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Potential for Alternative Uses of Sorghum and Pearl Millet[1]

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ABSTRACT

Sorghum and pearl millet grains have the potential to be utilized as novel foods as well as traditional foods. For novel use, the quality of grains needs improvement through processing and selection of grain types for specific end products. Grains can be dehulled to remove the coarse, fibrous outer coat and milled to make them more appealing to consumers. Most of the sorghum and pearl millet currently produced in the world is used for human consumption. Production in some countries has increased beyond current food needs, and it is thus important to explore alternative avenues for utilization as food preferences of consumers change.

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Important among extruded and sun-dried products traditionally made in India from sorghum and pearl millet are papad, badi, and kurdigai; they have shelf life of over 1 year. Processing technology may need to be refined for these products. Sorghum and pearl millet cultivars yielding fine flour with low starch damage are needed for blending with wheat flour in bakery products. Cultivars with high protein (>14.0%) and high lysine (>3.0%) contents in grains can be used for baby foods. However, improved protein quality remains to be incorporated into cultivars with a high yield potential. The scope exists for increased industrial uses of sorghum in starch production, brewing, and animal feeds.

Sorghum (Sorghum bicolor (L.) Moench) and pearl millet (Pennisetum glaucum (L.) R. Br.) production has increased in several countries during the past few years (FAO 1985). There has been a steady increase in the adoption of high-yielding varieties (HYVs) and new hybrids of these cereals. Sorghum is highly regarded as a food grain in rural Africa, but it has not withstood competition from maize (Zea mays L.) and wheat (Triticum aestivum L.) in towns and cities (Munck et al 1982). Even in those regions where sorghum and pearl millet have been the traditional staple grains in the past there is already an increasing trend in the use of wheat or rice (Oryza sativa L.). The price and the "status" of sorghum and pearl millet contribute to the declining trend in their utilization as food. Also, the nonavailability of foods in conveniently packaged forms or in restaurants contributes to low utilization and acceptance by middle-income group, particularly in urban areas. The name "coarse" grains does not bestow any advantage either, and it may foster the belief that they have too much fiber to be suitable.

Consequently these cereals are mostly used as traditional foods. They can be used in novel foods with suitable processing. To gain acceptability, the grains of improved HYVs should have an advantage over existing varieties in both yield and food quality. Where sorghum yields more than maize and wheat, it should be grown not only for feed but also for food, as an adjunct to breweries, and possibly for industrial production of products such as starch (Munck et al 1982). With increased production, there is an urgent need to look for alternative utilization, including industrial uses. The potential and possible grain-processing improvements and alternative uses of these cereals are discussed in this report

DEHULLING AND MILLING IMPROVEMENTS

The grains can be dehulled to remove the coarse, fibrous outer coat to make the product more appealing to consumers. Dehulling is done in Africa by hand pounding, which is laborious and time consuming. Several types of dehullers have been developed but they are costly and have not become popular among consumers. Mechanical dehulling saves time, and large quantities of grain can be processed with uniform and better quality.

Sorghum and pearl millet are ground to flour and grits by dry and wet milling. Dry milling can vary from simple grinding of whole grain between stones to a complex system using sophisticated roller mills. Sorghum is harder than wheat, is more difficult to grind, and yields coarse flour particles (Hoseney et al 1981). It may be possible to select cultivars with improved milling quality. Information on the dry milling of these cereals is scanty and the currently available technology is inadequate. Despite the fact that sorghum and millet grains have properties different than that of wheat, the milling technology of wheat can be effectively used for grinding these grains with suitable modification, such as the use of hammer mills. Grinding to a fine particle size has been accomplished by using impact grinders (Stringfellow and Peplinski 1966). Abdelrahman et al (1983) have developed a roller mill for producing low fat grits from pearl millet. It may be useful as a starting point for designing a large-scale system for use in urban areas. If industrially milled sorghum products must compete with wheat and maize products in urban areas, the white color of the product is essential for acceptability (Munck et al 1982). Adoption of suitable milling technology can produce a white flour.

