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A Review of Processing Technologies for Enhancing Millet-Based Foods

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Abstract: *Millets are a staple food in many parts of the globe because of their high nutritional value and the significant role they play in the people' diets. The use of millets as a food is still mostly limited to traditional consumers and the people of lower economic strata, despite the fact that millets have a higher nutritional value than cereals. Scientists and nutritionists face a challenge in the form of climate change, water scarcity, population growth, declining yields of major cereals, adequate access to sufficient food, and strengthening local agro-food systems. This challenge requires them to investigate the possibilities of producing, processing, and utilizing other potential food sources in order to put an end to hunger and poverty. Nevertheless, the unique characteristics of millets, the advantageous applications of these grains, and the growing awareness of the importance of health among consumers have prompted food scientists and engineers to produce a wide range of food items and to mechanize the procedures involved. In the current study, the procedures, numerous traditional and convenience meals, including ready-to-eat (RTE) food items made from millets, as well as product attributes, are discussed*

Keywords: Millets, processing, puffing, fermentation, malting, weaning, nutrition, glycemic index

I. INTRODUCTION

Millet is a general word that is used to refer to grains that are of a small size and constitute a heterogeneous group. Millet, along with maize and sorghum, is considered to be a kind of coarse cereal. Although millets are not particularly significant in western culture, they constitute an essential component of the diets of people in Asia and Africa. Their hardiness, resistance to harsh weather, and the fact that they may be cultivated with the least amount of inputs in regions with poor rainfall all contribute to their agricultural significance. Among the important millets that are cultivated primarily in Asian and African countries are the following: bajra, also known as pearl millet (Pennisetum americanum), ragi, also known as finger millet (Eleusine coracana), navane, also known as foxtail millet (Setaria italica), samai, also known as little millet (Panicum miliare), haraka, also known as kodo millet (Paspalum scrobiculatum), panivaragu, also known as proso millet (Panicum miliaceum), and banti, otherwise known as barnyard millet (Echinochloa frumentacea). The Fonio, also known as Digitaria exilis, and Tef, also known as Eragrostic Tef, are both indigenous to Nigeria and Ethiopia, respectively. A significant number of millets are cultivated in many parts of the globe, ranging from the east to the west. In 2010, India ranked first in the world with a production of 334500 tonnes of millet grain, which brought the overall output of millet grain throughout the globe to 762712 metric tonnes (FAO, 2012).

According to Ushakumari et al. (2004), millets are regarded to be a crop of food security because of their capacity to thrive in agroclimatic conditions that make them difficult to cultivate. According to Mal et al. (2010), these crops may significantly contribute to the expansion of the genetic variety present in the food basket, as well as to the improvement of food and nutrition security. According to Veena (2003), millets, in addition to providing nourishment, also provide health advantages in the daily diet and assist in the treatment of conditions such as diabetes mellitus, obesity, hyperlipidemia, and other conditions. Because of their high content of micronutrients, notably minerals and B vitamins, as well as nutraceuticals, millets provide a benefit to health that is unmatched by other foods. Despite the fact that millets are not a significant component of the diets of people in the United States and Europe, these regions have recently acknowledged the significance of millets as an ingredient in multigrain and gluten-free cereal products.

According to Chandrasekara and Shahidi (2011), millet is the primary source of nutrition for the people living in millet-producing regions of several Asian and African nations. It is also used in the preparation of a wide variety of traditional meals and drinks, including such items as idli, dosa, papad, chakli, porridges, breads, and baby and snack foods. According to Subramanian and Viswanathan (2003), the absence of large-scale industrial use inhibits farmers from cultivating millet crops. This is despite the fact that a variety of traditional meals are produced in the family household. As a result, several nations, including as India, China, the United States of America, and others, have initiated research programs in order to investigate and develop process technology for the purpose of enhancing nutritional quality, harvesting health advantages, and promoting the usage of these products as food on a broad scale. It is anticipated that the challenges of the 21st century, which include climate change, water scarcity, rising food prices, and other socioeconomic impacts, will pose a significant threat to agriculture and food security all over the world, particularly for the most impoverished individuals who reside in arid and sub-arid regions (Saleh et al., 2013). Millets have a conventional grain texture and a tough seed coat, which improves their ability to be stored for longer periods of time but also makes it challenging to process and prepare them in a suitable manner. It has been found that the absence of suitable primary processing technologies for the preparation of ready-to-use or ready-to-cook (RTC) products, as well as secondary and tertiary processing for the preparation of ready-to-eat value-added products, has been the most significant factor that has hindered their ability to have a wider range of food applications and improve their economic standing (Malleshi, 2014). As a result of the existence of natural anti-nutritional components, millets have a relatively low bioavailability of minerals and a low digestion. According to Nehir and Simsek (2012), more and more consumers are becoming concerned about their health and nutrition, which is becoming an increasingly essential factor in their food selection. There are challenges associated with the processing of millet grain; nevertheless, the nutritional and health advantages of millet, as well as the demand from consumers for health foods, provide potential for millet grain processing, the development of appropriate technologies for innovative products, and the automation of the millet grain processing process. For the purpose of growing the area under millets, preserving ecological balance, providing food security, preventing malnutrition, and expanding the scope for the exploitation of millet grains on an industrial scale, this shift in technology and consumer food choice would be of great assistance.

The processing of millets has been the subject of a number of research, and these investigations have produced encouraging findings about their effective usage for a variety of traditional as well as convenience health meals. As a result, several researchers have endeavored to produce processed goods such as popped, flaked, puffed, extruded, and roller dried items; fermented, malted, and composite flours; weaning meals, and other similar products. As an example, exploratory work on popping and milling millets have shown encouraging results (Malleshi, 1986). Extrusion of weaning meals made from pearl millet has been shown to boost the protein digestibility (Cisse et al., 1998). On the other hand, germination and probiotic fermentation have been shown to induce a considerable improvement in both the protein profile and the in-vitro mineral availability (Arora et al., 2011).

It is attempted to review the composition, specialties of ingredients, various food products derived from millets, processing techniques, their effect on nutrients, and product characteristics in order to gain an understanding of the miracle that millet grains are, as well as their ability to be processed, the current status of the range of food products, and the potential for future development of millet-based health, functional, and ready-to-eat products.

