Consortium for Educational Communication

Module
on
Millet Production, Processing And Products

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TEXT

Introduction

Millets are small-seeded cereals with different varieties. Most common are pearl millet (*Pennisetum glaucum*), finger millet (*Eleusine coracana*), kodo millet (*Paspalum setaceum*), foxtail millet (*Setaria italic*), little millet (*Panisum sumatrense*), and barnyard millet (*Echinochloa utilis*).They are known as coarse cereals beside maize (*Zea mays*), sorghum (*Sorghum bicolor*), oats (*Avena sativa*), and barley (*Hordeum vulgare*). The total world production of millet grains was about 762712 metric tons of which the highest producer being India with an annual production of 334500 tons (43. 85%). Millets would have been originated in Africa and Asia from a group of annual grasses arid and semiarid regions **(Table 1)**. In our country millets are known with different names in different states. Some of the common names are listed in **table 2**. Millet is very easy to digest; it contains a high amount of lecithin and is excellent for strengthening the nervous system. Millets are rich in B vitamins, especially niacin, B6 and folic acid, as well as the minerals calcium, iron, potassium, magnesium and zinc. Millets are a rich source of carbohydrates and minerals, such as calcium, phosphorous and iron. Millets contain no gluten, so they are not suitable for raised bread, but they are good for people who are gluten-intolerant.

Significance of Millet as Health food

Millets have a number of beneficial effect on humans. They are as follows.

Millets as a Healthy Food

Various traditional foods and beverages such as roti, bread (fermented or unfermented), porridge, snack and fast foods, baby foods, millet wine, millet nutrition powder etc are made up of millets. According to research and recent studies, consumption of millet can help women combat the occurrence of gallstones, as they are a very high source of insoluble fiber.

This form of cereal grain is very high in phosphorus content, which plays a vital role in maintaining the cell structure of the human body. This mineral is that it helps in the formation of the mineral matrix of the bone and is also an essential component of ATP (adenosine tri-phosphate), which provides energy to the body. A single cup of millet provides around 24.0% of the body's daily phosphorus requirement. This mineral is a very important constituent of nucleic acids, as they are a part of DNA and RNA.

Millets and Phytochemicals

Millets are also rich sources of phytochemicals and micronutrients. Phytochemicals such as phenolics (bound phenolic acid-ferulic acid, free phenolic acid - protocatechuic acid), lignans, β - glucan, inulin, resistant starch, phytates, sterols, tocopherol, dietary fiber and carotenoids are present in millets. The main polyphenols are phenolic acids and tannins, while flavonoids are present in small quantities; they act as antioxidant and play many roles in the body immune system.

Millets as Probiotic and Prebiotic

Prebiotics aid the existing flora or help repopulate the colon when bacteria levels are reduced by antibiotics, chemotherapy or disease. Probiotics are "living microorganisms" which when administered in adequate amounts confer a health benefit on the host. Fermented millet products act as a natural prebiotic treatment for diarrhea in young children. In Africa, millet koko is prepared in the form of fermented millet porridge and drink and lactic acid-fermented porridge.

Prebiotics are non-digestible food ingredients that beneficially affect the host by selectively stimulating the growth and activity of one or a limited number of bacteria in the colon. Millet's whole grain also shows prebiotic activity, which helps to increase the population of friendly bacteria that plays a key role to promote digestion. Malting induces important beneficial biochemical changes in the millet grain.

Millets as Nutraceutical

The concepts of food consumption are changing from previous to present time. Previous emphasis has been on survival, hunger satisfaction, health maintenance and absence of adverse effects on health. Current emphasis is on encouraging the use of nutraceutical foods which promise to promote better health and well-being. This in turn helps to reduce the risk of chronic diseases such as obesity, diabetes, CVD and cancer. Millets have nutraceutical properties in the form of antioxidants which prevent deterioration of human health. Regular consumption of millet is very beneficial for post-menopausal women suffering from signs of cardio-vascular disease, like high blood pressure and high cholesterol levels. Children's intake of whole grains like millet and fish has been shown to reduce the occurrence of wheezing and asthma.

