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Commercialization Prospects for Sorghum and Pearl Millet in Tanzania

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Abstract

Tanzania produces over 500,000 t of sorghum and 200,000 t of pearl millet per year. Yet virtually the entire production is subsistence-oriented. The lack of a commercial market has limited farmer interest in improving crop management, and average sorghum and pearl millet yields have changed little over the past 15 years.

This report analyzes the prospects for expanding commercial utilization of these crops. On the basis of a utilization survey, a review of price data, and discussions with industry representatives, it appears that the best opportunity for expanding the use of sorghum is in the opaque beer brewing industry. A target of 75% substitution over the next 5 years would create a demand for 1800 t per year of high quality white sorghum. According to industry representatives, the main constraint limiting the use of sorghum and pearl millet in animal feeds is the relative grain price. If sorghum is available at competitive prices, 5 years from now it could account for at least 5% of the grain used by the industry, or 5000 t per year.

The potential size of the market for milled sorghum and pearl millet meal is difficult to estimate, because of uncertainty about the strength of consumer preferences for alternative grains. Nonetheless, the milling industry can set a target of replacing perhaps 5% of the maize meal sold in Dar es Salaam with sorghum meal, generating a demand for more than 20,000 t of grain per year.

The prospects for pearl millet are less favorable than for sorghum given its generally higher price and lower yields and labor productivity. However, there may be a small market niche for pearl millet-based meals, particularly in communities drawn from pearl millet production zones. The milling industry could test this market with an initial throughput of 500 to 1000 t of pearl millet grain per year.

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Summary

Tanzania produces over 500,000 t of sorghum and 200,000 t of pearl millet[1] per year. These are the second and fourth most widely grown cereal grain crops in the agricultural economy. Yet virtually the entire production is carried out on a subsistence basis. Less than 2% of the harvest enters the formal market; the remainder is consumed on the farm. Thus, the main contribution of sorghum and pearl millet is to farm household food security.

The lack of a commercial market has limited farmer interest in improving the management of these crops. As a result, average sorghum and pearl millet yields have changed little over the past 15 years. However, the area planted to these crops is still increasing. Continuing growth in the number of farmers in Tanzania's drought-prone semi-arid areas contributes to a 1% average annual gain in planted area.

It is difficult to explain why only limited quantities of sorghum and pearl millet are marketed. Tanzania generally imports grain, and commercial production of sorghum and pearl millet could reduce dependence on imports. The country's sorghum and pearl millet yields are relatively high by African standards. And average sorghum grain prices in Dar es Salaam tend to be lower than those for maize.

This report examines this conundrum. We first review current levels of farm supply and market demand for sorghum and pearl millet. Next, constraints limiting the use of these crops by Tanzania's food and feed industries are outlined. Finally, opportunities for expanding industrial utilization are summarized. The analysis concludes that sorghum can readily replace most of the maize currently being used in the commercial manufacture of opaque beer. Problems of grain quality can be resolved by introducing improvements in grain cleaning.

In most years, sorghum should be highly competitive as an input for the manufacture of animal feed. Feed processors may benefit from the dissemination of information about the nutritional value of this crop. Uncertainties about grain supply can be resolved both through investments in grain stockholding, and by encouraging production specifically targeted at this market.

A substantial opportunity clearly exists for the production and sale of sorghum and pearl millet meal. However, it is difficult to estimate the ultimate size of this market without additional information on consumer preferences. Market development activities should include efforts to promote the production and delivery of high quality grain. Programs are needed to test consumer demand for various qualities of milled product.

Finally, the enterprising baker looking to cut input costs can extend wheat flour with small quantities of white sorghum in the production of biscuits and bread. The grain must be clean and consistent supplies must be assured; but the financial returns to wheat substitution may be substantial.

The study estimates that within 5 to 10 years Tanzania's food and feed processing industries could be using at least 25,000 t of white sorghum and perhaps 3000 t of pearl millet grain. However, these industries first need to work with farmers and grain traders to develop the trading links necessary to ensure consistent grain supplies. In order to invest in expanding production, farmers need to be assured of a consistent demand for any surplus grain. If end users seek particular varieties, they may need to facilitate access to improved seed. Informal contracting, by announcing commercial demand and target prices during the planting season, for example, can help reduce grain assembly costs. Once this market is established, the commercial competitiveness of sorghum and pearl millet will be further improved.

1. Also known in Tanzania as bulrush millet

Data Sources

This report is the product of a brief diagnostic study of constraints limiting the commercialization of sorghum and pearl millet in Tanzania. A semi-formal survey was conducted with 29 millers, brewers, and animal feed manufacturers situated in five major urban business centers – Dar es Salaam, Dodoma, Moshi, Arusha, and Mwanza (Table 1). These include all the industrial grain processors currently using sorghum or pearl millet, and many of the larger processors who might use these grains in the future.

The diagnostic survey collected information on the levels of grain processing in 1999. Industry representatives were asked to outline their perceptions of the relative value of sorghum and pearl millet and assess the substitutability of these coarse grains with maize. The survey was complemented by visits to major grain markets and discussions with grain traders. Most of these interviews took place in March and April 1999.

It should be noted that both sorghum and pearl millet were in limited supply during the period of the survey. National grain harvests were favorable in 1998, but heavy rains disrupted the flow of grain to the market. The loss of road infrastructure resulted in grain shortages in urban markets, high and unusually variable grain prices, and a dependence on grain imports. These constraints particularly affected outlying sorghum and pearl millet production zones. As a result, wholesale grain prices had risen to unprecedented levels.

The primary data collection was complemented by a review of secondary data and literature relating to sorghum and pearl millet in Tanzania. This included the extensive market and price data historically collected by the Marketing Development Bureau of the Ministry of Agriculture and Cooperatives.

Table 1. Survey sample of grain processors, 1999.

Urban area	Type of processor	Sample size
Dar es Salaam	Brewer	3
	Miller	5
	Animal feed manufacturer	3
Dodoma	Brewer	0
	Miller	1
	Animal feed manufacturer	2
Moshi	Brewer	1
	Miller	0
	Animal feed manufacturer	3
Arusha	Brewer	0
	Miller	3
	Animal feed manufacturer	4
Mwanza	Brewer	0
	Miller	0
	Animal feed manufacturer	4

Sorghum and Pearl Millet Production

During the past 10 years, farmers in Tanzania have annually planted approximately 700,000 ha of sorghum and 300,000 ha of pearl millet (MAC 1998; see Annex 1 for details). Both crops are primarily sown in the semi-arid regions of Dodoma, Singida, Shinyanga, Mwanza, Mara, Lindi, and Mtwara. Smaller areas of sorghum are planted in the drier parts of Morogoro (Fig 1).