Nutrient Composition of Millets

Because of a lack of essential nutrients, the majority of us are putting our health at risk. As a result, everyone is aware of the food that they consume on a daily basis, and food product development teams all over the globe are working hard to fill in the gaps in the health jigsaw. Therefore, nutrition is the most important aspect of a person's diet. According to Sehgal and Kawatra (2003), millet grains are nutritionally equivalent to major cereals and even superior to them in terms of the amount of protein, calories, vitamins, and minerals that they contain. Millets have a greater supply of dietary fibers, minerals, and nutraceuticals than rice or wheat, and they include 9-14% protein and 70-80% carbs (Hadimani & Malleshi, 1993). Millets are a rich source of minerals and nutraceuticals.According to Singh et al. (2012)b, they are considered to be abundant sources of phytochemicals and micronutrients. Because of this, the nutritional quality of a community has been acknowledged as a significant indication of the growth of a country (Singh and Raghuvanshi, 2012). In light of the fact that the population is growing but wheat and rice yields have remained unchanged, millets have the potential to be an option that has great promise in terms of addressing the issue of food insecurity and malnutrition. In most cases, the necessary amino acids of a protein are the primary factors that determine its quality. In comparison to the 33.9% essential amino acids found in FAO reference protein (FAO, 1991), the amount of essential amino acids found in finger millet is 44.7% (Mbithi et al., 2000). This is a greater percentage than the one found in FAO reference protein. Millets are relatively high in methionine, according to the characterization of the proteins of millet grains (Monteiro et al., 1987; Sudharshana et al., 1987; Kumar and Parmeswaran, 1999). The prolamin fraction is the major storage protein of the grain, and lysine is the most limiting amino acid, followed by cystine. Meanwhile, cystine is the most abundant amino acid. These millets have a true digestibility that varies from 95.0 to 99.3 and a biological value that spans from 48.3 to 56.5, respectively, according to Geervani and Eggum (1989b). In comparison to other types of millets, pearl millet, also known as Bajra, has the greatest concentration of macronutrients and micronutrients, including iron, zinc, magnesium, phosphorus, folic acid, and riboflavin. Additionally, it is exceptionally abundant in resistant starch, soluble and insoluble dietary fibers (Antony et al. 1996; Ragaee et al. 2006). In addition to being a substance that may be consumed, the seed coat of finger millet includes a significant amount of dietary fiber, minerals, and phytochemicals. According to Krishnan et al. (2011), the seed coat matter (SCM) is a by-product of the millet milling, malting, and decortication industries. It has the potential to be exploited as composite flour in the manufacturing of biscuits. One of the most remarkable sources of calcium is finger millet, sometimes known as ragi. In addition, it has been observed that Kodo millet and small millet contain between 37 and 38 percent of dietary fiber, which is the greatest among cereals and despite the fact that they are low in fat.

Table 1: Nutrient composition of sorghum, millets and other cereals (per 100 g edible portion; 12 percent moisture)

Food	Protein[a] (g	Fat	Ash	Crude	Carbohydrate	Energy	Ca	Fe	Thiamin	Riboflavin	Niacin
		(g)	(g)	fibre (g)	(g)	(kcal)	(mg)	(mg)	(mg)	(mg)	(mg)
Rice (brown)	7.9	2.7	1.3	1.0	76.0	362	33	1.8	0.41	0.04	4.3
Wheat	11.6	2.0	1.6	2.0	71.0	348	30	3.5	0.41	0.10	5.1
Maize	9.2	4.6	1.2	2.8	73.0	358	26	2.7	0.38	0.20	3.6
Sorghum	10.4	3.1	1.6	2.0	70.7	329	25	5.4	0.38	0.15	4.3
Pearl millet	11.8	4.8	2.2	2.3	67.0	363	42	11.0	0.38	0.21	2.8
Finger millet	7.7	1.5	2.6	3.6	72.6	336	350	3.9	0.42	0.19	1.1
Foxtail millet	11.2	4.0	3.3	6.7	63.2	351	31	2.8	0.59	0.11	3.2
Common millet											
	12.5	3.5	3.1	5.2	63.8	364	8	2.9	0.41	0.28	4.5
Little millet Barnyard millet	9.7	5.2	5.4	7.6	60.9	329	17	9.3	0.30	0.09	3.2
	11.0	3.9	4.5	13.6	55.0	300	22	18.6	0.33	0.10	4.2
Kodo millet	9.8	3.6	3.3	5.2	66.6	353	35	1.7	0.15	0.09	2.0

on a dry weight basis, all quantities are stated, with the exception of protein; protein equals N multiplied by 6.25.

It is rich in PUFA (polyunsaturated fatty acids) (Malleshi and Hadimani 1993; Antony et al. 1996), according to the content of Hulse, Laing, and Pearson (1980), the United States National Research Council/National Academy of Sciences (1982), the United States Department of Agriculture/HNIS (1984), and the Food and Agriculture Organization (1995). In addition to this, it is abundant in important amino acids such as lysine, threonine, valine, and sulphur-containing amino acids, and the ratio of leucine to isoleucine is around two (Ravindran, 1992; Antony et al., 1996). According to Hegde and Chandra (2005), the plant with the greatest free radical (DPPH) quenching activity is kodo millet. Great millet (sorghum) and finger millet come in second and third, respectively. Sorghum has an extraordinarily high level of antioxidant activity, then millets come in second place. The high levels of vitamin B, folic acid, phosphorus, iron, and potassium that are found in millets are factors that contribute to their value. The calcium content of finger millet is sixteen times higher than that of maize. The amount of niacin that is found in pearl millet is greater than that of any other grain. Additionally, millets do not contain gluten, are simple to digest, are an excellent source of antioxidants, and, according to Dykes and Rooney (2006), may have qualities that prevent the development of cancer.

Pearl millet has a lipid content that is typically high, ranging from 3 to 6 percent, which is greater than that of sorghum and the majority of other popular grains. The unsaturated fatty acids that make up pearl millet account for around 75% of the total, with linoleic acid accounting for 46.3% of the total. Because of this, the amount of energy that millet contains is higher than that of sorghum and is almost identical to that of brown rice. In addition to having a substantial amount of iron, finger millet and teff millet are also excellent sources of calcium and magnesium for the diet. Table 1 presents the total average nutritional content of millet and other cereal grains according to their respective compositions.

Processing of Millets

Processing refers to the technology that is used in the process of transforming the grain into a form that can be consumed, hence improving the grain's quality. There is a considerable function that the processing of grains and millets plays in the usage of these things as food. Rice, flour, sprouting, roasting, popping, salted ready-to-eat grains, porridges, and fermented items are all ways that minor millets may be eaten. Other ways include sprouting, roasting, popping, and sprouting. The removal of the husk is the first step in the processing of millet grains since these grains have a hard seed coat before they are processed.

Decortication/ Dehulling

Historically, millets were decorated at the home level via the process of hand pounding. At the present time, they are processed using technology designed for milling rice, with some minor adjustments made to the process. For the purpose of dehulling and decorticating the little millets, a centrifugal sheller may be used. According to Hadimani and Malleshi (1993), the percentage of husk that was present in little millet and pearl millet ranged from 1.5 to 29.3 percent. The hull may be removed from pearl millet grain by soaking it for fifteen hours in 300 milliliters (w/v) of 0.2 N hydrochloric acid and then washing it twice with water. After that, the grains are scarified in a laboratory scarifier made by Osawa for one to three minutes, which typically removes 8.10–15.84% of the hull (Pawar and Parlikar, 1990). The levels of polyphenolic pigments and phytate phosphorus were decreased to within the range of 60.0-74.0% and 66.9-71.3%, respectively. According to Krishnan et al. (2012), decortication results in a reduction in the overall mineral contents, but it also results in an increase in the bio-accessibility of calcium, iron, and zinc by 15, 26, and 24 g/100 g, respectively. There is a large reduction in total phytic acid, polyphenols, dietary fiber, and the quantity of tannins, and there is a commensurate improvement in the digestibility of protein. The phenolic content and antioxidant potential of millet grains are both affected by dehulling, which is carried out in conjunction with hydrothermal treatment. Based on the findings of Chandrasekara et al. (2012), the antioxidant activity of phenolic extracts was shown to be in the following order: hull > whole grain > dehulled grain > cooked dehulled grain.

