolic content as well as antioxidant capabilities among soluble and insoluble millets. and insoluble sure phenolic fractions [45]. The quantity of antioxidant hobby of phenolics relies upon the placement and quantity of hydroxylation of the phenolic jewelry [55]. Many different structural functions play a big function in figuring out the quantity of antioxidant hobby [56]. Ferulic acid is a famous very robust antioxidant, unfastened radical scavenging, and anti-inflammatory hobby [57].

1.5. Use and Application

In some places of the world, finger millet has both traditional and commercial programs. Traditionally, finger millet grain is used to make alcoholic and nonalcoholic drinks, while its flour is used to make exclusive food products such as porridge, snacks, biscuits, and bread [58]. Various commercial applications have been studied to use finger millet grain as composite flour, baked goods, extruded goods, and other gluten-free cereal-primarily based completely foods [59]. Finger millet-primarily based completely meals goods frequently vary from country to country and area to location, and the majority merchandise developed in developing nations aren't sold [58]. Commercially to be had and popularly eaten up finger millet-primarily based totally merchandise in the evolved country consisting of spaghetti, macaroni, pasta, noodles, vermicelli, and flakes [60]. In the production of extruded snacks, the crop is used collectively with greenback wheat and amaranth in the regions of maize and wheat [59]. In Ethiopia, finger millet is used for making injera, nearby drinks, porridge, bread, soup, and conventional breakfast known as chechebsa, and the straw is used as forage for animals [17]. Injera, fermented pancake-like, soft, round flat bread, can be organized by myself or blended with tef which is a high-quality crop for making injera. Tella and Areki are Ethiopian conventional drinks that might be organized from exclusive cereals, which include finger millet, from north Ethiopia encouraged mango-flavored finger millet juice [61]. According to the authors, the juice may be an extraordinary opportunity to get all of the dietary advantages of the crop. Unavailability of value-introduced handy finger millet primarily based totally on meals merchandise restrained intake of the crop in city regions of Ethiopia.

2. Conclusion

This review has demonstrated that finger millet is high in macro and micro vitamins, making it an important component of nutritional and dietary balanced diets. This, in turn, implies that the crop has the potential to improve family meals and nutrient security for Ethiopia's developing population, where energy-protein malnutrition affects an additional part of the country. Finger millet is a capable crop for combating hidden hunger due to its high mineral content and high vitamin content. Furthermore, because the crop is high in nutritious fiber content, minerals, phytochemicals, and coffee in glycemic index and gluten-free in nature, finger millet-based entirely items have been considered as useful foods. In comparison to other grains, finger millet research has received little attention, and data on nutrients in the crop is scarce. Even the advanced finger millet varieties are generally based entirely on agronomic tendencies such as yield and disease resistance. As a result, the breeding research must provide prior attention to nutritional first-rate parameters. Processing procedures for finger millet have critical roles in improving dietary quality, sensory acceptability, and, most critically, lowering inhibitors such as phytate and tannins, consequently improving vitamin bioavailability. However, such statistics are frequently lacking at the patron level and wish cognizance creation. Furthermore, using finger millet as a component of composite flours to make particular food products/recipes such as injera, bread, porridge, biscuits, and cookies should be an excellent way to market the crop in urban areas of the country [62-66].

Authors Contribution

Kebede Dida is the main author of the review; Kedir Kebero has co-authored and supervised manuscript preparation and helped to contribute to the literature collection and editing of the review. All two authors have read and approved the final manuscript.

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References

1. Devi, P. B., Vijayabharathi, R., Sathyabama, S., Malleshi, N. G., & Priyadarisini, V. B. (2014). Health benefits of finger millet (Eleusine coracana L.) polyphenols and dietary fiber: a review. Journal of food science and technology, 51, 1021-1040.
2. Li, J., Chen, Z., Guan, X., Liu, J., Zhang, M., & Xu, B. (2008). Optimization of germination conditions to enhance hydroxyl radical inhibition by water-soluble protein from stress millet. Journal of cereal science, 48(3), 619-624.
3. Gomez, M. I., House, L. R., Rooney, L. W., & Dendy, D. A. V. (1992). Utilization of sorghum and millets. International Crops Research Institute for the Semi-Arid Tropics.
4. Gull, A., Prasad, K., & Kumar, P. (2015). Physico-chemical, functional and antioxidant properties of millet flours. Journal of Agricultural Engineering and Food Technology, 2(1), 73-75.
5. Chimdo, A., Aberra, D., Shemelis, D., Fekadu, B., Nigusse, E., Belete, G., ... & Maikel, T. (2001). Research center based maize technology transfer: Efforts and achievements. Enhancing the Contribution of Maize to Food Security in Ethiopia, 11-13.