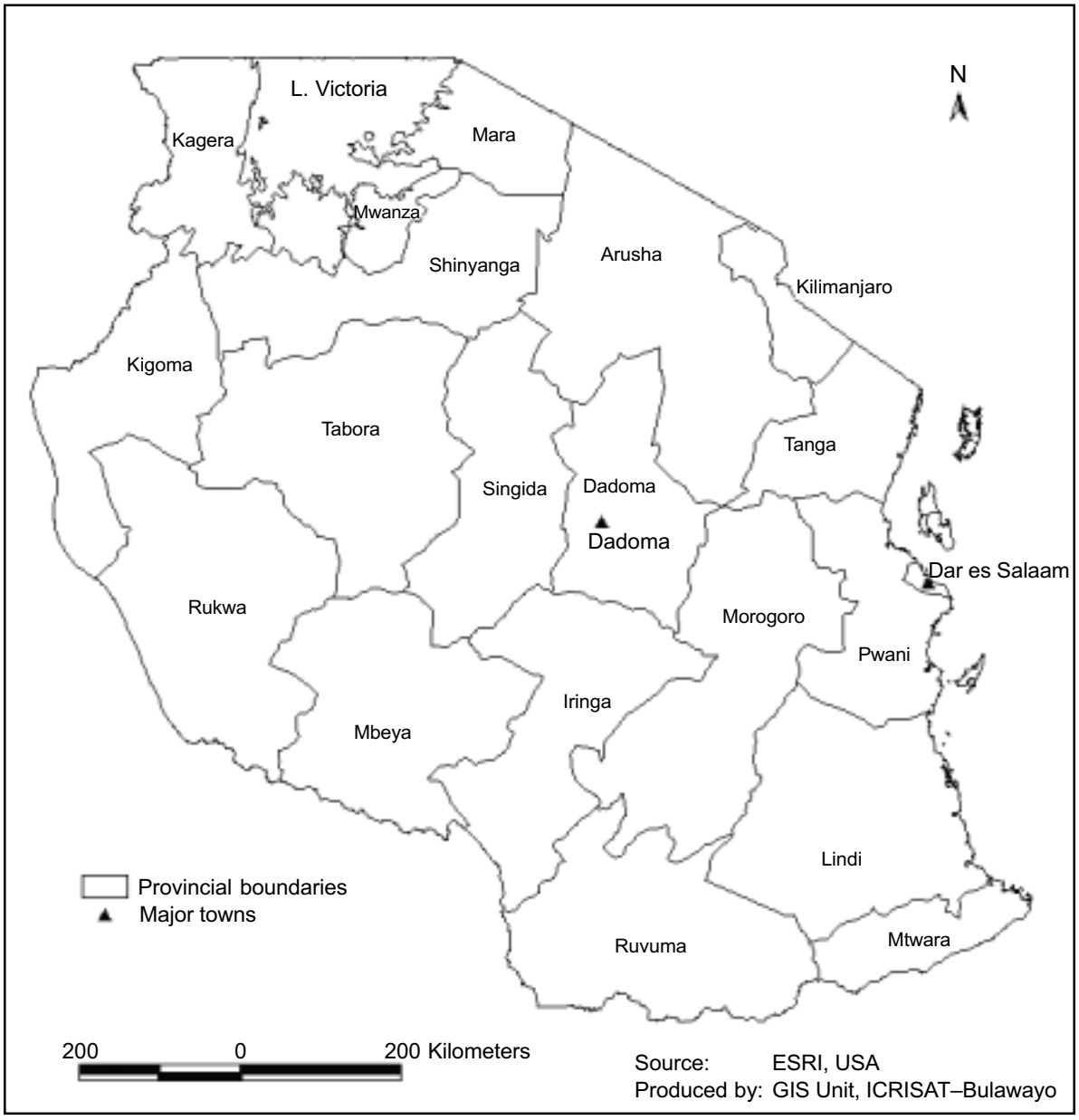

Figure 1. Map of Tanzania, showing districts and major cities.

Table 2. Annual sorghum and pearl millet harvests ('000 t) in Tanzania's main production regions[1], average, 1994/95 to 1996/97.

Region	Sorghum	Pearl millet[2]
Mwanza	155	9
Shinyanga	135	37
Dodoma	86	116
Singida	62	46
Tabora	52	8
Morogoro	50	negligible
Mara	32	15
Mtwara	28	negligible
Other regions	137	negligible
Total	737	231

1. The eight major production regions account for 81% and 90% respectively of the national sorghum and pearl millet harvest
2. Derived from national data on millet production. Authors estimate that pearl millet accounts for 95% of total millet production in each region. The remainder is finger millet

Source: MAC 1998

The central regions of the country stretching from Dodoma to Mwanza account for three-quarters of Tanzania's 500,000 to 800,000 t annual sorghum harvest (Table 2). Smaller quantities are harvested in the Mtwara region.

National statistics do not distinguish between brown and white sorghum. However, previous surveys (Minde and Mbiha 1993) and information gathered during the course of this study indicate that most of the sorghum grown in the southeastern half of the country is white-grained and low in tannin. In contrast, most of the sorghum grown in the Lake Zone, including Shinyanga, Mwanza, and Mara, is brown-grained and high in tannin. Individual farmers may grow both brown- and white-grained varieties. Both types of grain are used for food or for beer.

Almost all of Tanzania's pearl millet is grown in the dry central regions. While both crops are highly drought-tolerant, pearl millet can better withstand periods of heat stress than sorghum.

Evaluation of pearl millet production is complicated by the failure of national statistics to distinguish this crop. Pearl and finger millet are collectively classified as "millet". However, finger millet tends to be grown in higher-rainfall zones. Pearl millet production is concentrated in the drought-prone areas of Dodoma, Singida, and Shinyanga. The annual harvest is estimated at 230,000 t.

Sorghum and pearl millet are grown almost entirely by small-scale farmers on small plots of land, typically 1.5 to 3 ha (Minde and Mbiha 1993). Most of these farmers also plant maize. If early-season rains are favorable, a larger area may be planted to maize. If early-season rains are poor, relatively more land may be planted to sorghum or pearl millet.

These acreage allocation decisions may be understood by comparing yield data for sorghum, pearl millet, and maize in years of favorable rainfall versus years of drought (Table 3). In favorable years, maize commonly performs better than either sorghum or pearl millet. In drought years, however, sorghum generally yields more than maize. Pearl millet yields tend to be the most stable, though lower than sorghum yields.

Few farmers have invested in improving the management of their sorghum or pearl millet crops. According to surveys conducted in 1992, less than 15% of sorghum growers and 5% of pearl millet

Table 3. Mean grain yields (kg ha^{-1}) of sorghum, pearl millet, and maize in 1995/96 (favorable rainfall) and 1996/97 (drought).

	Drought, 1996/97			Favorable rainfall, 1995/96		
Region	Sorghum	Pearl millet[1]	Maize	Sorghum	Pearl millet[1]	Maize
Mwanza	1153	965	758	1589	969	1617
Shinyanga	846	1050	1344	1300	1051	1605
Dodoma	680	835	631	1251	840	1591
Singida	771	706	743	1200	1000	1476
Tabora	838	102	804	1500	598	1735
Morogoro	1175	182	439	1400	na	1590
Mara	667	685	938	1137	687	1444
Mtwara	407	667	911	900	667	901

1. Mean yield for the entire millet crop. Authors estimate that pearl millet accounts for 95% of total millet production in each region. The remainder is finger millet

Source: MAC 1998

growers have ever tried an improved variety (Minde and Mbiha 1993). Most sorghum and pearl millet area is sown to traditional, unimproved varieties. Less than 9% of sorghum and pearl millet producers have ever tried chemical fertilizer, and regular, continued fertilizer application is rare. When fertilizer is available, it is more likely to be used on maize or another cash crop. Only a minority of small-scale farmers use manure. Since most land is planted by hand, farmers also face difficulty in timing their sowing with the rains. Again, maize crops are more likely to be established when soils are moist. Since sorghum and pearl millet do not have a ready market, they are more likely to be planted and weeded as labor becomes available. This reduces the availability of water to these crops even further.

Despite limited investments in improved crop management, Tanzania's average sorghum and pearl millet yields are among the highest in southern Africa. This reflects the relatively long growing season and favorable soils found in the country's sorghum and pearl millet production zones.

Nonetheless, average grain yields can still be at least doubled through the adoption of improved inputs. The extension efforts of the NGO Sasakawa Global 2000 have shown that small-scale farmers can readily achieve sorghum yields above 2 t ha^{-1} through the use of better seed and small quantities of chemical fertilizer (Quinones et al. 1991). But adoption rates for these inputs sharply declined once Global 2000 stopped providing them to farmers. Rural markets generally do not stock improved seed and fertilizer. In addition, farmers face little incentive to purchase inputs and expand production without a steady market.

In effect, Tanzania's sorghum and pearl millet producers are caught in a "subsistence production trap". The lack of a commercial market for these crops encourages farmers to maintain a subsistence level of technology and production. Yet the development of a commercial market is discouraged by the lack of a consistent marketable surplus. As with cash crops like maize, cotton, and tobacco, markets are most likely to be built on the foundation of a demand for the product. Traders and grain processors first need to contribute to the improvement of production incentives. Farmers will respond by shifting resources to expand production of crops with favorable markets.