The granulation of flour particles is important in blending sorghum or pearl millet flour with wheat flour for bread making. Although bread can be baked from whole sorghum flour, the quality of bread can be improved by using fine sorghum flour without the bran fraction (Casier et al 1977). To compare milling quality, ICRISAT studied on laboratory milling of 52 sorghum and 23 pearl millet cultivars. The distribution of starch damage content and protein content besides particle size were recorded (Tables I and II). In general, pearl millet produces more quantity of fine flour fraction. Flour particles which passed through the 150 μm sieve, called the fine fraction based on the particle size showed appreciable variation and ranged from 35.7% to 70.6% (mean, 60.2%) in sorghum, and 60.6% to 70.7% (mean, 66.1%) in pearl millet.

Starch damage in sorghum flour varied from 9.8 to 37.4% (Table I) and in pearl millet from 21.1 to 28.6% (Table II). The damaged starch content progressively increased from coarse particles to fine particles in both sorghum and pearl millet. Starch damage values in fine flour particles (<150 μm) ranged from 12.0 to 46.1% (mean, 26.3%) in sorghum, and from 22.9 to 36.6% (mean, 28.7%) in pearl millet. Starch damage in flour influences the ability to absorb water and the quality of food depends on the extent of starch damage. Protein distribution in different flour fractions varied from 8.4 to 19.1% in sorghum, and from 9.6 to 17.9% in pearl millet (Tables I and II). The coarse fractions contained higher levels of protein, particularly in sorghum, which may be due to the presence of outer layers of endosperm, although the differences were not large among the fractions. The study suggests the existence of varietal variation in milling quality of these cereals ground under similar conditions. Thus cultivars can be used for different end uses, based on their milling performance. Cultivars yielding higher quantities of the fine fraction and with low starch damage can be useful for blending with wheat for producing biscuits and cakes, and cultivars yielding medium fine flour with low starch damage can be used for bread.

FOOD USES OF SORGHUM AND PEARL MILLET

Traditional foods made from sorghum and pearl millet are porridge, gruel, boiled and steamed products, fermented leavened bread (kisra, injera), unleavened bread (roti, tortilla), fried products, and snacks. These traditional foods will continue to be used by the consumers in sorghum and millet growing regions of the world. These grains can also be used for other new food products by using appropriate processing methods. Pearled sorghum rice analogue has reached test marketing stage in the Sudan, Kenya, Botswana, and India. Various other possibilities exist and are described briefly here.

Bakery Products

Sorghum and pearl millet are used in composite flours (with wheat) for making bread. Blending up to 10% of sorghum or pearl millet flour with wheat flour did not markedly affect the bread quality, and blends consisting of 45% of either sorghum or pearl millet gave acceptable biscuits (Olatunji et al 1982). The Food Research Centre at Khartoum in the Sudan has developed a technology to use up to 20% sorghum in the blend for bread making. Similarly the Institut Technologie Alimentaire (ITA), Senegal, advocated 15% pearl millet in composite flours (Perten 1981). In Senegal, in June 1979, a millet bread containing 30% millet flour and 70% wheat flour was commercially produced in two bakeries. From July 1979, it became obligatory to use 15% millet flour in Senegalese bread made in Dakar and Cape Vert region (Perten 1981). In the commercialization of sorghum flours, sorghum bread is highly appreciated by consumers in the Sudan. The bakery at Food Research Center, Khartoum, produces 2500 bread loaves with 20% sorghum and 1500 to 2000 buns with 15% sorghum daily (Anonymous 1981).

Unlike bread, biscuits have a long shelf-life that permits manufacturing at a central point and distribution over long distances (Belderock 1981). Biscuits made on a commercial scale out of 100% sorghum or millet flour are crumbly and have a sandy mouth feel. These drawbacks can be overcome by partial gelatinization or partial fermentation of flours (Belderock 1981). Biscuits can be made with a mixture of sorghum and wheat flours in equal proportions (Perten 1981). Use of sorghum and pearl millet flour for making cookies is possible by blending it with wheat flour (Badi and Hoseney 1977).