6. McDonough, C. M., Rooney, L. W., & Serna-Saldivar, S. O. (2000). The millets. In Handbook of cereal science and technology (pp. 177-201). CRC Press.
7. Freckmann, R. W., & Lelong, M. G. (2002). Nomenclatural changes and innovations in Panicum and Dichanthelium (Poaceae: Paniceae). SIDA, Contributions to Botany, 161-174.
8. Lu, H., Zhang, J., Liu, K. B., Wu, N., Li, Y., Zhou, K., ... & Li, Q. (2009). Earliest domestication of common millet (Panicum miliaceum) in East Asia extended to 10,000 years ago. Proceedings of the National Academy of Sciences, 106(18), 7367-7372.
9. Manning, K., Pelling, R., Higham, T., Schwenniger, J. L., & Fuller, D. Q. (2011). 4500-Year old domesticated pearl millet (Pennisetum glaucum) from the Tilemsi Valley, Mali: new insights into an alternative cereal domestication pathway. Journal of Archaeological Science, 38(2), 312-322.
10. Dendy, D. A. (1995). Sorghum and millets: chemistry and technology. American Association of Cereal Chemists.
11. Lyon, D. J., Burgener, P. A., DeBoer, K. L., Harveson, R. M., Hein, G. L., Hergert, G. W., ... & Vigil, M. F. (2008). Producing and marketing proso millet in the Great Plains. Univ. of Nebraska, Lincoln, Extension (EC137).
12. FAO, R. (1995). Sorghum and millets in human nutrition. FAO Food Nutrition Series, 27, 16-19.
13. Admassu, S., Teamir, M., & Alemu, D. (2009). Chemical composition of local and improved finger Millet [Eleusine Corocana (L.) Gaetrtin] varieties grown in Ethiopia. Ethiopian Journal of Health Sciences, 19(1), 1-18.
14. Tesfaye, K., & Mengistu, S. (2017). Phenotypic characterization of Ethiopian finger millet accessions ((L.) Gaertn), for their agronomically important traits. Acta Universitatis Sapientiae, Agriculture and Environment, 9(1), 107-118.
15. CSA (2018). Central Statistical Agency. The Federal Democratic Republic of Ethiopia, Agricultural Sample Survey 2017/18, Volume I, Report on Area and Production of Major Crops, Statistical Bulletin 586, April 2018, Addis Ababa, Ethiopia.
16. Ayalew, B. (2015). Trends, growth and instability of finger millet production in Ethiopia. Research Journal of Agriculture and Environmental Management, 4(2), 078-081.
17. Zewdu, A., Gemechu, F., & Babu, M. (2018). Pre-Scaling up of improved finger millet technologies: The case of daro lebu and habro districts of west hararghe zone, oromia national regional state, Ethiopia. Journal of Agricultural Education and Extension, 4(2), 131-139.
18. Mulualem, T., & Melak, A. (2013). A survey on the status and constraints of finger millet (Eleusine coracana L.) production in Metekel Zone, North Western Ethiopia. Direct Research Journal of Agriculture and Food Science, 1(5), 67-72.
19. FAOSTAT (Food and Agriculture Organization Statistics) (2015). 2013 data for major commodities.
20. Singh, P., & Raghuvanshi, R. S. (2012). Finger millet for food and nutritional security. African Journal of Food Science, 6(4), 77-84.
21. Manjula, K., Bhagath, Y. B., & Nagalakshmi, K. (2015). Effect of radiation processing on bioactive components of finger millet flour (Eleusine coracana L.). International Food Research Journal, 22(2), 556-560.
22. Shukla, K., & Srivastava, S. (2014). Evaluation of finger millet incorporated noodles for nutritive value and glycemic index. Journal of food science and technology, 51, 527-534.
23. Towo, E., Mgoba, C., Ndossi, G. D., & Kimboka, S. (2006). Effect of phytate and iron-binding phenolics on the content and availability of iron and zinc in micronutrients fortified cereal flours. African Journal of Food, Agriculture, Nutrition and Development, 6(2), 1-13.
24. Saleh, A. S., Zhang, Q., Chen, J., & Shen, Q. (2013). Millet grains: nutritional quality, processing, and potential health benefits. Comprehensive reviews in food science and food safety, 12(3), 281-295.
25. Dlamini, N. R., & Siwela, M. (2015). The future of grain science: the contribution of indigenous small grains to food security, nutrition and health in South Africa [AACCI Report]. Cereal Foods World, 60(4), 177-180.
26. Admassu, S., Teamir, M., & Alemu, D. (2009). Chemical composition of local and improved finger Millet [Eleusine Corocana (L.) Gaetrtin] varieties grown in Ethiopia. Ethiopian Journal of Health Sciences, 19(1), 1-18.
27. Siwela, M., Taylor, J. R., de Milliano, W. A., & Duodu, K. G. (2007). Occurrence and location of tannins in finger millet grain and antioxidant activity of different grain types. Cereal chemistry, 84(2), 169-174.
28. 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.
29. Verma, V., & Patel, S. (2013). Value added products from nutri-cereals: Finger millet (Eleusine coracana). Emirates Journal of Food and Agriculture, 169-176.
30. Patel, S., Naik, R. K., Sahu, R., & Nag, S. K. (2014). Entrepreneurship development through finger millet processing for better livelihood in production catchment. American International Journal of Research in Humanities, Arts and Social Sciences, 8(2), 223-227.
31. Ramashia, S. E., Gwata, E. T., Meddows-Taylor, S., Anyasi, T. A., & Jideani, A. I. O. (2018). Some physical and functional properties of finger millet (Eleusine coracana) obtained in sub-Saharan Africa. Food Research International, 104, 110-118.
32. Ottaway, P. B. (Ed.). (2008). Food fortification and supplementation: Technological, safety and regulatory aspects. Elsevier.
33. Dionex Corporation. (2010). Determination of water- and fat-soluble vitamins by HPLC (Technical Note, No. 89, LPN 2598). Sunnyvale: Dionex Corporation.
34. Chappalwar, V. M., Peter, D., Bobde, H., & John, S. M. (2013). Quality characteristics of cookies prepared from oats and finger millet based composite flour. Engineering Science and Technology: An International Journal, 3(4), 677-683.