Milling

Because there is a lack of appropriate milling technology in India, the majority of the millets that are grown there are consumed as staple foods, while only a small percentage are utilized in ready-to-use and handy food items. Millet's tough fibrous seed coat, colored pigments, astringent flavor, and poor keeping quality of processed goods are the primary factors that prevent it from being effectively used on a wider scale (Desikachar, 1975). A number of these limitations may be solved by the use of pearling, debranning, and chemical treatments of millets, which also increase the nutritional content and customer acceptance of the product (Akingbala, 1991). In the process of milling, the milling efficiency and shelling index are the crucial characteristics that have a significant impact on the head yield and subsequent processing.

In 1995, Hadimani and colleagues milled thirty-eight different varieties of pearl millet in a McGill mill for thirty seconds while applying a pressure of 1.4 kg. The glumes were separated by aspiration. The percentage of broken grains and pearled grains that were harvested ranged from around 0.9 to 30.3% and 80.0% to 96.8%, respectively. According to research that were conducted on the head yield and bran of pearl millet grains and minor millets, the results showed that the head yield ranged from 63.2% to 90.0% and 5.0 to 11.0%, respectively. Even after the husk and the majority of the bran have been removed, millet still contains a significant quantity of dietary fiber, which ranges from 9 to 16 percent (Hadimani & Malleshi, 1993). During the milling process, there is a substantial and positive link between milling breakage and thousand kernel weight. This suggests that grains with a higher percentage of bolder grains and kinds with lower protein levels are more likely to break. According to Mandhyan et al. (1987), the milling efficiency of tiny millet, kodo, and kutki (Panicum miliaceus L.) is 83.38, 76.43, and 74.10%, respectively. It is also important to note that the head yields of these three varieties after polishing are 71.5, 56.25, and 54.57%, respectively. With a moisture level of 10%, Lohani and Pandey (2008) reported a milling percentage that was even lower in barnyard millet (70.77). They also discovered that the degree of polish improved with an increase in the amount of time spent milling, but this came at the expense of a linear decline in milling yield and an exponential fall in head yield. Consequently, there is a substantial disparity in milling % and head yields across the milled millet varieties. This disparity may be attributable to the fact that the hard seed coat of the millet is still intact, as well as the relative differences in grain size among the many millet varieties.

For a considerable amount of time, milling and polishing millet grains was attempted using other processing equipment or machines that were not especially built for millet grains. The effective effort in this regard was done by Singh (2010), who attempted to mechanize the milling process by inventing a dehuller for barnyard millet and optimizing the machine settings for the purpose of maximizing efficiency, reducing specific energy consumption, and minimizing broken grains. The actual dehulling efficiency, which was measured at 88.3±2.8%, specific energy consumption, which was measured at 0.078± kW h/kg grain, and broken grain, which was measured at 6.1±1.1%, were obtained by optimizing the machine parameters, which included 9 canvas strips and 3 mm over hanging width, as well as the operational parameters, which were 8.6 m/s peripheral speed, 5 passes, and 8.4% db moisture content. In a single pass of dehulling, the actual dehulling efficiency, specific energy consumption, and broken grains were 76.3±3.6%, 0.018±0.004 kWhkg–1, and 7.3±1.5%, respectively. This was achieved by using steamed mustered oil (31 g/100 kg) for nine minutes as a pretreatment.

Composite Flour

In spite of the fact that millets are superior than cereals in terms of their nutritional value, their consumption is not widespread. According to Singh et al. (2005), one method that might be used to prolong their usage may include combining them with wheat flour once the appropriate processing has been completed. This would result in modifications to the physicochemical, nutritional, and functional properties of the mixture with the incorporation of millet flour. A wide variety of convenience items, including extruded products, are eaten by a significant number of people in industrialized nations. Among the goods that are extruded are pasta, macaroni, spaghetti, vermicelli and noodles, and other similar items. The items are manufactured using refined durum wheat flours or semolina as the primary component of their composition. The manufacture of composite millet flours has been tried by a large number of researchers. These flours are intended to be used in place of ordinary cereal flours in the manufacturing of pasta, ready-to-use (RTE) food items, and traditional dishes.

When wheat and finger millet are mixed together in a proportion of seven to three, a multi-grain flour is produced. This flour is one of the basic semi-finished products that may be used to make chapatti (roti). In their study from 2003, Kamaraddi and Shanthakumar introduced tiny millet flours into commercial wheat flour and investigated the impact that including refined millet flours had on the chemical, rheological, and baking aspects of the flour. It was discovered that millet flours may be substituted for wheat flour at a level ranging from 10 to 20 percent. Twenty percent and fifteen percent, respectively, of barnyard millet and proso millet may be added. It was determined that a 10% addition of finger millet, foxtail millet, and tiny millet was the optimal degree of supplementation. The increase in the amount of millets in blends led to an increase in the ash content, a drop in the gluten and sedimentation value, a loaf volume of dough, and a percentage of damaged starch and protein. On the other hand, the crust color and form of the bread remained same, but the color of the crumb changed from a creamish white to a dull brown.

The researchers Singh et al. (2005) created composite flours of foxtail, barnyard, and finger millet with wheat flour by adding 10-30% millet flour. They found that the addition of milled millet flour to wheat flour enhanced the concentration of protein, fat, and ash, but reduced the concentration of carbs. The addition of milled barnyard millet flour resulted in a substantial rise ($p<0.01$) in the levels of protein, crude fat, and total ash contents. On the other hand, the addition of whole barnyard flour resulted in a significant drop ($p<0.01$) in overall protein levels. The protein content of the mixture fell from 11.59 to 10.99% as the amount of finger millet flour in the mixture grew. On the other hand, the fat and ash contents rose from 1.06 to 1.37 and 0.55 to 1.37% respectively, while the carbohydrate content did not change significantly.

Using response surface approach, Singh et al. (2012a) developed two millet–wheat composite flours, CF1 and CF2, based on the rheological and textural qualities of dough. These flours were created. The optimal composition of composite flour CF1 consisted of 61.8% barnyard millet flour, 31.4% wheat flour, and 6.8% gluten. On the other hand, the composition of composite flour CF2 was 9.1% barnyard millet flour, 10.1% finger millet flour, 10.2% proso millet flour, and 70.6% wheat flour among its constituents. At the 5% level of significance, the specific loaf volume of CF1 bread (3.3 cm3/g) was comparable to that of the control (wheat bread; 3.5 cm3/g), and it was substantially larger than that of CF2 (2.9 cm3/g). The sensory quality of pearl millet flour was dramatically enhanced ($P \leq 0.05$) by irradiating it with gamma rays and then frying it thereafter. This improvement occurred throughout the processing and storage stages of the flour. Tannin and phytate concentrations were not affected by the radiation process on its own; however, when the radiation process was followed by cooking, it resulted in a substantial reduction ($P < 0.05$) in the amount of anti-nutrients present in both the whole wheat and the dehulled flour (ElShazali et al., 2011).

