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Virtues of Sorghum: Utilization and Supply Chain Management

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Introduction

Many excellent foods have been produced from sorghum and millets with increasing numbers of very successful, profitable products. Sorghum has outstanding potential to produce a wide variety of foods ranging from staples to special healthy foods. It has tannins, a wide variety of phenolic acids and other phytochemicals with significant health potential.

Consumer Demands

Urban consumers want food products that deliver convenience, taste, texture, color and shelf-stability at an economical cost. Upscale sorghum and millet products that meet these requirements are usually not available in many urban areas. We have made excellent prototype products from sorghum and millet using grain with good processing quality. However, disaster struck when products were made with grains obtained from the regular markets. The poor quality grain cannot be made into acceptable value-added products. It is impossible to compete with rice when 10% of the "white" sorghum kernels have a purple testa which produces a dark-colored product, and 10-15% of the sample is sand and other impurities, not to mention the damaged kernels and off-aromas.

Other major constraints (Table I) are discussed. Government policies significantly affect the utilization of local cereals because subsidized wheat flour and other products are often lower priced than local grains. The high cost and poor quality of local grains make it difficult to market acceptable food products.

TABLE I Major Constraints to Sorghum and Millet Utilization

Lack of consistent quality grain supplies
Logistics/markets
Subsidized imported cereals
Extension of existing processing technology unavailable
Few shelf-stable convenience foods
Governmental policies - VAT on sorghum, Republic of South Africa
Subsidized maize, rice or wheat-based food systems
Poor image of sorghum and millet
Nutritional myths: tannins, poor digestibility
Grain molds

Sorghum and millets have excellent quality for processing, but to obtain that inherent quality, a value-added chain securing identity-preserved grain for processing into profitable upscale urban products is necessary. Processing technology is not the major obstacle to successful production of products; consistent supply of a modest quality grain is the major constraint.

Excellent progress is occurring in West Africa, especially in Senegal, Mali, Burkina, Niger and others where progress to develop effective supply chains continues. Yogurt containing 30% of cooked, decorticated pearl millet is very successful along with many other processed products offering convenience at an affordable cost. The key to these successes is the development of an effective supply chain to produce profits for all involved. It has taken a long time, but many new products based on traditional foods, i.e., cous cous, porridges and related products, are now being produced profitably.

Professor Sanders, INTSORMIL, PI, and his colleagues have promoted supply chain management in West Africa with increasing success. Their work has benefited all members of the supply chain who produce and market value-added products.

Adequate supply chain development extending from producers to processors, and ultimately consumers, allows profitable production of new cultivars with improved quality, and thereby stimulates greater use of new technologies in these agribusiness systems. For example, processors do not need to spend significant time and labor cleaning the grain when farmers keep the grain free of sand. The concepts of supply chain management and sharing of profits with all participants are difficult to initiate, but are an essential need in most areas of the world including the developed countries.

Several myths, i.e., tannins, affect the perceived nutritional and processing quality of sorghum. Most sorghums are tannin free, have about the same levels of phytin and phytic acid as maize and other cereals, and the digestibility is only slightly reduced compared to maize. It is true that sorghum proteins are slightly less digestible than maize, but when consumed as processed forms, they are readily available and cause no major problems. The nutritional value of even the high tannin grains is acceptable when fed to livestock since they consume more sorghum to produce about the same amount of gain. Thus, the feed efficiency is reduced, but contrary to popular belief, the animals do not get sick and do not die. These myths are largely extended by scientists who read review articles where older, inaccurate data is cited. These myths adversely affect utilization of sorghum.

More local grain products are being sold, and demand is increasing for both export and domestic markets. This is especially true in Dakar, Senegal where a wide variety of high quality pearl millet products are marketed profitably. Processors have learned to produce high-quality products that are in demand by local consumers. The key is a supply chain to secure good quality grain for processing.

In South Africa, in spite of a local 14% value-added tax on processed sorghum products, large amounts of decorticated sorghum are sold to consumers. The product made from local sorghums with red or brown color is consumed even though it costs more than mealy meal. Thus, there is a demand for sorghum products. The major problems usually relate to the lack of a good-quality supply of grain for processing. Some processors have solved these problems by investing in cleaning facilities and by selling only high quality products. This improves the image of local grains and gives the convenience desired by modern consumers. Such products are successful in competing with rice and wheat since they have the convenience and quality desired by consumers.