Snack Foods

Products like idly (a steamed product), dosa (leavened product), and ponganum (shallow fat-fried) are breakfast foods from sorghum and pearl millet in some parts of India (Subramanian and Jambunathan 1980). Extruded and sun-dried products of rice have reached markets in urban areas. A few important extruded and sun-dried products from sorghum and pearl millet are papad, badi, and kurdigai; these are made in villages (Subramanian and Jambunathan 1980). These products have a shelf life of over 1 year. When fried in oil, they serve as acceptable snacks.

Baby Foods

Sorghum and pearl millet are commonly used as a thin porridge like Kuzh (India), nasha (Sudan), and rouye (Senegal) for babies. Sour porridges are traditionally used especially for feeding young children and old people (Alnwick 1986). However, the weaning foods have low nutrient density owing to their high water content. Use of nutritious grains will be advantageous, and it is important to incorporate such traits while developing new crop varieties in a breeding program. We have screened several thousands world germplasm accessions for protein and lysine contents. A few lines having high protein (>14.0%) and high lysine (>3.0) contents have been identified. These lines could be used for incorporating protein quality into breeding lines, without adversely affecting the grain yield. Waxy sorghums are extensively used in China, Zimbabwe, and other countries; more information is needed on the utilization of waxy lines.

Pops, Flakes, and Noodles

Sorghum is also popped and used as a snack in villages in India. In general, pop sorghum possesses a small grain size, medium thick pericarp, and hard endosperm with a very low germ/endosperm ratio. Sorghum pops can be used simiiar to popcorn. Some cultivars of pearl millet can also produce good pops. Flakes and noodles from millet flour or a mixture of millet and legume flour are extremely palatable (Desikachar 1975). Quality standards are available for wheat for use in specific foods. Such standards need to be developed for sorghum and pearl millet, and specifications have to be indicated for use of a particular food.

SCOPE FOR INDUSTRIAL UTILIZATION

Though sorghum and pearl millet have the necessary potential as raw material for industrial uses, presently they do not compete with maize. However, through agro-based industries in villages it may be feasible to adapt them for industrial uses. Anderson (1969) reported that sorghum flour has varied uses, such as in bakery products, extenders in meat and also several breakfast foods, and as snack foods. Numerous industrial applications of sorghum flours like use in aluminum ore processing, manufacture of building materials, such as gypsum board and ceiling tiles, and as foundry core binders, and molding sand additives have been reported (Anderson 1969). Further, gelatinized sorghum flours are used as fluid loss-control agents in oil-well drilling (Anderson 1969). Due to the similarity of several properties of pearl millet with those of sorghum, such uses for pearl millet may also be explored. Of the several possibilities that exist for industrial uses of these grains, a few important potential areas are starch production, alcoholic beverages, and animal feeds.

Starch Production

Presently maize is the major source of raw material for starch industry in the world (Anonymous 1985). Sorghum, pearl millet, and maize starches are similar in several physicochemical characteristics (Table III). If starches from some HYVs and hybrids of sorghum are similar to maize, then they can be utilized for starch production with suitable modifications. Sorghum grain fiber appears to be different from maize, which may interfere with the filtering mechanism. There is a need to improve the yield and quality of sorghum starch for industrial use. The main drawback in pearl millet may be its smaller grain size, which makes it difficult to wet mill effectively to recover starch. Starch yield from pearl millet was lower than the yields obtained with corn or sorghum, but pearl millet starches contained twice as much protein as corn and sorghum starches (Freeman and Bocan 1973), which is a disdvantage. Starch granule size is smaller in pearl millet than in maize and sorghum. Yield and composition of byproducts, such as gluten, squeegee, and other fractions from the millet grains, were essentially the same from those corresponding fractions of maize and sorghum. Suitable modifications at extraction plants for the production of starch from these grains are possible, and this may lead to their utilization in production of other commodities, such as glucose and alcohol. There is a need to identify the industries that are interested in starch production from these cereals, and the economics of such starch production needs to be compared with that of maize for long-term use.