Puffed/Popped and Flaked Millets

Cereals that have been puffed or popped are a traditional method of cooking grains that may be consumed as a snack or morning cereal, either in their natural state or with the addition of various spices, salt, and sweeteners. As the primary source of carbohydrates in human diet, starch has a wide variety of technical features that are very desirable. According to Lehmann and Robin (2007), the nutritional value of starch is highly dependent on the structure of starch as well as the degree to which it is processed. The puffing or popping process causes structural changes in the starch or starch-protein matrix of the millet grain or preconditioned pasta. These changes cause the grain or pasta pieces to expand, which results in the production of a puffed product that has a high degree of crispness and other textural characteristics. In order to create expanded grains or flakes, the high temperature short time (HTST) treatment takes use of the thermo-physical features of starch. The Millard reaction takes place during this process. This reaction involves the sugars that are present in the aleurone layer reacting with the amino acids that are found in the millet. This reaction results in the puffed product having a scent that is both pleasant and highly sought. Additionally, it decreases the levels of anti-nutrients such as phytates and tannins, increases the bioavailability of minerals, imparts a nice texture to the food, and improves the digestion of carbohydrates and proteins (Nirmala et al., 2000). The volume and ratio of popping are influenced by engineering variables such as moisture, porosity, bulk density, kernel size, and the quantity of ingredients such as salt or sugar that are utilized in the process. Through the use of HTST, Ushakumari et al. (2007) accomplished the preparation of expanded finger millet as a ready-to-eat new generation product. The most important criteria for achieving maximal expansion ratio are the process of flattening the grains to the required form factor and the amount of moisture present. The ideal parameters for expansion are a moisture content of around forty percent, a form factor of fifty-two to fifty-eight, and a drying period of one hundred thirty to one hundred fifty minutes. The millet that had been enlarged had an expansion ratio of at least 4.6, a hardness of at least 5.0 N, and an overall acceptability of at least 7.2. According to Ushakumari et al. (2004), the cereal processing technologies may be effectively used to foxtail millet in order to produce ready-to-use (RTE) goods. These products can be in the form of flaked, extruded, roller dried, decorticated, and popped grains. This is accomplished by submitting native grains (12% mc) to high-temperature starch treatment (HTST) at 230+/- 5 degrees Celsius. Roller-dried millet had the greatest degree of starch gelatinization, followed by popped, flaked, and extruded products. The highest degree of gelatinization was found in roller-dried millet. According to Fujita et al. (1996), the microstructure of puffed starch granules takes on a spherical shape, whereas the structure of a product that has been popped and extruded is similar to that of a honeycomb. Extrusion through a hand extruder, flaking to a thickness of 0.6 mm, and roasting at 90-110 degrees Celsius for 5–15 minutes are all methods that can be utilized to prepare expanded flakes (Viswanathan et al., 2009). Each of these methods involves cooking finger millet and foxtail millet flour at temperatures ranging from 80 to 100 degrees Celsius with varying amounts of water (100 to 130 milliliters) and time (1-3 minutes) to form dough. Puffed grains of several species of finger millet were created by Wadikar et al. (2007). The grains were conditioned for two hours with a moisture content of twenty percent, and then they were puffed using hot sand at a temperature of two hundred twenty to two hundred thirty degrees Celsius. The researchers found that the changes in fatty acid composition were not substantial. However, while puffing, neutral lipids fell by 9.3%, while glycolipids increased by 21.92% and phospholipids increased by 33.3% between puffing and non-puffing. When pearl millet was conditioned and then popped using hot sand at a temperature of 250 degrees Celsius, the result was a yield and expansion ratio of popped grains that ranged from 8.3 to 77.1% and 2.3 to 11.3%, respectively (Hadimani et al., 1995). The popping process greatly enhances the bio-accessibility of zinc in native millet by 18 grams per one hundred grams (Krisnan et al., 2012). On the other hand, the puffing process decreases phytic acid by 21–50 percent and tannins by 3–18 percent (Wadikar et al., 2006).

According to Shukla et al. (1986b), the varietal influence of finger millet on puffing quality revealed that brown seeded types are more suited for puffing, although white seeded variants produced puff of an organoleptically superior quality. The cultivar with brown seeds known as "PR 202" had the highest puffing output, followed by the variety known as "JNR 852," which had a medium expansion. According to the findings of Premavalli et al. (2005), who investigated the impact of hydration and pan roasting pretreatments on the puffing properties of the ragi (finger millet) variety MR1, they discovered that water and buttermilk hydration had an effect on puffing yield and bulk density, but water conditioning was more cost-effective.

For the purpose of preparing a ready-to-eat (RTE) snack meal based on barnyard millet (Echinochloa frumentacea), Jaybhyae and Srivastav (2010a; 2010b) formed thin rectangular-shaped samples, steam cooked cold extrudate (cut pieces of dough), and then puffed them using the HTST puffing method. Through the use of a dolly pasta machine, it was discovered that the most important criteria for shaping and cutting the dough into the required shape were the appropriate quantity of ingredients and the amount of wetness present. In order to produce puffed product with an expansion ratio of 2.05 and a moisture content of 0.09 kg/kg dry matter, the samples that were prepared from barnyard millet, potato mash, and tapioca powder dough in the proportion of 60:37:3 were steam cooked and puffed in hot air at the optimal temperature (238 degrees Celsius) and time (39.35 seconds). Following the puffing process, the product was toasted in the oven at the optimal temperature and time combination of 116.26 degrees Celsius and 20.23 minutes, respectively. This resulted in the production of toasted snack food with a moisture content of 0.0464 kilograms per kilogram, a color of 69.79, a crispness of 18.45 plusve peaks, and a hardness of 362.64 grams. During the process, popped or puffed grains and goods are dried to an exceptionally low level of moisture content (3-5%), which serves to increase the shelf life of the product. These days, technologically advanced air puffing machines have been invented, and they are capable of being used for the bulk manufacturing of millet grains that have been popped or puffed (Verma and Patel, 2013).

Pasta, Noodles and Other Products

The flours of cereals or legumes are used as the primary ingredient in the production of pasta or papad, while the dried products are utilized as the ready-to-eat component. Noodles are a kind of pasta product that is also known as a convenience meal. They are made using a cold extrusion technology, and after drying, they become brittle and rigid. These noodles may be prepared in a very short amount of time and are also quite convenient to prepare. A variety of various combinations of noodles are manufactured, including noodles that are made solely of finger millet, noodles that are composed of finger millet and wheat in a ratio of 1:1, and noodles that are made of finger millet mixed with wheat and soy flour in a ratio of 5:4:1. Pasta may be made using finger millet, refined wheat, and soy flour/whey protein concentrate composite flour formed (50, 40, and 10%) (Devaraju et al., 2006). Proso millet and wheat flour blend with an impressive shelf life (Sudhadevi et al., 2013) is another option for making pasta. The dolly pasta machine was used to remove the pasta.