Millets to manage lifestyle disorder

Millets have many nutraceutical properties that are helpful to prevent many health problems. Millet is an alkaline forming food. Alkaline based diet is often recommended to achieve optimal health, meaning when it combines with digestive enzymes. The soothing alkaline nature of millet helps to maintain a healthy pH balance in the body, crucial to prevent illnesses.

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Millets and Diabetes

Lower incidences of diabetes have been reported in millet-consuming population. Millet phenolics inhibits enzymes like alpha-glucosidase, pancreatic amylase reduce postprandial hyperglycemia by partially inhibiting the enzymatic hydrolysis of complex carbohydrates. Finger millet feeding controls blood glucose level improves antioxidant status and hastens the dermal wound healing process in diabetic rats. Recent research has indicated that the regular consumption of millet is associated with reduced risk of type 2 diabetes mellitus. This is mainly due to the fact that whole grains like millet are a rich source of magnesium, which acts as a co- factor in a number of enzymatic reactions in the body, regulating the secretion of glucose and insulin.

Magnesium is also beneficial in reducing the frequency of migraine attacks. It is even very useful for people who are suffering from atherosclerosis and diabetic heart disease.

Millets and Cardiovascular Disease

Millets are good sources of magnesium that is known to be capable of reducing the effects of migraine and heart attack. Millets are rich in phyto-chemicals containing phytic acid which is known for lowering cholesterol. Finger millet may prevent cardiovascular disease by reducing plasma triglycerides in hyperlipidemic rats.

Millets and Celiac Disease

Celiac disease is an immune-mediated enteropathy triggered by the ingestion of gluten in genetically susceptible individuals. Millets are gluten-free, therefore an excellent option for people suffering from celiac diseases. Gluten-sensitive patients too are irritated by the gluten content of wheat and other more common cereal grains

Millets and Cancer

Millets are known to be rich in phenolic acids, tannins, and phytate that act as “antinutrients” However, these anti-nutrients reduce the risk for colon and breast cancer in animals. It is demonstrated that millet phenolics may be effective in the prevention of cancer initiation and progression in vitro.

Millets and Anti-Inflammatory Activity

Ferulic acid is very strong antioxidant, free radical scavenging and anti-inflammatory activity. Antioxidants significantly prevent tissue damage and stimulate the wound healing process. It is reported good antioxidant effects of finger millet on the dermal wound healing process in diabetes induced rats with oxidative stress-mediated modulation of inflammation.

Millets and Aging

The chemical reaction between the amino group of proteins and the aldehyde group of reducing sugars, termed as non-enzymatic glycosylation, is a major factor responsible for the complications of diabetes and aging. Millets are rich in antioxidants and phenolics; like phytates, phenols and tannins which can contribute to antioxidant activity important in health, aging, and metabolic syndrome

Millets and Antimicrobial Activity

Millets fraction and extract have antimicrobial activity. Seed protein extracts of pearl millet, sorghum, Japanese barnyard millet, foxtail millet, samai millet and pearl millet were evaluated in vitro for its ability to inhibit the growth of *Rhizoctonia solani, Macrophomina phaseolina, and Fusarium oxysporum*. Protein extracts of pearl millet are highly effective in inhibiting the growth of all 3 examined phytopathogenic fungi

Anti-Nutrients Present in Millets. Millets are also known to have anti-nutritional factors. In developing country, cereal-based foods have low bioavailability of minerals like iron, zinc initiate critical problem for infants and young children. These anti-nutritional factors which acts on iron and zinc bioavailability are certain phenolic compounds, phytates, and fibres. The proportions of these anti-nutrients in diet can be reduced by some household food processing techniques like decortication, germination, malting, fermentation etc, which may also change mineral content and bioavailability. Some of the common products from millets are listed in **table 3**

Processing Technology for millets

Processing of millets involves

- Decortication
- Milling and sieving

Decortication:

Millet and some other coarse grains are usually dehulled and subjected to different treatments before consumption to improve their sensory & edible quality. It has been reported that the food uses of finger millet are confined to flour based products because it has not been possible to decorticate millet similar to other cereals. This is mainly due to millet grains that are small compared to other cereals.The hydrothermal treatment of millet hardened the endosperm texture and enabled its decortications **(fig 1 and 2).** The decorticated millet could be cooked as discrete grains similar to rice to obtain soft edible texture. The pasting and the dough properties and also some of the functional characteristics of the product indicated its versatility for diversified food uses. However, decortication of hydrothermally processed finger millet caused significant changes in the nutrient contents.

The decortication characteristics and nutritional composition (iron, zinc, phytates, lipids, fibers,and starch) of decorticated grains were measured. The results showed that decortication had numerous effects on grain composition, but no significant differences were observed between the by hand-pounding or using a mechanical device methods of decortication. Further more, decortication was found to have no effect on the protein and fat content of millets; however, it significantly decreased the content of crude fiber, dietary fiber, minerals, total phenols content, and antioxidant capacity **(table 4).** Therefore, the applicability of millets as functional food was decreased. It has also been reported that dehulling of pearl millet grains reduced total phytic acid, polyphenols, and tannin and significantly ($P< 0.05$)

increased the protein digestibility but decreased the quality attributes of miller. The reduction in some nutrients (minerals, fibers, and antioxidants) and antinutrients (Phytates, tannin) could be attributed to the fact that they are mainly located in the peripheral parts of the grains (pericarp and aleurone layer); therefore, removing of the pericarp during decortication leads to their reduced content.

Milling and sieving:

Millet grains are usually milled by a non motorized grain mill that cranks by hand or another nonelectric method, especially in rural areas for household uses. However, a manual grain mill that has been attached to a gas or electric motor by a pulley system can also be used. Effects of milling on nutritional contents of millet grains and their milling fractions have been studied by a number of researchers.Milling of pearl millet grains was found to reflect a change in gross chemical composition. However, baking did not cause a significant change in nutrient content of raw pearl millet flour. In addition, milling and heat treatment during chapati (an unleavened bread) making lowered polyphenols and phytic acid and improved the protein digestibility and starch digestibility to a significant extent. In another study, 2 pearl millet varieties were milled into whole flour, semirefined flour, and a bran- rich fraction and were evaluated for nutrients, antinutrients, and mineral bioaccessibility. The results showed that nutrient content of semirefined flour was comparable to whole flour, except for the fat content (1.3%). Due to partial separation of the bran fraction, semirefined flour was low in antinutrients that improved its mineral bioaccessibility making it nutritionally superior. The bran-rich fraction, a by-product of flour-milling contained a significantly ($P<0.05$) higher ash content. In addition, steaming the millet at elevated pressure and temperature increased the milling yield, and steaming beyond the threshold level showed a detrimental effect on the yield of head grains.

Finger millet whole flour (WEM), sieved flour millet (SFM), Wafers, and vermicelli with altered matrices (added Fe or Zn or reduced fiber) were analyzed for chemical composition, bioaccessible Fe, Zn, and protein (IVPD) and bioactive components (polyphenols and flavonoids). It was found that WFM and SFM flours differed significantly in their composition. Sieving decreased the content of both nutrients and antinutrients in WFM had the highest levels of total polyphenols and flavonoids, 4.18 and 15. 85 g/ kg, respectively; however, bioaccessibility was highest in SFM vermicelli. It has also been reported that protein, fat, ash, and fiber contents were decreased according to the increase of moisture and milling time and 8% to 10% (db) of moisture content, and 3 min of milling time could be recommended for polishing barnyard millet in a rice polisher without much loss of nutritional values. Therefore, removing of the bran fraction by sieving, which is known rich in nutrients, such as fiber, minerals, and antioxidants, leads to decrease the nutritive value and potential health benefits of grains, thus using whole grains flour in human nutrition is suggested more beneficial in health promotion.