35. Muthamilarasan, M., Dhaka, A., Yadav, R., & Prasad, M. (2016). Exploration of millet models for developing nutrient rich graminaceous crops. Plant Science, 242, 89-97.
36. Gunashree, B. S., Kumar, R. S., Roobini, R., & Venkateswaran, G. (2014). Nutrients and antinutrients of ragi and wheat as influenced by traditional processes. International Journal of Current Microbiology and Applied Sciences, 3(7), 720-736.
37. Shahidi, F., & Chandrasekara, A. (2013). Millet grain phenolics and their role in disease risk reduction and health promotion: A review. Journal of Functional Foods, 5(2), 570-581.
38. Fernandez, D. R., Vanderjagt, D. J., Millson, M., Huang, Y. S., Chuang, L. T., Pastuszyn, A., & Glew, R. H. (2003). Fatty acid, amino acid and trace mineral composition of Eleusine coracana (Pwana) seeds from northern Nigeria. Plant Foods for Human Nutrition, 58, 1-10.
39. Serna-Saldivar, S. O., & Espinosa-Ramírez, J. (2019). Grain structure and grain chemical composition. In Sorghum and millets (pp. 85-129). AACC International Press.
40. Mamatha, H. S., & Begum, J. M. (2013). Nutrition analysis and cooking quality of finger millet (Eleusine coracana) vermicelli with hypoglycaemic foods. International Journal of Farm Sciences, 3(2), 56-62.
41. Pradeep, P. M., & Sreerama, Y. N. (2015). Impact of processing on the phenolic profiles of small millets: Evaluation of their antioxidant and enzyme inhibitory properties associated with hyperglycemia. Food chemistry, 169, 455-463.
42. Subastri, A., Ramamurthy, C., Suyavaran, A., Mareeswaran, R., Mandal, P., Rellegadla, S., & Thirunavukkarasu, C. (2015). Nutrient profile of porridge made from Eleusine coracana (L.) grains: effect of germination and fermentation. Journal of Food Science and Technology, 52, 6024-6030.
43. 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), 22-33.
44. Rurinda, J., Mapfumo, P., Van Wijk, M. T., Mtambanengwe, F., Rufino, M. C., Chikowo, R., & Giller, K. E. (2014). Comparative assessment of maize, finger millet and sorghum for household food security in the face of increasing climatic risk. European Journal of Agronomy, 55, 29-41.
45. Chandrasekara, A., & Shahidi, F. (2011). Inhibitory activities of soluble and bound millet seed phenolics on free radicals and reactive oxygen species. Journal of Agricultural and Food Chemistry, 59(1), 428-436.
46. Subba Rao, M. V. S. S. T., & Muralikrishna, G. (2002). Evaluation of the antioxidant properties of free and bound phenolic acids from native and malted finger millet (Ragi, Eleusine coracana Indaf-15). Journal of Agricultural and Food Chemistry, 50(4), 889-892.
47. Viswanath, V., Urooj, A., & Malleshi, N. G. (2009). Evaluation of antioxidant and antimicrobial properties of finger millet polyphenols (Eleusine coracana). Food Chemistry, 114(1), 340-346.
48. Chavan, J. K., Kadam, S. S., & Beuchat, L. R. (1989). Nutritional improvement of cereals by sprouting. Critical reviews in food science & nutrition, 28(5), 401-437.
49. Wadikar, D. D., Vasudish, C. R., Premavalli, K. S., & Bawa, A. S. (2006). Effect of variety and processing on antinutrients in finger millet. JOURNAL OF FOOD SCIENCE AND TECHNOLOGY-MYSORE-, 43(4), 370.