meal products that have a longer shelf life and are of good commercial relevance include noodles, which are among the most popular meal items among people of all ages. According to Veena (2003), barnyard millet has a comparatively low carbohydrate content of 58.56% and a delayed digestion of 25.88%. Using barnyard millet flour, value-added low-glycemic index noodles were prepared by combining sago flour, pulse flour, and bengal gram leaf powder at varying quantities to create plain, pulse, and vegetable noodles, respectively (Surekha et al., 2013). This was done in order to take use of the health benefits that millet offers. According to the data, there was a discernible progression in the nutritious content of both vegetable noodles and pulse noodles. If we compare the glycaemic index of plain noodles (42.07) to that of pulse noodles (35.65), we find that vegetable noodles (38.02) have a much lower glycaemic index. From kanagini or foxtail millet (Setaria italica), Punia et al. (2003) prepared ladoo (sweet balls) and shankarpara (from dough and formed into flakes) by substituting maida with fifty percent kangini flour. They found that kangini ladoo had a protein content of 13.13 percent, ash content of 4.92 percent, and iron and zinc content of 13.83 and 2.35 mg/100 grammes, respectively. Additionally, it was discovered that both of the items that were created were satisfactory, and that the product's look, texture, and flavor were all in the category of being "liked very considerably." Through the use of ordinary salt as a heating medium, Srivastava et al. (2003) were able to make popped grains from barnyard, foxtail, and small millet. This was accomplished by heating the sample and salt in an open iron pan at temperatures ranging from 240 to 260 degrees Celsius for 15 to 25 seconds. Ladoos, which are sweet balls with a diameter of five centimeters, were manufactured in two different ways: the first kind was made with individual popped millet grains and jaggery, while the second type was made with millets, roasted groundnut, and coconut powder. According to the hedonic scales with nine points, the sensory scores for first type ladoo were 5.0-6.9, while the scores for second type ladoo were 7.2-8.1. In comparison to products made from barnyard millet, those made from foxtail millet contained levels of protein and calcium that were much greater. When compared to the first kind of ladoo, which had just millets and jaggery (which is derived from sugarcane juice), the incorporation of groundnut and coconut into the formulation resulted in a twofold increase in the amount of protein (7.27-8.39 g/100 g), calories, calcium, and iron. Fortified minor millets were created by Geervani and Eggum (1989a) by adding lysine as a supplement in order to compensate for the lack of amino acid that occurred as a result of heat treatment. Both the biological value (BV) and the net protein utilization (NPU) of the Italian, French, Barnyard, Kodo, and Little Millet grains increased after they were autoclaved and then supplemented with lysine at a concentration of 0.6 g/100 g dry matter. The good effect of supplementation was established by Eggum et al. (1985), who showed an average increase of 0.016 in true digestibility (TD), 0.154 in BV, and >144 in NPU values with the administration of methionine to diets based on casein, skim milk powder, beef, and brown beans. These findings were based on the researchers' findings that supplementation had a positive impact on the digestive system. Ifon (1980) conducted a bioassay on rats and found that millet porridge that had been fortified with soy proteins had a considerable improvement in its nutritional content. This improvement was reflected in the significant improvements in PER (protein efficiency ratio), NPR, NPU, and BV. Jowar crunch is a snack meal that has a light crunchy texture and is created by deep-fat frying of dried kernels (pellets) of alkaline-cooked whole sorghum. This snack food was invented by Suhendro et al. (1998). The procedure that was optimized for sorghum consisted of autoclaving it for sixty minutes at a temperature of 120 degrees Celsius, washing it, drying it to a moisture content of nine percent (at room temperature and then fifty degrees Celsius), and then deep fat frying it at a temperature of two hundred twenty degrees Celsius.

Baked Products

Bakery goods are very well-liked all over the globe, and their production has increased by a significant amount as a result of their cheap cost, diverse flavor profiles, and textural profiles, as well as their beautiful packaging and extended shelf-life, which makes them suitable for simple marketing (Patel and Rao, 1996). Not only will the usage of millets in bakery goods be better in terms of the amount of fiber and micronutrients that they contain, but it will also offer a good potential for millets to join the world of bakery for a series of products that have value added (Verma and Patel, 2013). In most cases, they are created from wheat flour; however, there are attempts being made to substitute a small percentage of it with millets in order to give an alternative, minimize excessive dependency on wheat, and produce gluten-free bread. The flour made from finger millet and foxtail millet may be used in a variety of bakery products, including biscuits, nan-khatai, chocolate, cheese, cakes, muffins, and other baked goods. It has been shown via research that it is feasible to replace forty percent of the wheat flour in baked goods such as cakes and biscuits with finger millet flour (Begum et al., 2003; Yenagi et al., 2013). The chocolate cup cake, gel cake, masala cake, carrot cake, soup sticks, rusk, and muffins that were made using finger millet all received high marks for their look, texture, flavor, and general acceptance. According to Desai et al. (2010), there have been efforts made to enhance the nutritional quality of cakes by including malted finger millet flour as a supplement. This has been done with the intention of enhancing the minerals and fiber content of cakes.

Pearl millet flour (40–80 percent), refined wheat flour (10–50 percent), and green gram flour (10 percent) were used in the preparation of sweet, salty, and cheese biscuits by Sehgal and Kawatra (2007). They discovered that the biscuits were extremely satisfactory with no significant differences to be identified. According to Selvaraj et al. (2002), biscuits made from a combination of maida and finger millet flour (80:20) may have a self-life time of 120 days when packed in double packs of polypropylene/pearlized BOPP and metalized polyester/polylaminate packs. This is when the relative humidity is 65% and the temperature is 27 degrees Celsius.. According to Sehgal and Kwatra (2007), biscuits made from refined wheat flour, blanched pearl millet, and green gram in the proportions of 50:40:10 (Type I) and 30:60:10

(Type II) are more nutritious than biscuits made with refined wheat flour alone. However, Type II biscuits have a higher content of anti-nutrients, specifically polyphenol and phytic acid. Saha et al. (2010) made cookies using flour composites that included 60:40 and 70:30 (w/w) finger millet: wheat flour. They discovered that the combination of 60:40 and 70:30 resulted in a harder biscuit dough than the 70:30 level. In spite of the fact that the expansion of biscuits and breaking strength after baking was greater in the 70:30 composite than in the 60:40 composite, the adhesiveness and resistance of biscuit dough rose as the levels of wheat flour increased throughout the baking process. The water absorption capacity of wheat composite flour (40 g/100 g) was much greater than that of the composite flour (30 g/100 g).

Using composite flour with comparable crisp texture, breaking strength (1480–1690 g), and higher protein, dietary fiber, and calcium contents compared to control biscuits (1560 g), Krishnan et al. (2011) attempted to investigate the possibility of using seed coat matter (SCM) of finger millet in the preparation of biscuits making use of the composite flour. A sensory examination of the biscuits revealed that 10% of the SCM may be derived from native and hydrothermally processed millet, while 20% of the SCM could be derived from malted millet. This would allow for the creation of composite biscuit flour.

According to Taylor et al. (2006), the production of wheat-free sorghum or millet bread in the form of bread continues to be a difficulty. The manufacture of cookies made entirely from sorghum or pearl millet was also attempted by a study of researchers. The cookies in question were capable of being manufactured, but they were rough, hard, gritty, and mealy in both texture and flavor. These items also did not have any cracks on the top surface or spread, all of which are considered to be favorable characteristics. There is a possibility that the composition of the lipids is partially responsible for this subpar grade.

Extruded Products

The majority of the world's population is affected by both qualitative and quantitative deficiencies in the amount of calories and protein that they consume via their diet. Malnutrition is the outcome of all of these situations, which are characterized by decreased physiological maintenance and development. In this particular setting, the method of extrusion is advantageous. Extrusion cooking is a kind of high-temperature, high-strain cooking (HTST) cooking procedure that may be used for the processing of both proteinaceous and starchy materials. The use of extrusion cooking provides a number of unique benefits, including adaptability, high productivity, good product quality, a rise in in-vitro protein digestibility (Dahlin and Lorenz, 1992), and the development of new food without the use of effluents. An extrusion The input of heat, either directly by steam injection or indirectly through jacket, or more indirectly through the waste of mechanical energy through shearing that occurs inside the mixture, is what is required to achieve the process of cooking.