Traditional and Bioprocess Technologies

Germination or malting

Germination or malting of cereal grains may result in some biochemical modifications and produce malt with improved nutritional quality that can be used in various traditional recipes. Germination also appreciably improved the *in vitro* protein (14% to 26%) and starch (86% to 112%) digestibility in pearl millet, and the improvement by germination was significantly higher than by blanching. The improvement in protein digestibility after germination, soaking, debranning, and dry heating can be attributed to the reduction of antinutrients such as phytic acid, tannins, and polyphenols, which are known to interact with proteins to form complexes. It has also been found that the *in vitro* extractability and bioaccessibility of minerals such as calcium, iron, and zinc were increased in finger millet and pearl millet by germination.

Fermentation and enzymatic hydrolyzation

Due to the importance in food preservation, fermentation is widely used throughout Africa where modern food preservation methods are still not common. It helps to preserve many food products, provides a wide variety of flavors, and significantly improves the nutritional properties of the raw material. Fermentation is one of the processes that decrease the levels of antinutrients in food grains and increase the protein availability, *in vitro* protein digestibility (IVPD), and nutritive value.

Popping or puffing

Popping or puffing is one of the traditional food processing methods used for the preparation of expanded cereals and grain legumes to prepare ready-to-eat products. It has been reported that the traditional (popping and flaking) as well as contemporary methods (roller-drying and extrusion-cooking) of cereal processing could be successfully applied to foxtail millet to prepare ready-to-eat products, thereby increasing its utilization as a food.

Soaking and cooking

Soaking of grains is a popular food preparation technique used for reducing antinutritional compounds such as phytic acid to improve bioavailability of minerals. The degradation and leaching of phytates, phytase activity, and iron and zinc concentrations have been studied after soaking of whole seeds, dehulled seeds, and flours of millet.

Food Manufacturing and Formulation Technologies

Pasta, Noodles and Other Products Pasta or papad are made from the flours of cereals or legumes as main ingredient and the dried products are used as Ready to Cook (RTC). Noodles of different combinations are prepared such as noodles exclusively made of finger millet, finger millet and wheat in the ratio of 1:1 and finger millet blended with wheat and soy flour in the ratio of 5:4:1. Pasta can be prepared with finger millet, refined wheat and soy flour/whey protein concentrate composite flour formulated (50, 40 and 10%)

<u>Baked Products</u>

The use of millets in bakery products will be superior in terms of fibre content, micronutrients but also create a good potential for millets to enter in the bakery world for series of value added products. Millets provide an alternative and reduce over dependence on wheat and make gluten free bread. Substitution of 40% wheat flour with finger millet flour in baked products like cake and biscuits is possible. Biscuits prepared from maida finger millet flour blend (80:20) can have shelf-life period of 120 days.

Extruded Products

A majority of world population suffers from qualitative and quantitative insufficiency of dietary protein and calories intake. Extrusion cooking is a High Temperature Short Time (HTST) cooking process, which could be used for processing of starchy as well as proteinaceous materials. The use of extrusion cooking has distinct advantages like versatility, high productivity, high product quality, increase in in-vitro protein digestibility and production of new food without effluents.

Fermented products and fermented food

Dosa and Idli are popular,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.

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, 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.

Conclusion: Among the cereals millets are considered as the wonder grains. These grains requires the least water to grow, hence can be produced in arid regions. India is the largest producer of millets in the world. Even though a number of health benefits are associated with millets, consumer acceptance in urban areas are still restricted. This is mainly because of the course nature of the grain. It is now well established that the millet flour is amenable for fortification of metals and can also be supplemented with other flours. With the increasing awareness of the health benefits of these wonder grains, the consumers are experimenting with millets. This will further encourage the farmers to grow millets in larger quantities.