50. Namiki, M. (1990). Antioxidants/antimutagens in food. Critical Reviews in Food Science & Nutrition, 29(4), 273-300.
51. Cuvelier, M. E., Richard, H., & Berset, C. (2014). Comparison of the antioxidative activity of some acid-phenols: structure-activity relationship. Biosci. Biotechnol. Biochem, 56(2), 324-325.
52. Maillard, M. N., Soum, M. H., Boivin, P., & Berset, C. (1996). Antioxidant activity of barley and malt: relationship with phenolic content. LWT-Food science and Technology, 29(3), 238-244.
53. AshaRani, P. V., Low Kah Mun, G., Hande, M. P., & Valiyaveettil, S. (2009). Cytotoxicity and genotoxicity of silver nanoparticles in human cells. ACS nano, 3(2), 279-290.
54. Hegde, P. S., Chandrakasan, G., & Chandra, T. S. (2002). Inhibition of collagen glycation and crosslinking in vitro by methanolic extracts of Finger millet (Eleusine coracana) and Kodo millet (Paspalum scrobiculatum). The Journal of nutritional biochemistry, 13(9), 517-521.
55. Miyake, T., & Shibamoto, T. (1997). Antioxidative activities of natural compounds found in plants. Journal of agricultural and food chemistry, 45(5), 1819-1822.
56. Bravo, L. (1998). Polyphenols: chemistry, dietary sources, metabolism, and nutritional significance. Nutrition reviews, 56(11), 317-333.
57. Castelluccio, C., Paganga, G., Melikian, N., Paul Bolwell, G., Pridham, J., Sampson, J., & Rice-Evans, C. (1995). Antioxidant potential of intermediates in phenylpropanoid metabolism in higher plants. FEBs letters, 368(1), 188-192.
58. Ramashia, S. E., Anyasi, T. A., Gwata, E. T., Meddows-Taylor, S., & Jideani, A. I. O. (2019). Processing, nutritional composition and health benefits of finger millet in sub-saharan Africa. Food Science and Technology, 39, 253-266.
59. 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.
60. Jaybhaye, R. V., Pardeshi, I. L., Vengaiah, P. C., & Srivastav, P. P. (2014). Processing and technology for millet based food products: a review. Journal of ready to eat food, 1(2), 32-48.
61. Hailu, Z., & Gebreyohans, M. (2017). Production and Characterization of Juice Produced from Ethiopian Finger Millet. J Chem Eng Process Technol, 8, 350.
62. Basahy, A. Y. (1996). Nutritional and chemical evaluation of pearl millet grains (Pennisetum typhoides (Burm. f.) Stapf & Hubbard, Poaceae) grown in the Gizan area of Saudi Arabia. International journal of food sciences and nutrition, 47(2), 165-169.

63. Chavan, U. D., McKenzie, D. B., & Shahidi, F. (2001). Functional properties of protein isolates from beach pea (Lathyrus maritimus L.). Food chemistry, 74(2), 177-187.
64. Anchala, C., Kidane, H., & Mulatu, T. (2006). Impacts of improved finger millet technology promotion in the central rift valley of Ethiopia. Success with Value Chain, Ethiopian Institute of Agricultural Research, Addis Ababa, 129-140.
65. Ferguson, L. R. (2001). Role of plant polyphenols in genomic stability. Mutation Research/Fundamental and Molecular Mechanisms of Mutagenesis, 475(1-2), 89-111.
66. Rao, P. U. (1994). Evaluation of protein quality of brown and white ragi (Eleusine coracana) before and after malting. Food chemistry, 51(4), 433-436.