Sorghum and Pearl Millet Market Deliveries

More than 95% of the sorghum and pearl millet harvested in Tanzania is consumed on the farm. Since many sorghum and pearl millet producers experience periodic food deficits, most grain trade is between neighboring households. Small quantities of grain move from the few farmers able to produce a surplus to the many experiencing production deficits. Larger regional grain deficits are resolved through imports of maize and rice. There is relatively little long-distance trade in sorghum and pearl millet.

It is hard to accurately estimate the quantities of sorghum and pearl millet entering the national market. The Marketing Development Bureau of the Ministry of Agriculture and Cooperatives maintains partial records of grain flows into the major urban wholesale markets. These indicate, for example, that between 1991 and 1997, a total of only 18,000 t of sorghum entered the wholesale markets of Dar es Salaam (Table 4). Annual market deliveries averaged 2500 t, and deliveries in 1998 and the first half of 1999 were negligible.

Much smaller quantities of sorghum enter Tanzania's two other main wholesale markets, Mwanza and Arusha. Between June 1998 and June 1999, only 107 t of sorghum was recorded as entering the wholesale markets in Mwanza, and less than 50 t in Arusha.

It should be noted, however, that the liberalization of Tanzania's grain markets during the 1990s has led to a proliferation of wholesale trading centers in Dar es Salaam and other urban areas. The government has maintained monitors at the main city markets, but has not been able to track grain entering the smaller trading centers. Elimination of the grain trading monopoly of the National Milling Corporation has also encouraged direct trade between farmers or traders and the food and feed processing industry. It is therefore possible that additional quantities of sorghum are being traded in smaller markets, and directly to industry. But the volumes being transacted appear small.

No records are maintained for wholesale market deliveries of pearl millet. This reflects both the limited quantities of pearl millet grain traded, and the general lack of interest in this crop.

In contrast, finger millet is widely traded and records are maintained on market deliveries. Though finger millet is planted on only one-quarter as much land as pearl millet, this crop attracts more attention from traders and policy makers because it is commonly traded at premium prices for the production of beer and meal. Pearl millet, by comparison, remains a 'minor' subsistence crop.

The majority of sorghum grain being traded is destined for the informal, small-scale opaque beer brewing industry. This encompasses hundreds of small-scale brewers operating in low-income urban

Table 4. Sorghum grain deliveries to wholesale markets in Dar es Salaam, 1990/91 to 1996/97.

Market year	Quantity delivered (t)
1990/91	75.9
1991/92	154.1
1992/93	785.0
1993/94	4246.6
1994/95	6419.8
1995/96	4909.5
1996/97	1142.3

Source: Marketing Development Bureau

areas and on the margins of grain markets. These brewers are commonly willing to pay high prices for sorghum to ensure access to this grain, particularly following a drought season. When rains are favorable, sorghum prices drop sharply. Demand appears relatively inelastic.

Small quantities of both sorghum and pearl millet are traded for food consumption, both in the form of grain and meal. Small quantities are also used for poultry feed.

Current Utilization of Sorghum and Pearl Millet in the Brewing, Milling, and Animal Feed Industries

The limited quantities of sorghum and pearl millet currently used by Tanzania's food and feed industries reflect both a lack of familiarity with these crops and uncertainty about consumer demand. Industry is also commonly concerned about problems of grain quality and price.

Utilization in the brewing industry

During the survey of industrial demand for sorghum and pearl millet, manufacturers of both clear (lager) and opaque beer were interviewed. Representatives of the clear beer industry expressed little or no interest in using these grains. The opaque beer industry expressed a desire to expand its use of sorghum.

Opaque beer

One of the most common industrial uses of sorghum in southern Africa is in the manufacture of opaque beer. The South African brewing industry, for example, uses at least 70,000 t of sorghum per year in the production of sorghum malt. Zimbabwe's opaque beer industry uses about 17,000 t of sorghum, and the smaller opaque beer industry in Botswana uses about 4000 t.

Though white, red[2] or brown sorghums are most commonly incorporated into opaque beer as malt, sorghum can also be used as a source of beer starch. This is a common practice in Nigeria when sorghum prices are lower than maize prices.

Only one brewing company in Zimbabwe uses pearl millet in the production of opaque beer, and the quantities involved are small, approximately 300 t per year.

Darbrew (Kibuku) has traditionally used 1000 to 3000 t per year of white sorghum in the production of opaque beer and beer powder (Msangula 1993, Tiisekwa and Laswai 1993). This grain was largely obtained from its own farm in Morogoro. This helped the brewery ensure a consistent supply of a particular white-grained variety. However, the farm proved uneconomical to manage, and problems arose because sorghum grain became contaminated with seeds of a bitter tasting weed. In 1994 the company closed its farm and replaced the sorghum in its beer with maize.

As of early 1999, Darbrew no longer used sorghum in its beer or beer powder. However, the company expressed interest in re-initiating the use of sorghum if high quality grain is consistently available.

Sorghum is preferred for opaque beer production in order to meet the taste preferences of beer drinkers. Sorghum beer is commonly brewed on the farm, and also commonly produced near town and

2. Brown high-tannin sorghum should not be confused with sweet red sorghum varieties. The latter are commonly grown in South Africa to reduce the risks of grain mold affecting white-grained varieties when rains occur during the harvest period. The relative distribution of red versus brown sorghums in Tanzania is unknown.

city grain markets. Darbrew seeks to service this demand with industrial-scale production. In Dar es Salaam, the only location where Darbrew currently operates, consumers are perceived to prefer light colored beer made from maize and white sorghum. However, the brewery is considering opening a plant in Mwanza where there may be a stronger preference for red colored beer made from red- or brown-grained sorghum varieties. A brewing plant is also being considered for Mbeya.

In contrast to sorghum beer production in Zimbabwe, Botswana and South Africa, Darbrew uses imported industrial enzymes instead of sorghum malt.[3] There is no commercial malting plant suitable for sorghum in the country.

The main constraint limiting the company's use of sorghum, according to Darbrew, is the poor quality of grain available on the local market. The brewery must have clean grain in order to reduce wear and tear on its steeping tanks. The sorghum available on national grain markets is generally contaminated with sand and stones.

Sorghum must also be priced competitively with maize. The brewery currently considers maize and sorghum to be close substitutes. Maize will be used if it is cheaper and more readily available. However, if consistent supplies of clean sorghum grain are available at prices similar to maize, the brewery will shift back to a sorghum-based brew.

Lager beer

Sorghum is commonly used in the production of lager beer in Nigeria and Rwanda. In Nigeria, most of the sorghum being used in the lager beer industry is for starch (Rohrbach et al. 1992). Either white sorghum or maize is used, depending on which is cheaper. Several smaller breweries also use sorghum malt (probably in combination with industrial enzymes) in the production of lager beer. In addition, Nigeria has a rapidly growing industry for sorghum-based non-alcoholic malt drinks (cf Bogunjoko 1992). In Rwanda, sorghum has traditionally been used as both malt and starch in the manufacture of lager beer. However, the quantities used are unknown.

Despite evidence of the practicality of using sorghum in lager beer, the prospects for such utilization in Tanzania are limited. Domestic brewers are unfamiliar with the use of sorghum, and not interested in experimenting with alternative inputs. Several of these brewers expressed little interest in the use of any type of domestically grown grains, relying instead on imported grain.

Usage in the milling industry

Tanzania's milling industry comprises a few large-scale maize and wheat mills based in the major urban centers, and a growing number of medium- and small-scale maize mills situated in both urban and rural business centers (Mdadila et al. 1996). The number of small-scale mills has grown rapidly as grain markets have been liberalized. Commercial throughput of maize and wheat through formal sector mills is estimated to be 300,000 t and 150,000 t respectively.

Virtually no sorghum or pearl millet is used in the commercial milling industry, either for the production of meal or for the production of flour used to make baked products. Only two small-scale millers, one based in Arusha and the other in Dar es Salaam, were identified as using sorghum. The total sorghum throughput of these mills is estimated to be approximately 40 t per year. Most of this is sold as a specialty product in 1 kg bags in the urban markets of Dar es Salaam, Dodoma, Mwanza, Arusha, and Moshi.