Table 1: Common name and origin of the millets

Crop	Common names	Likely origin
Sorghum bicolor	Sorghum, great millet, guinea corn, kafir corn, aura, mtama, jowar, cholam. Kaoliang, milo, milo-maize	Northeast quadrabt of Africa (Ethiopia – Sudan border)
Pennisetum glaucum	Pearl millet, cumbu, spiked millet, bajra, bulrush millet, candle millet, dark millet	Tropical west africa
Setaria italic	Foxtail millet, Italian millet, german millet, Hungarian millet, Siberian millet	Eastern asia (China)
Panicum sumatrense	Little millet	Southeast Asia
Paspalum scrobiculatum	Kodo millet	India
Panicum miliaceum	Proso millet, common millet, hog millet, broom-corn millet, Russian millet, brown corn	Central and eastern Asia
Echinochloa crus-galli	Barnyard millet, sawa millet, Japanese bamyard millet	Japan
Eleusine coracana	Finger millet, African millet, koracan, ragi, wimbi, bulo, telebun	Uganda or neighboring region

Source:FAO,1995

Table 2. Millets Types and Name in Different Languages

English	Pearl Millet	Finger Millet	Foxtail Millet	Kodo Millet	Little Millet	Barnyard Millet	Sorghum
Hindi	Bajra	Nachani, Mundua, Mandika, Marwah	Kangni, Kakum, Rala	Koden, Kodra	Kutki, Shavan	Jhangora, Sanwa	Jowar
Tamil	Kambu	Kezhvaragu, Kelvaragu, Keppai, Ragi	Thinai	Varagu	Saamai	Kuthiravali (Kuthiraivolly)	Cholam
Telugu	Sajjalu	Ragula, Ragi Chodi	Korra	Arikelu, Arika	Sama, Samalu	Udalu, Kodisama	Jonna
Kannada	Sajje	Ragi	Navane	Harka	Saame, Save	Oodalu	Jola
Malayalam	Kambam	Panji Pullu	Thina	Koovaragu	Chama	Kavadapullu	Cholam
Marathi	Bajri	Nagli, Nachni	Kang, Rala	Kodra	Sava, Halvi, Vari	-	Jowari, Jondhala
Punjabi	Bajra	Mandhuka, Mandhal	Kangni	Kodra	Swank	Swank	Jowar
Gujarati	Bajri	Nagli, Bavto	Kang	Kodra	Gajro, Kuri	-	Jowari, Juar
Bengali	Bajra	Marwa	Kaon	Kodo	Sama	Shyama	Jowar
Oriya	Bajra	Mandia	Kanghu, Kangam, Kora	Kodua	Suan	Khira	Juara

Table 2. Utilization of Minor Millets in India

Millet/Products	Nature of Products	Raw material form
FINGERMILLET		
Sangati	Stiff porridge	Rice brokers and flour
Roti	Unleavened bread	Flour
Ambali	Thin porridge	Flour
PROSO MILLET		
Annam	Rice-like	Dehulled grain

Muruku	Deep fried	Flour
Karappoosa	Deep fried	Flour
Ariselu	Deep fried	Flour
FOXTAILMILLET		
Annam	Rice-like	Dehulled grain
Ariselu	Deep fried	Flour
Sangati	Stiff porridge	Flour
Roti	Unleavened bread	Flour
KODOMILLET		
Annam	Rice-like	Dehulled grain

Table 4. Millets Nutrition Facts per 100gms

Crop / Nutrient	Protein(g)	Fat (g)	Fiber(g)	Minerals(g)	Iron(mg)	Calcium(mg)	Calories (kcal)
Pearl Millet	10.6	4.8	1.3	2.3	16.9	38	378
Finger Millet	7.3	1.5	3.6	2.7	3.9	344	336
Foxtail Millet	12.3	4	8	3.3	2.8	31	473
Kodo Millet	8.3	3.6	9	2.6	0.5	27	309
Little Millet	7.7	5.2	7.6	1.5	9.3	17	207
Barnyard Millet	11.2	3.9	10.1	4.4	15.2	11	342
Sorghum	10.4	3.1	2	1.6	5.4	25	329
Proso Millet	12.5	2.9	2.2	1.9	0.8	14	356
Rice	6.8	2.7	0.2	0.6	0.7	10	362
Wheat	11.8	2	1.2	1.5	5.3	41	348