Lactic and citric acids were used by Onyango et al. (2005) as substitutes for backslop fermentation in the production of extruded uji, which is a thin porridge made of maize and finger millet that originates from eastern Africa. Before the blends were extruded, the acidity of the mixtures was either reduced by fermentation or gradually decreased with the addition of 0.1, 0.5, and 1.0 mol/l of citric or lactic acid. Extrusion is a process that dissolves starch without causing the development of maltodextrins. There was an increase in the in vitro starch digestibility from 20 mg maltose/g in the raw mix to around 200 mg/g following the extrusion process. The in-vitro protein digestibility and the nitrogen solubility index were both raised by twenty percent as a result of the fermentation of lactic acid and citric acid treated blends prior to extrusion. Extrusion had no effect on the phytate level, which stayed same at 248-286 mg/100 g. The tannin concentration reduced from 1677 mg/100 g in the raw mix to between 551 and 1093 mg/100 g in the extrudates. At the same time, the phytate content remained the same. The method of extrusion enhances the amount of iron that is available in weaning meals that are extruded and are based on pearl millet, cowpea, peanuts, or any milk.

Powder by a factor that is between three and six and a half times more than the similar roasted weaning meals (Cisse et al., 1998).

The twin-screw extruder is used to prepare millet-based extruded snack foods with the desired quality. These snack foods can be made from a kodo millet-chickpea flour blend (70:30) (Geetha et al., 2012); pearl millet, finger millet, and soybean flour blend (Balasubramanian et al., 2012); or ragi, sorghum, soy, and rice flour blend (42.03, 14.95, 12.97, and 30%) (Seth and Rajamanickam, 2012). For pearl millet (81.68%), finger millet (7.02%), and decorticated soy bean (11.29%) composite flour, the expansion index (2.31) and sectional expansion index (5.39) were found to be at their highest values when the feed rate and screw speed combination was 9.5 kg/h and 250 rpm. The temperature of the barrel has a substantial impact on all of the product characteristics, including the expansion ratio, bulk density, hardness, and crispiness. At a higher screw speed of 280 revolutions per minute (rpm), a lower feeder speed of 20 rpm, and a medium to high temperature of 123 degrees Celsius, the Kodo-chickpea flour mix produces extrudates that are crisp and attractive. According to Singh et al. (2008), an appropriate amount of moisture content for millet-pulse or millet-soy feed has been determined to be around 15% when the mix ratio is between 10 and 15%. The researchers Dhumal et al. (2014) produced ready-to-eat fasting meals that were based on barnyard millet and were prepared using microwave cold extrusion. These foods had equivalent sensory quality.

A protein-rich composite Sorghum-Cowpea porridge was created by Pelembe et al. (2002) by the process of extrusion cooking at a temperature of 1300 degrees Celsius and a water content of 200 grams per kilogram. In terms of functional qualities, this porridge was comparable to commercial quick maize–soy porridge. There was a reduction in expansion ratio (ER) and an increase in protein content as a consequence of an increase in cowpea. The water absorption index (WAI) also increased. The researchers Sumathi et al. (2007) produced a healthy extruded ready-to-eat meal by combining pearl millet with grain legumes (30%) and also with defatted soy (15%) separately. Both the millet-based meals and the millet-soy mix included a protein content of 14.5% and 16%, respectively, with protein efficiency ratio values of 2.0 and 2.1. Devi and Narayanasamy (2013) investigated the possibility of preparing composite millets milk powder by combining finger millet and pearl millet. Their goal was to create a ready-to-use (RTC) extruded product from a composite of millet powder and maida (50:50) that was within the acceptable range in terms of nutrient content, color, texture, and cooking quality as well as sensory characteristics.

Fermented Products

Fermented foods like Dosa and Idli are popular and common breakfast foods and even as the evening meals in many parts of India. Millets are good source of protein but the protein quality in terms of lysine and tryptophan content is low, hence there is growing emphasis on the improvement of protein quality.

Fermentation not only improves the taste but at the same time enriches the food value in terms of protein, calcium and fibre, B vitamins, in vitro protein digestibility and decreases the levels of anti-nutrients in food grain (Chavan and Kadam, 1989; Maha et al., 2003; Verma and Patel, 2013). Fermentation of the ground germinated pearl millet grains gives higher protein digestibility (>90%). Khetarpaul (2003) fermented the pearl millet by inoculating the micro flora namely, S. diastaticus, S. cerevisiae, L. brevis and

L. fermentation and incubated at 30^{o} C for 72 h in single culture, mixed culture and sequential culture fermentation. The samples were oven dried and ground to fine flour and found that controlled pure culture fermentation did not change the protein and ash content of pearl millet (sprouted and flour) and increased the starch digestibility of flour significantly. High dietary calcium and phytic acid reduces bio-availability of zinc by Zn-Ca-phytate or Zn-phytate complex. Fermentation is one of the most economic and effective measure for reducing polyphenols and phytic acid significantly and improves HCL-extractability of zinc (Sripriya et al., 1996b; Murali and Kapoor, 2003), iron, copper, calcium and manganese but maximum reduction is brought out by sequential fermentation. Dry heating and acid treatment of pearl millet also increases the mineral availability significantly (Arora et al., 2003). Germination and probiotic fermentation causessignificant improvement in the contents of thiamine, niacin, total lysine, protein fractions, sugars, soluble dietary fibre and in vitro availability of Ca, Fe and Znof food blends (Arora et al., 20011).

Fermentation of finger millet flour using endogenous grain microflora showed a significant reduction in phytates by 20%, tannins by 52% and trypsin inhibitor activity by 32% at the end of 24 h resulting in increase in percent mineral availability of calcium (20%), phosphorous (26%), iron (27%) and zinc (26%) (Antony and Chandra, 1998). The various recipes were prepared including cutlets, weaning mixtures, vermicelli and biscuits from naturally and mixed fermented pearl millet flour and were highly acceptable. The findings indicated that pure culture fermented products can be safely included in the diet of the people for improving starch digestibility, increase bioavailability of minerals and proteins. The availability of zinc during pure culture fermentation was found to be more effective than natural fermentation. A highly significant ($p \leq 0.05$) improvement in the in vitro protein digestibility of pearl millet genotypes can be achieved if fermented for 14 h (Maha et al., 2003). Onyango et al. (2004) prepared high energydensity fermented uji from different combinations of maize, finger millet, sorghum and cassava using alpha-amylase and extrusion. It was observed that fermentation alone was not able to reduce viscosity of uji but addition of 0.1-2.1 ml/100 ml alpha-amylase to the fermented slurry or extrusion of the fermented and dried flour at 150-180° C and a screw speed of 200 rpm reduced viscosity of uji from 6000-7000 to 1000-2000 cp with acceptable energy densities (0.6-0.8 kcal/g) for child feeding.