3. This practice changed after this survey was completed. Darbrew currently imports red sorghum malt from South Africa.

Several other small-scale millers mill finger millet meal or mixtures of finger millet meal with the meal of maize or rice. No evidence was found of commercial milling and packaged sale of pearl millet meal.

The survey did not interview the hundreds of small-scale hammermill operators providing service milling in and around larger business centers and urban markets. Many of these entrepreneurs have initiated the semi-commercial milling of maize to complement their service milling operations. Small quantities of maize grain are purchased, and corresponding amounts of milled meal sold from the mill or through nearby retail shops. Many of these operators also mill sorghum on a service basis, largely for the informal opaque beer industry. In a survey by Mlingi et al. (1998), virtually all the 36 small-scale hammermillers interviewed in Dar es Salaam claimed to mill both maize and sorghum. Some also milled finger millet, but none reported milling pearl millet.

No evidence was found that sorghum (or pearl millet) is being used as a compositing ingredient in wheat flour. Tanzania currently imports approximately 100,000 t of wheat per year. White sorghum could readily replace 5% of these imports without affecting the quality of most bread products, but the baking industry appears unfamiliar with this opportunity.

Four main constraints appear to limit the use of sorghum and pearl millet in the milling industry:

- Uncertain demand
- Non-availability of grain
- Thin markets
- Poor grain quality.

Uncertain demand

First, most of the millers interviewed were skeptical about the level of demand for sorghum and pearl millet meal. Efforts to sell sorghum meal have not been particularly successful, as evidenced by the limited quantities on the market. Millers suggest that most consumers have a taste preference for maize, rice, and wheat products. Sorghum or pearl millet meal might survive simply as a specialty product.

The limited size of the market may be partly due to the high price of packaged sorghum meal – commonly more than three times the price of maize meal in major urban markets (Table 5). Such a marketing margin partly reflects the slow sales of sorghum meal, and consequent costs of maintaining product inventory. In addition, sorghum meal is being priced as a close substitute to finger millet meal, which has relatively high grain and processing costs.

However, since market tests for sorghum meal have never been conducted, grain substitution patterns remain essentially unknown. Sorghum may, in fact, be a closer substitute for maize on the domestic foodgrains market. Further studies are needed on consumer taste preferences and on the price elasticity of demand. Certainly, the substantial price premium currently demanded for sorghum meal is not justified by wholesale sorghum grain prices or processing costs.

Table 5. Sorghum versus maize meal prices (Tsh kg^{-1}) in Dar es Salaam and Arusha, March-April 1999.

	Sorghum meal	Maize meal
Dar es Salaam	1000	335
Arusha	1000	200

Source: Informal market surveys conducted in Dar es Salaam (March 1999) and Arusha (April 1999)

No data are available for estimating the elasticity of demand for meal made from different grains. However, if the price of sorghum meal drops close to the price of maize meal, it is likely that demand will sharply expand. Sorghum and pearl millet remain main staples for more than 40% of the country's farmers. It is unlikely that urban migrants from these production zones will simply change their taste preferences upon arrival in a new environment. However, there may be social pressures to consume 'city foods' or the staple grains of higher income groups, such as maize and rice.

Investments in testing urban demand for sorghum (and pearl millet) meal could offer large payoffs. In Botswana, for example, retail purchases of sorghum meal have rapidly increased with the expansion of the sorghum milling industry. Fifteen years ago, less than 10,000 t of sorghum meal was annually sold through retail shops. According to early 1999 estimates, more than 60,000 t of sorghum meal is now commercially sold (Rohrbach et al. 2000). This growth is attributed to many factors, including the ready availability of sorghum grain, and government support for development of the milling industry. In addition, the majority of people in Botswana still view sorghum as a traditional staple. However, the rapid growth in the consumption of commercially manufactured sorghum meal, once it became readily available on the market, is still remarkable.

Non-availability of grain

A second major factor limiting the commercial milling of sorghum and pearl millet in Tanzania is the limited and inconsistent availability of clean grain. This problem is partly explained by the limited historical market demand for these crops. Whereas maize and rice are broadly identified as cash crops, sorghum and pearl millet are known as subsistence crops. Few traders look for these grains, so farmers have little incentive to produce a consistent surplus.

In addition, incentives to develop the market for sorghum and pearl millet are reduced by the variability of grain production. Rains may be favorable one season, leading to a significant surplus, and then unfavorable over the next two to three seasons, causing a deficit. In any given year, traders are uncertain about the location and level of marketable surpluses. The variability of grain surplus reduces incentives to invest in building grain trading infrastructure in semi-arid zones. Marketing costs are further raised by the low population density in many semi-arid areas. Traders may have to visit five villages to assemble one truck load (35 t) of sorghum grain — in high-potential areas, this quantity of maize grain may be easily found in one village. In consequence, markets in sorghum-growing areas are characterized by fewer traders, fewer trucks, fewer grain assembly points, and higher marketing margins than in most maize production zones.

Thin markets

Sorghum markets in Tanzania are best characterized as thin. Only small quantities of grain are traded. As a result, wholesale prices are highly variable across time and space. Also, the difference between wholesale market prices in different parts of the country do not reflect transport and related marketing costs. They are more likely to reflect localized differences in grain supply and demand. In comparison, wholesale prices for maize in different markets are closely related.

The variability of sorghum prices is increased by the fact that most sorghum entering the market is used by small-scale, informal brewers for the production of opaque beer. The elasticity of demand in the informal brewing industry appears low; when grain supplies are short, local brewers will pay a premium price for sorghum in order to ensure the integrity of their product. These costs are simply passed on to the customer. At the same time, sorghum traders are willing to sit on limited stocks for

extended periods of time. They know that if the sorghum is not sold this week it may still be sold, at a higher price, a month later. Wholesale prices take account of these storage costs.

In contrast, maize trade is characterized by rapid turnover. New stocks enter the market each week. Grain traders will consistently return to the rural market when supplies run short. As a result, grain prices are less variable. A further review of these price relationships is provided below.

Grain quality control

Finally, grain quality is more variable in sorghum and pearl millet than in maize. The range of varieties grown and traded are more variable than maize in terms of color, size, shape, and hardness. If grains are mixed, mill extraction rates decline. If a consistent type of grain is sought, marketing costs may rise.

In addition, millers complain that sorghum is more difficult to clean compared to maize. When sorghum is threshed, sand and stones are commonly picked up and deposited in the grain bags. These are similar in size and color to the grain, and therefore difficult to clean.

Usage in the stockfeed industry

Analysts from the Marketing Development Bureau of the Ministry of Agriculture and Cooperatives estimated that in 1995, approximately 290,000 t of grain annually were used by animal feed manufacturers in Tanzania (MAC 1998). Of this grain, 60% (about 172,000 t per year) is used for the production of poultry feed, 30% (87,000 t) for dairy feed, and 10% (31,000 t) is used for pig feed.

These estimates appear high, however, compared with estimates reported by animal feed manufacturers in the survey. The manufacturers estimated total grain feed demand at around 5000 t per month or 60,000 t per year. Most of this is believed to be used for chicken feed.

The 1999 survey also found no evidence of sorghum or pearl millet use in the commercial stockfeed industry. Stockfeeders expressed two major concerns about the use of these grains. First, sorghum and pearl millet are perceived to have lower nutritional value than maize. The energy content of sorghum is viewed to be 15-20% below that for maize. Pearl millet is perceived to have a lower energy content than sorghum.

In fact, animal feed manufacturers in Tanzania appear to be underestimating the nutritional value of sorghum. In most feed formulations white sorghum offers about 92% of the digestible nutrients and metabolizable energy of maize (Table 6). This may be increased depending on how the sorghum is processed. Brown sorghum has a slightly lower nutritional value due to its tannins. However, high-tannin sorghum can be readily used if a lower price justifies the marginal loss in feed efficiency. Some stockfeeders claim that animals will not consume high-tannin brown sorghum. If animals are given a choice, this may be correct. However, if no choice is available, the high-tannin grain will be consumed (cf Rooney 1992, Amira 1992).