Progress has been made in recent years in the United States to provide identity-preserved white food sorghums for use in domestic ethnic and dietary foods, and for export to Japan for snacks and other products. Many new ethnic and special dietary recipes using sorghum have been developed and published in cookbooks. The white food sorghums have excellent properties and are appreciated by consumers. These markets are growing rapidly.

Value-Added Supply Chain

Excellent food products can be and are made from sorghum and millets; however, the lack of a consistent supply of good quality grain for processing usually precludes successful marketing of these products. The value-added supply chain includes:

- Seed supplier (seed production) - quality and purity
- Grain producer
- Harvesting
- Storage
- Handling and transportation
- Processing into products
- Marketing

The major limitation is the lack of high-quality grain in sufficient quantities for processing. More efficient methods of threshing and cleaning the grain to remove sand and other impurities are essential. Millets and sorghum grains in existing markets are extremely variable in kernel size, color, and cleanliness. The processors in Senegal indicated clearly that they wanted cleaner and less variable grain. In addition, available varieties and improved cultivars will lead to significantly improved processing quality. For example, Thlack, a millet variety in Senegal, has given excellent composite breads with increased loaf volume.

Methods to assess quality are required to facilitate supply chain management. A set of standards along with practical specifications for each important quality criteria is required. These specifications must be agreeable and practical both to producers and processors. The type, or cultivar, of grain can be determined by mutual agreement, but environment will modify grain quality and this must be measurable.

Communications among seed producers, production specialists, farmers and processors are required. Contracts are required along with credit systems to build grain storage facilities to hold grain throughout the year to assure a consistent supply of grain for the processor. More efficient methods of threshing and cleaning the grain to remove sand and other impurities are essential. It is inherently difficult for producers and processors to understand each others needs and problems. A long-term relationship between producers and processors is required. Profit for all is necessary to make the scheme work.

Strategy for Value-Added Products

The best strategy for developing convenient, shelf-stable foods is to use identity preserved grains to produce high-value products that can be priced slightly lower than imported products (Table II). The targets should be middle class and wealthy people where sufficient prices can be obtained to provide profits for all. There is no need to develop low cost, inferior quality foods that do not provide significant profits.

The image of sorghum and millet as a poor man's food can be overcome by developing highly improved products that have attractive, more socially acceptable names that appeal to wealthy consumers. The new name along with identity preserved production schemes would lead to improved acceptability. The marketing of new grains calls for imagination along with new superior types.

TABLE II Strategy for Value-Added Products

Identify upscale products
Niche markets - supermarkets
Develop sorghum and millet products
Use low input, appropriate technologies
Use identity preserved grain
Specify variety and hybrids
Educate farmers and producers
Economics - share value-added processing profits with members of the supply chain.

Functionality of Sorghum and Millets

Functional advantages for sorghum include a white, light color and bland flavor without GMO that has excellent processing properties similar to rice for use in snacks, breakfast cereals and an array of flours, grits, meals and porridges. There are many different sorghums that are used in various ways. However, the bland flavor and light color of food type sorghums afford a real advantage in functionality to sorghum. It does not contain gluten and its slower hydrolysis makes it attractive to diabetics, celiacs and ethnic groups. In addition it is an alternative to rice in extruded and processed foods because of its bland flavor, light color and good expansion. Unfortunately, the white sorghum cannot be produced in many areas so other sorghum with tannins may be used. They could in fact be promoted on the basis of health claims regarding high antioxidants and slow digestibility for diabetics.

Pearl millet has a stronger flavor and dark color that is desired in millet consuming areas. For example in Senegal many processed products are sold domestically and for export. A yogurt containing cooked pearl millet grits is profitable. In fact they cannot supply the demand for these products. Some white and yellow grain types would have functional advantages for processed foods.

Rice is considered a convenience food in many areas because it is ready for cooking. Similar products, e.g., meals, cous cous, flours, grits, snacks made from sorghum and millet could be targeted. There are numerous examples of small entrepreneurs in Bamako, Mali profitably selling locally produced high quality products that can be cooked conveniently. These ladies are expanding their markets.