Alcoholic Beverages

Sorghum and pearl millet grains are malted and used for production of traditional fermented beverages in several countries in Africa. In South Africa, sorghum beer is commonly produced. In the USA and Mexico, sorghum grits were used as adjuncts for making lager beers (Hahn and Stewart 1965, Pyler and Thomas 1986). Sorghum brewers grits can be used to produce beer fully equivalent to that made with other cereal-brewing adjuncts, yielding beer of good flavor, composition, and stability (Hahn and Stewart 1965). Dhamija and Singh (1978) reported that 35% and 25% pearl millet as malt adjuncts with barley resulted in a beer that was comparable analytically and organoleptically to commercial beer. In Nigeria, sorghums have been tested as a barley malt substitute for producing beer (Obilana 1985). Beer has been produced successfully by blending equal amounts of sorghum and barley. Lager beer was brewed from sorghum malt using the three-stage decoction method and 30% sucrose as adjunct (Okafor and Aniche 1987). Physical and chemical properties of the beer as well as organoleptic tests showed that it was very similar to barley beer.

Grain quality of sorghum and pearl millet has to be improved for their use in beer production. Two of the most important grain characters in this respect are good germination capacity and high diastatic activity. Pal et al (1976) reported that barley and pearl millet malts had comparable amylolytic as well as proteolytic activities and only minor differences existed. Singh and Tauro (1977), however, reported that pearl milet had low amylolytic activity as compared to barley. Malt from pearl millet is bitter in taste. We evaluated the diastatic activity in 96-h germinated sorghum grains of 8 cultivars (Table IV). Variations have been observed among the cultivars for diastatic activity and malting loss. Studies to induce more diastase activity in grains have to be attempted, but this may lead to a trade-off on malting losses. Alcohol also can be produced with suitable processing modifications, and sorghum may have good potential in the industry.

Animal Feeds

Though most of the sorghum and pearl millet produced is presently used for human consumption, it may become evident when storage becomes uneconomical with surplus stock that, use of these grains as feed for animals and poultry has to be examined. Hale (1970) indicated that some form of grinding or processing of sorghum is essential to make grains more digestible for most of the animals. Processes like steam-rolling, and pressure-cooked flaking, expansion-extrusion, popping, and micronizing have been adopted for sorghum grains for use as animal feed (Hulse et al 1980). White-grained types in India do not have tannins and thus may well be acceptable as animal feed. Sorghum grains with low tannin can replace maize in poultry diets without any adverse effect on their performance (Thakur et al 1987). For cattle, feeding of processed sorghum grain has been found superior to unprocessed grain. For feeding to swine, sorghum-based rations should be well balanced in terms of amino acids, minerals, and vitamins. It is thus clear that sorghum can replace maize completely or partially in animal feeds, depending upon the variety used (Thakur et al 1987). Fodder and grains used as feed for animals are also becoming increasingly expensive; sorghum and probably pearl millet can substitute as nutritious animal feed.

SWEET SORGHUMS

Production of sugar, syrup, and alcohol from sorghum stalks is well known. ICRISAT has identified several sweet sorghum lines and these are being used in some national programs. A few lines have high concentration of sugars in their stems (Subramanian et al 1987). There is good potential to use these lines for jaggery, syrup, and alcohol production. The syrup may have a good market in the soft drink industry. Efforts can be made to develop higher biomass yield in sorghum, which will be useful as a livestock and as a source of fiber in the paper and other chemical industries.

CONCLUSIONS

Sorghum and pearl millet production will be high in the future, demanding various technological processes for increased utilization. By adopting improved processing methods, the potential exists to adapt these grains for different end uses. These grains can be used in bakery products and snack foods. There exists scope for industrial utilization, such as for starch and beer production. However, it is important to look at the competitive price structure of sorghum and pearl millet in relation to wheat, maize, and rice, because government subsidy may make rice and wheat cheaper in some instances. This policy affects the utilization of sorghum and pearl millet, and farmers may not be enthusiastic about growing sorghum and pearl millet unless encouragement is given to them in a tangible way.

Cooperative and multidisciplinary programs need to be developed, involving plant breeders, food technologists, biochemists, socioeconomists, home economists, and industrialists. A joint, concerted, and sustained effort is required for rapid progress in these areas.