Several respondents voiced a perception that all sorghums have tannins. This view is not correct. Only a small subset of sorghum varieties, classified as brown in color, have enough tannin to affect the nutritional value of the grain. These include the variety Serena, which was commonly promoted for production in Tanzania during the early 1980s; and many of the ‘red’ sorghum varieties grown in the Lake Zone.

The main advantage of brown sorghum is that tannin in the seed coat discourages predation by birds. Thus, brown sorghum may be the only type that can be grown in areas of high bird population. However, bird populations are spatially variable, and there are many areas in Tanzania where white sorghum suffers little or no appreciable bird damage.

Table 6. Nutritional values of sorghum, pearl millet, and maize.

Nutrient analysis (as is), %	Brown sorghum	White sorghum	Pearl millet	Maize
Crude protein	10.4	10.0	11.7	7.7
Total digestible nutrients	72.7	79.0	78.0	85.0
Metabolizable energy (mcal kg^{-1}) (pig)	2.94	3.19	2.85	3.47
Metabolizable energy (mj kg^{-1}) (dairy)	11.0	11.93	9.54	13.00
Crude fiber	2.1	2.0	2.9	2.3
Fat	3.1	3.0	4.3	4.5
Ash	1.5	2.1	2.9	1.5
Calcium	0.01	0.04	0.02	0.00
Phosphorus	0.30	0.30	0.27	0.14
Available phosphorus	0.09	0.09	0.08	0.13
Sodium chloride	0.13	0.13	0.02	0.00
Magnesium	0.15	0.15	0.16	0.10
Sulfur	0.12	0.16	0.12	0.12
Lysine	0.18	0.22	0.23	0.24
Methionine	0.09	0.18	0.20	0.18
Total source amino acids	0.18	0.27	0.54	0.37
Tryptophan	0.09	0.10	0.17	0.07

Source: Atlas of Nutritional Data on US and Canadian Feeds, 1971, cited in Amira 1992

Pearl millet offers stockfeeders an input of more variable quality, depending on the type of feed. The metabolizable energy of pearl millet is about 73% that of maize in dairy rations and 82% that of maize in pig rations. However, pearl millet contains a higher level of amino acids than either sorghum or maize. Both sorghum and pearl millet generally have higher protein content than maize.

According to specialists in the Zimbabwe animal feeds industry (cf Amira 1992), white sorghum can replace 100% of the maize used in poultry and ruminant diets (Table 7). Pearl millet can replace 50% of the maize in these same diets. Red sorghum can be used up to 15% in poultry rations, and 30% in ruminant rations, without substantial reduction in feed quality.

Table 7. Limits on the use of fine milled sorghum and pearl millet in feeds for various classes of animals (% maximum inclusion).

Class of livestock	Brown sorghum	White sorghum	Pearl millet
Poultry			
Broiler	12	No limit	50
Layer	15	No limit	55
Pigs			
Growing	20	No limit	No limit
Breeding	20	No limit	0 (not suitable)
Ruminants	30	No limit	No limit

Source: Adapted from Amira 1992

Several feed manufacturers questioned how feed value is affected by grain processing. Complaints were expressed about the tendency of sorghum to disintegrate to powder when crushed in a hammermill. As a result, sorghum grain intake by poultry is viewed to be less efficient than for maize. This problem can be reduced by using harder-grained sorghum varieties. In addition, further investment in grain processing may offer a competitive advantage in a growing market. Much of the sorghum feed used by poultry in the United States is in the form of pellets. Much of the sorghum feed used by ruminants is flaked or puffed.

The main constraint limiting the use of sorghum and pearl millet in Tanzania's feed industry is the perceived lack of grain at prices competitive with maize. One stockfeeder did not believe that sorghum or pearl millet were major crops in Tanzania, but most larger animal feed manufacturers indicated a willingness to use these grains if they were priced 15-20% less than maize, and were readily available throughout the year. None expressed a willingness to look for sorghum or pearl millet grain in the rural market, or to promote the development of production to support the industry.

The conservative views of the industry were reinforced by concerns about company viability in an evolving market. Several companies complained about growing competition from small-scale feed manufacturers with lower quality standards. Cheaper feeds with low nutrient content are being sold in competition with expensive feed mixes of higher quality. Some companies are selling feed largely derived from maize or wheat bran. However, few consumers have the expertise to tell the difference. In consequence, the market for high-quality animal feeds produced by the formal sector has shrunk.

Are Sorghum and Pearl Millet Grain Prices Competitive?

Sorghum prices generally track 5% less than the price of yellow maize in the international market. This difference reflects the relative value attached to these grains in the global market for animal feeds. Since the international market places a premium on food quality white maize, sorghum prices tend to trade around 10% below this price. Little pearl millet is traded in international markets. And most of this is priced at premium levels set by the European market for bird seed (cf ICRISAT 1996).

On Tanzania's domestic market, the ratio of sorghum to maize price is substantially more variable. Following favorable harvests, sorghum prices may decline 30-40% below the price of maize. Following drought or periods of severe grain shortage, sorghum prices may rise above maize prices.

This variability is exemplified in the record of recent sorghum and maize wholesale prices in the Dar es Salaam market. The 1996 harvest was excellent in most parts of Tanzania, and sorghum prices in the Dar es Salaam market dropped 46% below the price of maize (Table 8). Over the next 12

Table 8. Wholesale sorghum and maize prices in Dar es Salaam, July 1996 to Dec 1997.

	Sorghum (Tsh per 100 kg)	Maize (Tsh per 100 kg)	Sorghum price discount relative to maize (%)
Jul-Sep 1996	5679	10,531	46
Oct-Dec 1996	7659	9211	17
Jan-Mar 1997	9687	12,302	27
Apr-Jun 1997	14,672	14,176	–3
Jul-Sep 1997	13,478	13,971	4
Oct-Dec 1997	10,196	14,283	29

Source: Marketing Development Bureau

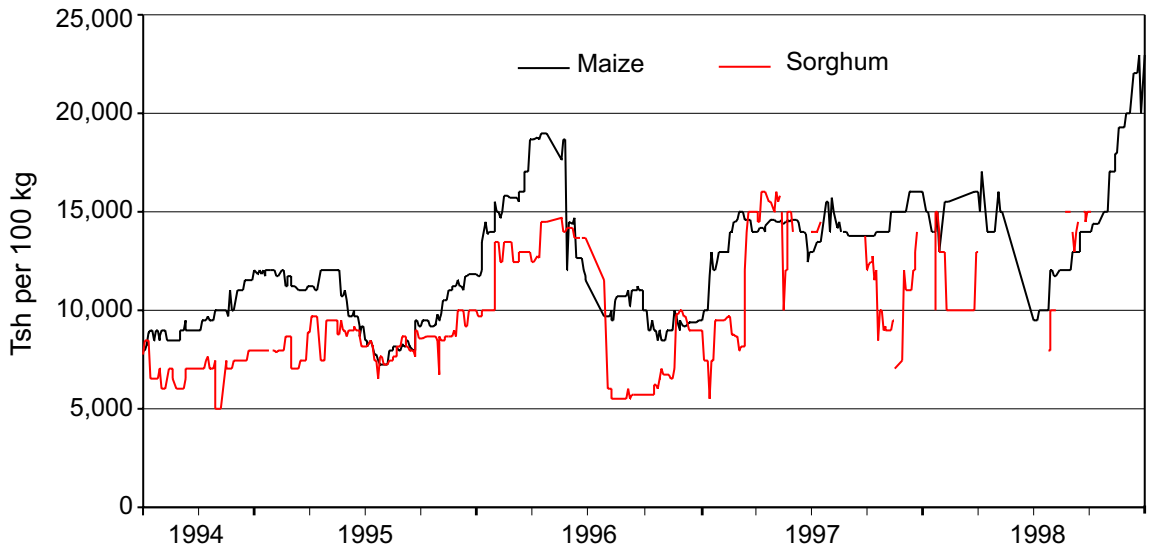

Figure 2. Wholesale maize and sorghum prices in Dar es Salaam, 1994-98.

months, this margin fell sharply. By the 1997 pre-harvest period, sorghum and maize prices were virtually equal in Dar es Salaam. But following the 1997 harvest, sorghum prices again fell below those for maize. By the last quarter of 1997, sorghum could be obtained at 29% lower than the cost of maize.