Technology for processing sorghum and millet is available and is not the most limiting factor. In most cases, existing milling techniques applied to good quality grain can make acceptable products. More efficient technology is always welcome, but we cannot wait until we have perfect processing procedures. The perfect new process will not work efficiently on poor quality grain.

Sorghum Food Use in Central America

White tan food quality sorghums have been developed and are grown extensively in Central America where local people utilize them in a wide variety of foods including tortillas and related products and a wide variety of baked products where they are blended with varying levels of wheat flour. Many bakeries and related food companies found that the white sorghums could be milled into flour and used to substitute for expensive wheat flour in a wide variety of products including replacement of rice. Many small producers in Salvador market their sorghums by milling the grain, baking different products and selling them in local villages and markets. Several small mills have been introduced and are used to economically mill local sorghums. The sorghum flour has a clear advantage over maize because the light color and bland flavor allows for greater substitution levels without affecting the taste. Corn affects the taste of composite breads negatively.

Plant Breeding and Improvement of Grain Quality

For plant breeders, yield should be considered in terms of useful quantities of food produced per unit of land (Table III).

TABLE III SM Breeding Objectives

Useful products per hectare
Value-added characteristics
Need economic grain yields and quality
Mold/head bugs /weathering resistance
Screening methods available

Breeding for yield without regard for quality is a major mistake. Farmers in the Semi-Arid Tropics have not planted many improved sorghum varieties because they are susceptible to weathering and head bugs, and have unacceptable processing and food properties. For example, we showed many years ago that women will not accept thin-pericarp sorghum because the work required to dehull it by hand pounding is increased by 50% or greater. Therefore, it is important that sorghum breeders recognize that food quality in many areas is critically important and is an essential part of grain yield (Table IV). This has proven true in Honduras where Sureno, an improved sorghum has been adopted by farmers because it has good tortilla-making qualities and a sweet juicy stalk that improves its forage quality.

TABLE IV Properties of New Varieties / Hybrids

Optimum grain yields and quality
Photosensitivity required in some areas
Avoids - molds / weathering / head bugs
White Tan plant, straw glumes
Bright white or red color, no pigmented testa
Milling yields - hardness, spherical shape,
White / yellow millets - light color products for processing

In the more humid areas of West Africa, a major priority should be to develop improved local varieties that have photosensitivity and good food quality (tan plant, straw color glumes). Such varieties could be utilized for identity preserved sorghum production for value-added products. Until we obtain consistently superior quality, sorghum food use in urban areas is difficult because of inadequate quality in some years when molds are prevalent. In Mali, a white tan sorghum is providing grain with superior food properties and good yields. The weathering of these grains is important in some environments.

Sorghum Image

The allegedly "poor nutritional quality" of sorghum is detrimental to its use in foods and feed. Tannins and poor protein digestibility are major problems in the eyes of some. Often, key nutritionists and others believe that all sorghums contain tannins, and thereby potential users are scared away. For example, a poultry nutritionist from India indicated he "would only feed sorghum if it was priced at 60 to 70% the value of maize because of the tannins in sorghum", even though most, if not all, Indian sorghums do not contain condensed tannins.

Special Sorghums Are an Advantage for Healthy Foods

The tannin sorghums (brown sorghums) have a very definitive pigmented testa which is caused by combinations of dominant B_1-B_2-S-genes. Such sorghums have significant levels of condensed tannins with resistance to birds and grain molding and may be more slowly digested which is an advantage for type II diabetic diets. Also evidence is accumulating that shows tannin sorghums and or their brans have anti cancer activities along with anti-inflammatory properties. Tannins also produce excellent dark colors in a wide array of food products and may even be an extender of cocoa products.

The tannin sorghums have high antioxidant activities in addition to being more slowly digested and contain many highly desirable phytochemicals that are desirable for healthy foods. Sorghums with a pigmented testa and dominant spreader genes are potent sources of antioxidants that provide more efficient sources than fruits or berries. Other sorghums contain very high levels of flavones, flavanones and 3-deoxyanthocyanins which in several in vitro assays have desirable effects on cancer cell cultures.