Malting and Weaning Foods

Traditionally, the millet malt is utilized for infant feeding purpose. Finger millet possesses good malting characteristics and its malting is popular in Karnataka and part of Tamil Nadu. Malting helps to increase significantly the nutrient composition, fibre, crude fat, vitamins B, C and their availability, minerals (Sangita and Srivastav, 2000), improve the bioavailability of nutrients, sensory attributes of the grains. Millet malt is used as a cereal base for low dietary bulk and calorie dense weaning foods, supplementary foods, health foods and also amylase rich foods. Malting reduce paste viscosity of flour than many other heat treatments (Malleshi and Desikachar, 1981). The millets, like sorghum, have high-starch gelatinization temperatures, pearl millet (Pennisetum glaucum(L.) 61-68 °C and finger millet (ragi) 65-69 °C (Serna-Salsivar and Rooney, 1995). Hence, they are subjected to same constraints in terms of conservation of enzyme activity during brewing. Brewing process for millets has not been extensively investigated. Like sorghum, arabinoxylans seem to be the major cell wall component of pearl millet and finger millet (Subba Rao and Muralikrisna, 2004). As with sorghum, the arabinoxylans of pearl millet are also substituted with uronic acids. However, uronic acid was not reported in analysis of finger millet non-starch polysaccharides (Subba Rao and Muralikrisna, 2001). The optimum malting conditions for pearl millet seem to be essentially same for sorghum. In malting germination is an important unit operation which needs greater attention. The germination temperature normally suggested is greater than 22 °C. Pelembe et al. (2002) found 25-30° C to be optimal with a germination period of 3-5 days. Malting finger millet reduces tannin (brown millet) and phytic acid content, and improves ionisable iron and soluble zinc significantly but malting, steaming and roasting of little millet increase the nutraceutical and antioxidant properties in terms of total phenolic, flavonoid and tannin contents (Pradeep and Guha, 2011). The amylase activity of malt flour from brown finger millet seed was higher than white seed varieties (Shukla et al., 1986a). Malting of pearl millet and finger millet reduces protein content, but improves protein efficiency ratio (PER), bioavailability of all minerals and has pronounced effect in lowering anti-nutrients (Desai et al. 2010; Krishnan et al., 2012). Asma et al. (2006) prepared weaning blends composed of 42% sorghum supplemented with 20% legumes, 10% oil seeds, and 28% additives (sugar, oil, skim milk powder, and vanillin) as per FAO/WHO/UNU recommendations and processed in a twin-roller drum dryer. The blends were found to contain good proportion of protein 16.6% to 19.3%, fair fiber content of 0.9% to 1.3%, satisfactory energy level 405.8 to 413.2 kcal per 100 g and a healthy iron content of 5.3 to 9.1 mg/100 g. The calcium content ranged from 150 to 220 mg/100 g and lysine content improved considerably ($p <$ or $= 0.05$) for all blends. The paste of this blend was comparable to commercial weaning foods in terms of water-holding capacity, wettability and bulk density.

Malleshi and Klopfenstein (1998) tried to use seed germination as a tool to improve the nutrient potential of millets. The malted flour was prepared from germinated, dried and milled fractions of sorghum, pearl millet and finger millet. Moist- conditioning the malt and milling the same in roller mill are reported to be promising in preparation of low fibre malt flour. The amino acid profile of low fiber malt flour from sorghum as well as millets was comparable to barley malt flour. Thus the essential amino acid pattern of finger millet malt flour is superior and bran fraction is a rich source of proteins and minerals and may be useful in high fibre health foods and feed formulations. The yields of refined malt flour from sorghum, pearl and finger millet were 86, 85 and 78% respectively and their protein and crude fiber contents were 10.4, 15.5, 4.5% and 1.2, 1.0, 1.8% respectively. The lysine content of finger millet (3.4%) malt flour protein was higher than pearl millet (2.16%) and sorghum (1.45%) malt flour protein. Nirmala et al. (2000) found that Indaf-15 variety of finger millet develops high levels of amylases during germination, and its malt form is a rich source of reducing sugar which increased from 1.44 to 8.36% at 96 h of germination period. Adewale et al. (2006) extracted starch-digesting enzymes from malted maize, finger millet and sorghum and found that the α-amylases extracted were heat sensitive but the sorghum amylases were slightly more resistant proving more suitable for commercial malt production. In case of malted weaning food (MWF) prepared by mixing refined malted ragi with malted green gram flour in the ratio of 70:30, there was significant increase in amylase activity and decrease in paste viscosity with progressive germination (Malleshi and Desikachar, 1981). Hot paste viscosity of MWF was much lower than that of several proprietary brands of weaning foods. There was lower cooked (hot) paste viscosity and high cold paste viscosity of the extruded precooked RTE weaning food from sorghum, pearl millet, finger millet flour (60%) blended with roasted mung bean flour (30%) and nonfat dry milk (10%) (Malleshi et al., 1996). The soluble dietary fiber content of foods was 10% higher than that of the corresponding blends with increase inthe in-vitro protein digestibility but no marked difference in carbohydrate digestibility. The NPR, PER and BV were higher for the finger millet flour than for pearl millet food. Similar effort was made by Thathola and Srivastava (2002) to prepare weaning food based on malted flours of foxtail (30%), Barnyard (30%), roasted soybean (25%) and skim milk powder (15%). There was no significant difference in sensory quality of un-weaned mix and marketed weaning mix and well acceptable.

Health and Functional Foods

Small millets are important coarse grains and rich in nutrients. The term functional foods has been commonly used for foods that promote health through prevention of specific degenerative diseases like diabetes, cancer, Parkinson's disease, cataract etc. due to the effect of health-promoting and bioactive phytochemicals in plant foods. The term nutraceuticals (like pharmaceuticals) is used for such bioactive compounds like vitamins, minerals, essential fatty acids having protective effect against degenerative diseases,in isolated form. Epidemiological studies reflect that persons on millet based diet suffer less from degenerative diseases such as heart diseases, diabetics, hypertension, etc. Millets have received attention for their potential role as functional foods due to health- promotive phytochemicals. Millets are safe for people suffering from gluten allergy and celiac disease. They are non-acid forming and non-allergenic hence easy to digest (Saleh et al., 2013).

Finger millet, foxtail millet, pearl millet and sorghum are the potential sources of antioxidant compounds which can quench the free radicals (Sripriya et al., 1996a). The total phenolics and tannin content of pigmented type of finger millet; moderate reducing ability and high free radical scavenging activity of pearl millet serve as a source of antioxidants in our diets (Muthulisi et al., 2007; Odusola et al., 2013). The presence of flavonoids, like tricin, acacetin,3, 4 Di-OMe luteolin, and 4-OMe tricin in traditional recipes, indicate the chemo-preventive efficacy of pearl millet (Nambiar et al., 2012). They may be inversely related to mortality from coronary heart disease and to the incidence of heart attacks in the pearl millet consuming belts of the world similar to lower incidence of diabetes reported in millet consuming populations (Saleh et al., 2013). The diabetes preventing effect of millets is primarily attributed to high fibre content.

Some antioxidant phenols in millets also tend to have anti-diabetic effect. Among minor millets, fox tail and barnyard millet have low glycaemic index (40-50). University of Agriculture Sciences, Dharwad (and others) have prepared ready to eat foods from these minor millets and demonstrated their anti-diabetic effects. Biscuits prepared by substituting 50% of refined wheat flour with barnyard millet flour had lower glycemic index, GI (50.17) compared to the GI of wheat biscuits (73.58) without much difference in the nutrient composition (Srivastava and Singh, 2003). The burfi was prepared by substituting Bengal gram flour with foxtail millet flour upto 57% and a control. It was found that both types of burfi had similar sensory score (8.2) but millet burfi had less GI (51) than control (68). It was also observed that there was significant reduction in serum glucose and serum cholesterol due to foxtail millet biscuits and burfi. Shobana et al. (2007) prepared diabetic food formulations based on finger millet, popped and expanded rice each blended separately with legumes, non-fat dry milk, oil, spices and a few hypoglycemic ingredients and found that millet based food (93.4+/-7) produces less glycemic index (GI) values than rice based formulation (109+/- 8). Finger millet vermicelli prepared from mixed blend of finger millet flour (45%) with wheat flour (40-45%), defatted soy flour (10%) and hypoglycemic ingredient amruth balli (5%) recorded lowest cooking loss and ashwagandha showed higher sensory score for different storage periods (Mamatha et al., 2003). Millets being high in fibre and antioxidant have beneficial effect on serum lipid profile besides blood sugar.