In general, Dar es Salaam's sorghum prices remained substantially below maize prices for most of the period from July 1994 to Dec 1998 (Fig 2). However, the thin market for sorghum grain caused substantial week-to-week variability in prices. According to government statistics, the cost of a 100 kg bag of sorghum could rise by 25% within a week, and then quickly fall once a new shipment of grain arrived in the market.

In Dodoma, sorghum prices more closely track those for maize. This suggests that sorghum and maize are, in fact, relatively close substitutes for direct human consumption in this region. If relative maize prices rise, households will switch to sorghum. If sorghum prices rise too high, consumers will choose maize. In most seasons, sorghum tends to cost 5-10% less than maize. However, sorghum will become more expensive than maize following a drought season.

In Mwanza, maize prices appear substantially more seasonal than sorghum prices – falling sharply after the grain harvest and then rising gradually until the next harvest. The more limited changes in sorghum prices probably reflect the consistency of grain supply from surrounding farming areas, and the willingness of traders to hold small inventories for sale into the opaque beer market. The limited availability of grain in late 1997 and most of 1998 caused greater fluctuations in both sorghum and maize prices.

Sorghum prices in the three markets appear closely related to localized forces of supply and demand. If supplies are limited, the traditional small-scale brewing industry will bid up the price of sorghum, even to levels well above the price of maize. This is because sorghum and maize are not particularly close substitutes in the production of traditional beer. But if sorghum supplies are adequate, prices quickly drop below those for maize. By implication, efforts to improve the level and consistency of sorghum supplies should increase the competitiveness of sorghum relative to

maize. Development of the sorghum market could well reduce farmgate and millgate prices to levels consistently below those for maize.

Seasonality and storage costs

The high seasonal variability of wholesale grain prices in most markets justifies investments in post-harvest purchases and grain stockholding. This is particularly true for sorghum grain stored after a favorable harvest. In Dar es Salaam, sorghum purchased during the July-Sep quarter of 1996 could be stored at a 30% average annual interest charge, and still be substantially cheaper than maize. In fact, depending on storage costs, it may even have paid to store this sorghum for a 2-year period, because poor rains during the 1996/97 cropping season led to a general escalation of both maize and sorghum prices.

The seasonal variation in sorghum prices is even more apparent in the record of Dar es Salaam wholesale prices during the 1998/99 marketing year. The combination of poor rainfall during the 1996/97 cropping season, and floods affecting market deliveries in 1998, drove sorghum prices sharply higher than maize prices in early 1999. The rise in maize prices was offset by imports of maize from Kenya and South Africa. However, no sorghum was imported, and shortages of grain on the market led the small-scale brewing industry to bid up sorghum prices to unprecedentedly high levels compared with maize.

These price relationships also indicate the value of grain imports for stabilizing prices. Sorghum could have been readily imported from the international market during this period. The landed cost of sorghum would likely have been 5-10% less than the landed cost of white maize. To make imports worthwhile, however, substantial quantities would need to be purchased.

The high variability in both sorghum and maize prices raises questions about the apparent lack of investment in grain storage facilities in and around Dar es Salaam. The National Milling Corporation maintains excess storage space, but private millers do not trust the parastatal to maintain their grain (Mdadila et al. 1996). There are likely to be high economic returns to selling off this facility to private traders. Alternatively, grain processors may be encouraged to invest in expanding their storage infrastructure through various sorts of investment incentives.

Purchasing from the farmgate

Unexpectedly, wholesale prices for sorghum tend to be lower in Dar es Salaam than in most up-country markets, particularly in the months immediately following the harvest. The low prices in Dar es Salaam may reflect the common practice of traders to purchase grain directly from producers. Some farmers bring their grain directly to the city market, but most of the remaining grain entering the city market is purchased from farmers by intermediary traders. There is little evidence that sorghum grain moves between different wholesale markets. Rather, each business center seems to maintain enough independent grain stocks to satisfy local market demand, largely from small-scale brewers.

The prevailing patterns of maize trade are a little different. Maize is more commonly assembled in village and regional markets just after harvest. Most of this grain is shipped to the urban market, although some stocks are also maintained in the rural assembly point. Correspondingly, maize wholesale prices are consistently lowest in the rural and regional wholesale markets during the months following the harvest. They rise above urban prices during the months preceding the next harvest, as grain supplies become more limited in rural areas.

Table 9. Margins between wholesale and retail prices (Tsh kg^{-1}) for maize and sorghum in Dar es Salaam.

	Sorghum		Maize	
July 1996	wholesale price	60	wholesale price	97
	retail price	200	retail price	144
	difference	140	difference	47
July 1997	wholesale price	140	wholesale price	133
	retail price	300	retail price	159
	difference	160	difference	26
July 1998	wholesale price	92	wholesale price	100
	retail price	286	retail price	219
	difference	194	difference	119
March 1999	wholesale price	420	wholesale price	230
	retail price	800	retail price	238
	difference	380	difference	8

Source: Market Information Services, Marketing Development Bureau

If sorghum markets become more developed, the trading relationships for this commodity should become similar to those for maize. Regional assembly points would bulk grain for the urban market. This should reduce the costs of grain assembly and further reduce the price of sorghum relative to maize.

Wholesale versus retail grain prices

The underdeveloped nature of sorghum markets, compared with those for maize, is readily apparent in the margins between wholesale and retail prices in Dar es Salaam. Maize wholesale prices generally track maize retail prices fairly closely. In contrast, sorghum wholesale price is often half to one-third the retail price (Table 9). These differences can be explained by the fact that maize grain is commonly purchased by the 100 kg bag. This grain is then taken to a nearby hammermill for pounding into meal. In contrast, sorghum tends to be purchased by the kilogram. Small quantities are used for sorghum meal, but the dominant share is used for the production of opaque beer.

The large price margins demanded by retail traders are a further sign of the limited quantity of sorghum traded on the wholesale and retail markets. The retailer incurs higher trading and storage costs per unit of grain traded. End users tolerate this because of the limited substitution opportunities for the production of opaque beer.

Can Sorghum and Pearl Millet Supplies be Assured?

Concerns about the size and consistency of sorghum (and pearl millet) supplies were heightened, at the time of this diagnostic survey, by the general shortage of grains on the Tanzanian market. While the 1998 harvest was favorable, market deliveries were constrained by nationwide flooding and the loss of road infrastructure. Wholesale market prices for sorghum and maize had increased to unprecedented levels. Maize was being imported from Kenya and South Africa.

The limited deliveries of grain to urban wholesale markets, despite a favorable harvest in 1998, exemplifies the main constraint affecting sorghum and pearl millet deliveries. Market infrastructure, including the process of grain assembly and transport, is not well developed in many sorghum and pearl millet production zones. Even if roads are in good shape, farmers and traders are not oriented toward delivering large quantities of grain to the national market.

Grain processors interested in using sorghum or pearl millet will need to invest in the development of these trading linkages. This requires improvements in communication to rural communities regarding industry demand for these crops. Companies concerned about reducing grain delivery risks may formally contract for the supply of grain of specified quality. Alternatively, a rural community may be encouraged, prior to the planting season, to supply a given quantity of grain to a particular trader or end user.

Several years of effort will be required to build up enough trust between a rural community and a grain buyer to ensure a consistent, high quality grain supply. Farmers are often suspicious of traders offering promises at the beginning of the cropping season. It may take several seasons before quality standards for grain delivery are widely known and accepted by farmers. Once trade flows are established, however, these transaction costs should drop sharply.