Our laboratory has found high levels of flavones, flavanones and 3-deoxyanthocyanidins in special sorghums. These compounds may impart significant health properties to these special sorghums. This is a rapidly evolving field and will positively improve the image of sorghums. We are identifying new components from sorghums depending on variety of the grain.

Food Utilization

Sorghum and millets can be processed into a wide variety of very acceptable commercial food products. These grains can be extruded to produce a great array of snacks, ready to eat breakfast foods, instant porridges and other products. The flakes of a waxy sorghum obtained by dry heat processing can be used to produce granola products with excellent texture and taste. Tortillas and tortilla chips have been produced from sorghum and pearl millet alone or with maize blends. The sorghum products have a bland flavor while pearl millet products have a unique strong flavor and color. The critical limitation is again cost efficient, reliable supplies of grain.

Neither sorghum or millet have gluten proteins, so to produce yeast-leavened breads, they are usually substituted for part of the wheat flour in the formula. The level of substitution varies depending upon the quality of the wheat flour, the baking procedure, the quality of the sorghum or millet flour and the type of product desired. In biscuits, (cookies) up to 100% sorghum or millet flour can be used. The non-wheat flour gives a drier more sandy texture so the formula must be modified. White sorghum has a definite advantage over maize and millet in composite flours because of its bland flavor and light color.

The colored sorghums have significant potential as natural pigments and colorants for various food products and applications where natural pigments are desired. The Black sorghums are significantly more stable than other natural sources like red cabbage.

Gluten free foods from sorghum have excellent properties. Use of sorghum in Celiac foods is increasing rapidly because it is more readily available with reduced more competitive cost. Wide arrays of products have been made for Celiacs.

Improving Sorghum Quality

It is difficult to improve digestibility without enhancing the susceptibility of the grain to deterioration since sorghum kernels are exposed to ambient conditions during maturation, and are prone to attack by molds and insects. Soft, digestible sorghums are destroyed by molds in the field prior to harvest except in very dry areas i.e., Sudan, Ethiopia. Thus, efforts to enhance digestibility of sorghum must be done with care.

Waxy sorghums have improved digestibility for ruminants and possibly swine, but, that improvement is accompanied by poor seed emergence and viability. Current waxy sorghum hybrids have lower yields of grain, although that can be improved by greater breeding and selection efforts. A heterowaxy hybrid, where one parent is waxy and one nonwaxy, provides high-yielding hybrids with some improvement in digestibility.

Some yellow endosperm hybrids that are more digestible have reduced seed vigor and poor emergence. Thus, the most efficient way to increase sorghum digestibility is to properly process it. Thus, the emphasis should be to breed grains that resist molds and post harvest weathering. It is not feasible to grow soft, floury sorghums in most areas of production. The Sudan and some other areas of the world where extremely dry conditions occur after anthesis are exceptions to this statement.

Increasing the levels of lysine and tryptophan in sorghum is extremely valuable in terms of human and animal nutrition. Developing high yielding sorghums with improved levels of lysine and trypotophan would greatly enhance its value for both humans and animals.

Effect of Molds, Insects and Weathering on Grain Quality

Grain molds, weathering and head bugs are major problems in many sorghum-producing areas. Molds discolor the grain, break down the endosperm and significantly deteriorate processing qualities. Mold damaged or weathered grain cannot be decorticated; the flour or grits are badly discolored and cannot be used for food. This problem can be overcome most quickly by the production of white, tan plant, straw-colored glume photosensitive sorghums.

Mycotoxins

Sorghum does not develop aflatoxins prior to harvest like maize does. Sorghum contains A. flavus and other species, but, apparently the exposure of the grain to the atmosphere prevents significant levels of aflatoxin formation in the field. Sorghum containing aflatoxin occurs during improper storage of high moisture grains. In addition, sorghum does not produce significant amounts of fumonisin. The relative resistance to field contamination of sorghum by these major mycotoxins is a major advantage for sorghum over maize. As maize is grown under more marginal conditions, the risk of increased levels of mycotoxins should be considered. Sorghum has fewer problems with mycotoxins. There is less information on pearl millet but it evidently does not produce significant levels of aflatoxins and fumonisins in the field either.

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