Thakkar and Kapoor (2007) found roti, upma and idli (Indian breakfast recipes) prepared from gum acacia and finger millet showed lowest glycemic index (41–48%). Similarly Arora et al. (2003) found that finger and barnyard millet preparations with legumes and fenugreek seeds (Sharma and Raghuram, 1990) reduce the GI with non-significant difference between them. The hypoglycemic effect of millet based diets has been observed by Gopalan (1981) and Kamath and Belavady (1980). The native starch (NS) extracted from rice and minor millets when subjected to five autoclaving and cooling (4 °C) cycles contain higher resistant starch (RS) than NS. Rats fed with NS and RS from barnyard millet had the lowest blood glucose, serum cholesterol and triglycerides than rice and other minor millets (Kumari and Thayumanavan, 1997). However, new slowly digestible carbohydrates (SDC) such as Isomaltulose/Palatinose, which claim a slow and sustained blood glucose level after intake, have been commercialized. But no such commercial product made of entirely millet is reported.

Traditional Foods and Beverages

In millet-growing regions of South India, it has become customary to use finger millet as one of the fundamental components, to the tune of 15-20% (w/w), along with other vital ingredients like black or green gram, rice, and spices (Verma and Patel, 2013). In certain regions of Karnataka, finger millet may be added to papad up to 60% of the time (Begum, 2007). When preparing millet papad (rolled, circular, thin sheets), Vidyavati et al. (2004) substituted finger millet flour for 50% of the combination of black gram dhal flour and sago flour, and then compared the results with black gram (Phaseolus mungo) dhal papad. Compared to black gram dhal papad (82 mg% in roasted and 99.6 mg% in fried), finger millet flour papad had a higher sensory score of 4.7 on a five-point hedonic scale and were richer in calcium (102% in roasted and 109 mg% in fried). The addition of millet and pulse proteins resulted in an improvement in protein quality despite a little decrease in the content of nutrients. Acceptability of finger millet by consumers Finger millet may be a wonderful replacement for conventional papad since the papad tasted great even after being stored for a long time. Naikare et al. (2003b) attempted a similar attempt to produce papad using finger millet flour, malted sorghum flour, and composite flours in varying ratios of 80:20, 60:40, and 40:60. On a five-point hedonic scale, the finger millet papad received the highest rating (4.6), besting other dishes with its crisp, appealing flavor and outstanding presentation.

You may improve the protein content of sorghum and small millets by adding grains or pulses. By adding chickpeas and peanuts to Kisra, a traditional meal of Sudan, Badi et al. (1990) attempted to enhance its quality. For babies older than a year old, this kind of kisra may be used as a well-balanced baby meal made with sorghum and millet. The commercial manufacture of infant food based on sorghum or millet is a good fit for this formulation and processing method. Babies' brown bread shouldn't include more than ten percent wheat or sorghum bran since this will negatively impact the bread's digestion.

The main ingredient in millet and sorghum flours is starch. As Tester et al. (2004) point out, the structure of a starch granule is really rather intricate and is based on variations in the constituents' content and arrangement. According to Balasubramanian (2014), hydrothermal treatments (soaking up to moisture $30 \pm 2\%$, steaming 1.05 kg cm-2, 20 min) considerably inactivate lipase activity and decrease anti-nutritional factors ($p \leq 0.05$). Ndiaye (2008) made an effort to shorten the time that rolled flour products needed to cook. Arraw using distinct sorghum and germinated millet flours for 37 minutes without any treatment and 9 minutes. Grain germination takes three to four days. After that, malt is manufactured, dried at 50 °C, and processed to form flour. Five and ten percent shelled germinating flour were added to Arraw, a product formed from rolled flour.

A classic dish in Chinese, German, and Russian cuisines is millets porridge. In Southern Karnataka, Mudde—a thick porridge made of finger millet—is consumed by both rural and urban residents. An essential food crop for a sizable portion of Central India's tribal population is kodo millet. Millet is used by the people living in the foothills of the Himalayas as a cereal, in soups, and to make Chapatti, a rich, whole grain bread. In the Indian state of Maharashtra, sorghum or millet flour is often used to make the flat, thin Roti cakes that serve as the foundation for meals. According to Veena et al. (2004), barnyard millet flour can be used 50–75% of the time to make rotis, idlies, dosa, and chakli; finger millet dishes like idli, pakora, vedai, adai, and sweet halwa and kolukattai; foxtail millet dishes like Navane sampali, huggi, burfi, or kabab; and little millet dishes like Samai dosa, porridge, paddu, and paysam.

The most popular fermented alcoholic beverage in the Eastern Himalayan districts of Sikkim and the Darjeeling hills of India is called "kodo ko jaanr," and it's made from dried finger millet seeds. Another fermented finger millet beverage that is well-liked in India's Ladakh area is called chhang. In Tamil Nadu, ethnic tribes drink koozh, another fermented drink prepared with rice and pearl or finger millet flour (Ilango and Antony, 2014). Ambali is the traditional name for the naturally fermented finger millet product. In India, finger millet is the preferred grain for making porridges for young patients as well as the elderly and sick. Since ancient times, millet malt has also been used to make drinks with either milk or warm water and sugar added. Made in Zimbabwe using traditional fermentation, mahewu is a non-alcoholic beverage made from finger millet (1/3) and sorghum (2/3) malt (Gadaga et al., 1999). In India, there are some liquid cuisines made from millets that go by distinct regional names. Another well-known dish is ragi soup, which is made by combining one part ragi flour with 2.5 parts water. A scientific attempt was done by Vijayakumari et al. (2003) to create ethnic common dishes based on finger millet. In a sensory test, two beverage types—Ambli and malt—were produced and received acceptable marks for flavor, texture, and appearance. Overall acceptance ratings ranged from 4.0 to 4.5. Every sensory attribute measure showed a non-significant difference between the experimental and control goods. There are also modern goods on the market that include finger millet, such as the ragi health drink (baby vita). Pearl millet may be used to make instant beverage powder by extruding the grains, which considerably decreases the peak viscosity of the starches ($p < 0.05$) (Obilana et al., 2014). Similarly, Naikare et al. (2003a) found that the best cultivars of sweet sorghum millet are ideal for making khandsari, jaggery, and syrup. Additionally, it was said that the SSV-84 variety yielded high-quality jaggery (3.5–4.0 tons per hectare) with a 65.4% non-reducing sugar content and a 12.5% reducing sugar content.

II. CONCLUSION

Advances in post-harvest processing and value addition technologies have made it possible to process and prepare value added products acceptable to bothrural and urban consumers. Millets and sorghum have huge potential for wider use. With finger millet this potential is much harnessed. The other millets particularly minor millets remain un-researche.

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