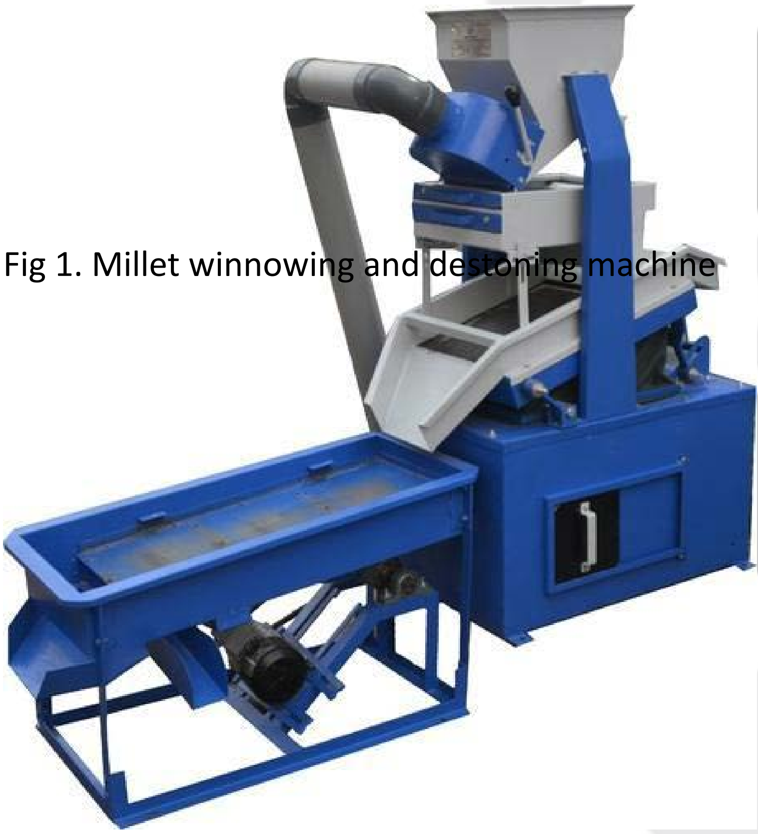

Fig 1. Millet winnowing and destoning machine

Fig 2. Millet decoration machine

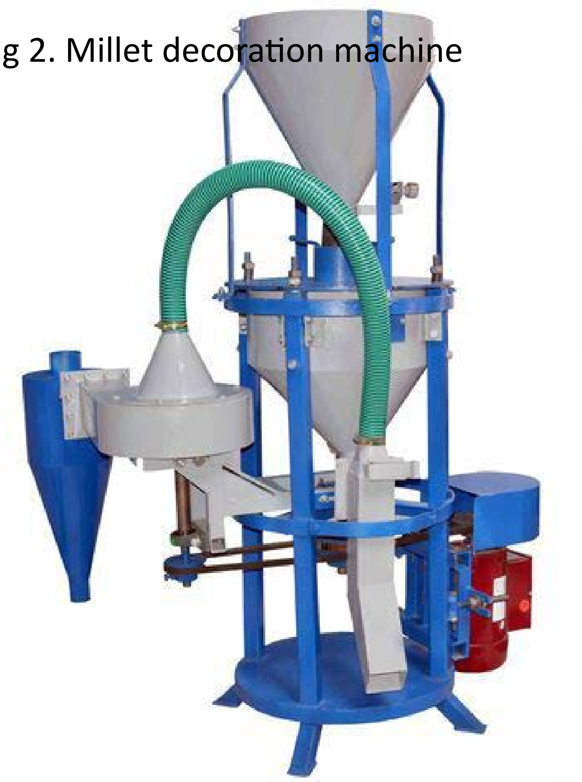

Fig 3 Millet Mill