The consistency of grain supply also depends on the variability of harvests. Between 1991/92 and 1997/98, the national sorghum harvest ranged from a high of 872,000 t in 1996 to a low of 499,000 t in 1997. This variation is almost entirely related to rainfall-induced variability in yield. However, such variability does not affect all sorghum-growing regions equally. In Dodoma, a major potential source of sorghum supply for Dar es Salaam, yields declined from 1.25 t ha^{-1} in 1996 to 0.68 t ha^{-1} in 1997. Over the same period, yields in Morogoro declined only marginally, from 1.4 to 1.2 t ha^{-1}. Yields in Mwanza declined from 1.6 to 1.2 t ha^{-1}.

According to government statistics, variability in sorghum production is not significantly different from variability in maize production. The national maize harvest ranged from 2.8 million t in 1995 to 1.8 million t in 1997. Average maize yields in Dodoma declined from 1.6 t ha^{-1} in 1996 to 0.6 t ha^{-1} in 1997. Yields in Mbeya similarly dropped from an estimated 2.8 t ha^{-1} in 1995 to 1.7 t ha^{-1} in 1997 and 1998.

Industry can reduce its risks by concentrating its purchases in areas less prone to drought. Efforts to promote a more commercialized production system should also encourage farmers to adopt technologies capable of improving yield stability, e.g. more timely planting and weeding.

Industry has two options for coping with sorghum supply shortfalls. First, Tanzanian industry can complement maize and wheat imports with imports of sorghum grain. There is a well developed global market for sorghum, with approximately 7 million t being traded each year. Most of this grain is used in the international stockfeed industry. But Botswana, for example, annually imports at least 50,000 t of grain for direct human consumption. Food grain quality standards would simply need to be specified in the same terms as is commonly done for maize and wheat. This sorghum should be readily available from most of the large grain exporters, including the United States, Argentina, Australia, and China.

Alternatively, sorghum (or pearl millet) grain shortages should naturally encourage a shift in utilization patterns offsetting at least a portion of the price variation. As sorghum availability declines, sorghum prices will rise. The most price-sensitive industries, such as the stockfeed industry, will quickly shift to alternative inputs. This shift will reduce the upward pressure on sorghum prices. Once sorghum supplies become plentiful and prices drop to 10-15% below those for maize, the stockfeed industry would face an incentive to shift back to the use of sorghum.

Prospects for Expanding Industrial Utilization of Sorghum and Pearl Millet

The interviews and data analysis underlying this study provide a basis for estimating the quantities of sorghum and pearl millet that might be used by Tanzania's commercial food and feed industry 5 to 10 years from now. Some of these targets can be achieved within a few years. Others require medium-term investments in market development.

Within the next 5 to 10 years, Tanzania's food and feed industry could be using over 30,000 t of sorghum and pearl millet in the domestic milling, baking, brewing, and stockfeed industries (Table 10). Once sorghum trading links become firmly established, these levels of utilization could double.

Commercial opaque beer

The easiest opportunity for expanding the use of sorghum is in the opaque brewing industry. A target of 75% substitution over the next 5 years would create a demand for 1800 t per year of high quality white sorghum. This demand could possibly double once Darbrew's new breweries planned for Mwanza and Mbeya are commissioned.

The main constraint limiting the expanded use of sorghum in opaque beer is the lack of adequate quantities of clean grain. Yet this problem appears readily resolved with a firmer effort to purchase white sorghum grain immediately following the harvest. The probability of a successful purchase can be further improved by promoting production specifically for the industry. This can be accomplished by formally or informally contracting for grain at the beginning of the planting season.

Contracting for production is a common practice employed by industries seeking to ensure access to a particular input, particularly if the quality of that input is important. For example, the opaque brewing industry in Zimbabwe offers written contracts for most of the 17,000 t of sorghum grain purchased annually. These contracts are issued with an allotment of seed at the beginning of the planting season. Distribution of seed ensures the delivery of varieties with good malting qualities. The sorghum malting industry in South Africa similarly contracts for most of its sorghum supply, and also widely distributes information about its grain quality requirements.

Grain production contracts are best managed with a few large-scale producers. The costs of administering thousands of contracts with smaller-scale producers tend to be prohibitive. Darbrew can resolve these problems in two ways. The company could contract with a few traders for the bulk of its supply, encouraging them to communicate its needs to target groups of farmers, e.g. in several districts of Dodoma. Or the company could work with extension services to encourage the expansion of production for its requirements.

In order to improve grain quality, contracts or extension programs could be linked with seed distribution of a particular variety of acceptable brewing quality. White sorghum may be sought for beer destined for sale in one part of the country (e.g. Dar es Salaam) and red sorghum may be sought to supply a brewery in another part of the country (e.g. Mwanza) where darker sorghum beer is preferred.

Darbrew has also expressed concerns about the cleanliness of its grain intake. This may be ensured by either promoting better threshing methods on the farm, or through the purchase of grain cleaning equipment. Cleaner threshing can be obtained by using mechanical threshers, though these are difficult to manage when the crop must be obtained from many scattered small-scale farmers. Alternatively, farmers can be encouraged to thresh their grain on tarpaulins or on cement threshing floors, as is done in some parts of the country for rice.

Table 10. Commercial grain demand and potential use of sorghum and pearl millet, 1999.

Product	Current annual utilization, all grains	Current annual utilization, sorghum or pearl millet	Potential annual utilization, sorghum or pearl millet	Targets for substitution	Grain quality requirements
Meal	300,000 t [1]	40 t	15,000 t	5% substitution of maize; mostly sorghum, limited quantities of pearl millet	Large white grains clean of foreign matter, sand and stones
Wheat flour	150,000 t [2]	0	7500 t	5% substitution of wheat; all sorghum	Large white grains clean of foreign matter, sand and stones
Animal feed	60,000 t [3]	0	6000 t	10% substitution of maize	Low tannin grains preferred
Opaque beer	2500 t [4]	0	1875 t	75% substitution of maize used in Dar es Salaam brewery	White sorghum clean of foreign matter, sand and stones
Urban and peri-urban small-scale opaque beer	1500 t [5]	1250 t	1250 t	Assumes little or no maize is used	Clean red or white sorghum depending on region
Lager beer	unknown	0	0	Unlikely at this time	White sorghum

1. Mdadila et al. 1998. This report does not include the large quantities of grain flowing through the small-scale milling industry. Roughly 50% of throughput is estimated to be through large and medium-scale maize mills and 50% through small-scale mills
2. Extrapolation from FAO imports database
3. Estimate derived from interviews with major stockfeed manufacturers
4. Estimate from Darbrew interview
5. Estimate derived from information about sorghum flows into wholesale markets of Dodoma, Arusha, and Dar es Salaam

However, reliance on the farmer to ensure clean grain leaves the possibility that grain lots may be contaminated between the farm and factory gate. This problem can be resolved by investing in grain cleaning equipment, either by grain traders supplying Darbrew or by the brewery itself. ICRISAT has recently identified a grain cleaner capable of meeting these needs. A small grain cleaner manufactured for the wheat industry in South Africa has proven capable of removing stones, sand, and dirt from sorghum and pearl millet. The machine is suitable for small to medium-scale milling operations, offering a throughput of up to 4 t hr^{-1}.

Animal feeds

The main constraint limiting the use of sorghum and pearl millet by Tanzania's animal feed industry is the relative grain price. Yet a review of historical price data from Dar es Salaam's wholesale markets indicates that sorghum should be competitively priced, relative to maize, in most years. Animal feed manufacturers should be able to guarantee themselves a white sorghum supply at prices 15-20% below the price of maize, particularly if it is purchased immediately following the harvest. If stockfeed manufacturers purchase grain only when needed during the year, there is justification for using sorghum during the post-harvest period when prices are lowest relative to maize. The industry can then switch to maize as sorghum prices rise (relative to maize) during the pre-harvest season.