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TABLE I

Distribution of Particle Size, Starch Damage, and Protein Content in Flour Fractions of Sorghum Cultivars[a].

Particles retained on sieve µm	Flour fractions (%)			Starch damage in flour fractions (%)			Protein in flour fractions (%)		
	Range	Mean	SE±	Range	Mean	SE±	Range	Mean	SE±
355	0.9-3.7	2.0	0.10	6.3-15.5	9.8	0.28	8.4-19.1	12.4	0.28
250	8.3-18.6	11.7	0.30	7.6-21.9	12.3	0.44	10.1-17.6	13.0	0.23
180	9.4-23.6	14.9	0.42	7.9-25.4	15.1	0.51	9.5-18.0	12.8	0.24
150	6.3-26.4	10.4	0.58	8.7-29.5	18.1	0.64	9.1-15.9	12.0	0.22
<150	35.7-70.6	60.2	1.10	12.0-46.1	26.4	0.71	8.4-19.1	11.2	0.20
Whole flour				9.8-37.4	21.8	0.56	7.8-14.8	11.7	0.22

[a]n=52; Grains were ground in UDY mill.

TABLE II

Distribution of Particle Size, Satarch Damage, and Protein Content in Flour Fractions of Pearl Millet Cultivars[a].

Particles retained on sieve µm	Flour fractions (%)			Starch damage in flour fractions (%)			Protein in flour fractions (%)		
	Range	Mean	SE±	Range	Mean	SE±	Range	Mean	SE±
355	1.2-2.7	2.1	0.44	10.0-15.2	12.5	0.28	9.6-16.2	12..4	0.32
250	7.7-13.5	10.4	0.31	11.9-16.9	14.4	0.32	11.0-17.2	13.1	0.34
180	9.9-14.3	11.8	0.19	14.1-19.9	17.3	0.40	11.4-17.9	13.5	0.38
150	6.6-10.4	8.1	0.21	16.6-23.8	19.0	0.46	10.3-17.6	13.7	0.39
<150	60.6-70.8	66.1	0.55	22.9-36.6	28.7	0.72	10.7-15.5	12.1	0.28
Whole flour				21.1-28.6	24.9	0.53	11.1-16.2	12.5	0.25

[a]n=23; Grains were ground in UDY mill.

TABLE III

Comparison of Starches From Sorghum, Pearl Millet, and Maize Grains.

Cahracteristics	Sorghum (n=11)	Pearl millet (n=12)	Maize (n=5)
Starch in grain (%)	68.0±2.36	67.0±2.18	74.0[a]
Amylose in starch (%)	35.1±0.88	39.6±0.33	27.0[a]
Gelatinization temp. (°C)	68.0±0.63	68.3±0.60	62.7[a]
Swelling power at			
70°C	7.0±0.17	8.8±0.22	7.0±0.22
90°C	15.5±0.56	15.3±0.16	13.0±0.24
Solubility (%) at			
70°C	5.0±0.21	6.4±0.37	7.0±0.29
90°C	14.6±0.46	17.4±0.66	17.4±0.59
Inherent viscosity (η)	1.31±0.02	1.51±0.04	1.38±0.05

[a] Source : Medcalf (1973)

TABLE IV

Diastatic Activity and Malting Loss in 96-h germinated Sorghum Grains[a]

Cultivar	Origin	SDU g^{-1}	Malting loss (%)
Red Swazi	Zimbabwe	30.0	11.1
Dobbs	Uganda	53.3	10.9
WS 1297	Ethiopia	52.5	10.0
SAR 1	ICRISAT, India	13.2	8.5
SPV 386	ICRISAT, India	36.0	9.6
Framida	ICRISAT, Burkina Faso	41.7	12.5
IS 7055	Sudan	44.3	9.3
IS 14384	Zimbabwe	35.3	8.5
Mean		38.3	10.1
SE		±4.60	±0.49

[a]Grains were germinated in the dark at 30°C, with 30% relative humidity. SDU = Sorghum diastatic units activity.