The competitiveness of sorghum prices can be improved by broadly encouraging sorghum production as a commercial crop. Sorghum is currently viewed simply as a food security crop. Semi-subsistence production limits the adoption of improved technology. Maize tends to be managed more carefully, in part because of the perception that it can be more readily sold. If farmers perceive a similar demand for sorghum, they are more likely to shift more land to this crop, plant it on a more timely basis, and provide better weed management. Each of these management changes offers the prospect of higher productivity, more consistent harvests, and lower grain prices.

In the occasional year of severe drought, white sorghum supplies will inevitably be limited. Based on past evidence, sorghum prices can be expected to rise well above the price of maize. In such cases, the industry can use imported sorghum grain to offset shortfalls in domestic production.

Concerns about the nutritional value of sorghum should be allayed by the fact that sorghum is a major feed grain traded on the global market. There is ample evidence that sorghum offers nutritional value similar to maize. However, uncertainty about these data may justify technical support from an international stockfeed specialist familiar with the use of both maize and sorghum in various types of animal feed. This specialist could be obtained from South Africa or the United States, where sorghum is widely used in animal feed.

Several industry representatives expressed concerns about how the nutritional value of sorghum feed is related to processing methods. The puffing and flaking commonly practiced in the United States improves the nutritional value of sorghum relative to maize. Similarly, there may be justification for examining the profitability of feed pelleting, a common practice with sorghum used for poultry feed. Such investments may reduce the margin between sorghum and maize feed values close to the 5% price differential evidenced on the global stockfeed market. However, technical assistance may also need to be sought here.

Finally, the animal feed industry would benefit from stricter quality standards in the labeling of feed mixes, and from extension campaigns to educate farmers about the relative value of alternative feed formulations. Feed manufacturers should have the freedom to use whatever ingredients they believe appropriate. However, consumers need a basis to compare mixes with varying types and levels of inputs. Poultry growers, in particular, may benefit from extension advice targeting improvements in feed efficiency. Demand for poultry products can be expected to grow quickly as national incomes rise.

Five years from now, sorghum could account for at least 5% of the grain used by the national stockfeed industry. If sorghum supplies become more consistent and prices remain competitive, this could readily increase to 20% of grain throughput. The demand at a 5% substitution rate for maize is roughly estimated at 5000 t per year.

Grain milling

The potential size of the market for milled sorghum and pearl millet meal is most difficult to estimate, largely because of uncertainty about the strength of consumer preferences for alternative grains. Preferences are as commonly affected by social pressures encouraging the consumption of 'superior' food products, as by taste and relative price. Recent market tests in Zimbabwe, for example, reveal that sorghum meal is more likely to be consumed by higher-income households than in low-income neighborhoods. In lower-income urban areas, surveys reveal that consumers are concerned about the social stigma attached to the purchase of 'inferior' cereal grains. High-income consumers view sorghum porridge as a health food.

By the same token, the consumption of sorghum meal has rapidly expanded in Botswana over the past 10 years. The grain, once perceived as an inferior product at least in urban areas, is now considered a main staple. Sorghum consumption looks set to overtake maize consumption on the national market. And several millers are trying to develop a similar market for pearl millet meal.

The current market for sorghum meal in Tanzania is extremely small. There is almost no market promotion. Sorghum meal sells at a large price premium over maize meal. It is impossible to determine how much meal could be sold with a more competitive price and an investment in product promotion.

Most immediately, the size of the market for sorghum and pearl millet meal in Tanzania needs to be more methodically tested. This includes the use of advertising and product promotion to encourage consumers to try the new meal product. Investments are required in testing the demand for alternative types of meal (including alternative extraction rates) and various sorts of packaging (e.g. clear plastic or paper). The price sensitivity of consumer demand needs to be evaluated. How will sorghum meal sales be affected if this product is placed on the market at a price similar to maize meal? What if the price of sorghum meal is set 5% below the price of maize meal? An analysis of the market must also consider opportunities for segmentation. Sorghum (or pearl millet) meal sales may first be targeted to urban communities whose residents originate from sorghum (or pearl millet) growing regions.

If the market is to be developed, millers need to ensure themselves a consistent source of clean grain every month of the year. In effect, this industry would be competing with opaque beer brewers and animal feed manufacturers for the same grain. The strategies pursued can be similar to those discussed for Darbrew above, including contracting for grain and the use of grain cleaning equipment. Again, if millers are willing to work with farm communities at the beginning of the season, and to help farmers commercialize production, they are more likely to ensure themselves a consistent grain supply.

The milling industry should set a target of replacing perhaps 5% of the maize meal sold in Dar es Salaam with sorghum meal. In addition, the baking industry may profitably aim to replace 5% of the wheat used for bread and biscuits with sorghum flour. The combined usage could generate a demand for over 20,000 t of grain per year.

The prospects for pearl millet are less favorable than for sorghum given the generally higher price for this grain, and lower average yields and labor productivity. However, there may be a small market niche for pearl millet-based meal, particularly in urban communities originating from pearl millet production zones. The milling industry could test this market with an initial throughput of 500 to 1000 t of pearl millet grain per year.

Complementary Government Investments in Commercializing Sorghum and Pearl Millet

Most of the recommendations outlined above depend on the initiative of private sector companies in the food and feed industry. However, with relatively minor complementary investments the government of Tanzania can improve the probability that such initiatives will be profitable.

Market information

The government already invests substantial resources in the collection and dissemination of market information on grain prices and availability. Yet most of the industry representatives interviewed expressed uncertainty about these data. The impact of the current data collection effort may be improved by better advertising the availability of this information to industry and evaluating the demand for alternative sorts of data. Data of strongest interest to the industry could be sold to end users.

In addition, reporting may need to be geared to the specific needs of particular end users. What data do grain traders most need to improve their trade efficiency? What data are required by specific industries to improve input supply and reduce production costs? Market information systems are commonly employed by public agencies to diagnose grain shortages or market failures. What information would encourage reconsideration of the commercial viability of sorghum? Ultimately, a unit such as the Marketing Development Bureau could provide a sort of consulting service to industry. First, however, the Bureau needs to evaluate what sorts of data, types of analyses, and forms of reporting are most useful to the private sector.

Market infrastructure

The multiple payoffs from improvements in road and related transport infrastructure are well known. These should be particularly evident after the grain shortages in Tanzania's major urban markets despite a relatively favorable 1998 harvest.

The brief review of price data in this survey also highlights the pressing need for investment in grain storage and stockholding. This should target a substantial reduction in seasonal variation in grain prices. Between mid 1998 and early 1999, wholesale maize prices in Dar es Salaam increased from Tsh 100 to Tsh 250 kg^{-1}. By the beginning of the 1999 harvest (in June), prices had dropped back to Tsh 160 kg^{-1}. Over the same period, wholesale sorghum prices increased from Tsh 80 to Tsh 420 kg^{-1} before dropping back to Tsh 180. Both maize and sorghum prices began to decline during the 1999 harvest. Though the 1998/99 marketing season was particularly difficult, similar variability is evident in the wholesale price data for Dar es Salaam during the 1995/96 and 1996/97 marketing years.

A 50% reduction in seasonal price variation would provide farmers a higher product price while reducing the costs of grain to urban consumers. A steadier market would likely also reduce trading costs. This can be accomplished by encouraging private traders and the grain processing industry to hold larger grain stocks. The appropriate forms of government support for this stockholding merit further investigation. However, these are likely to include efforts to improve capital availability to grain traders and a clarification of the trading strategies underlying national grain security stocks.

Input supply

While several new varieties of sorghum and pearl millet have been released in recent years, almost no farmers have access to these varieties. The parastatal Tanseed produces small quantities of sorghum

seed, but no pearl millet seed. Several NGOs have also invested in the production of sorghum seed, but the quantities remain small relative to national requirements. And the distribution networks necessary to get this improved seed into the hands of most farmers remain extremely limited.

Fertilizer use also remains rare. Yet broader application of this input could readily change Tanzania's status from being a country commonly dependent on grain imports to one commonly exporting grain to other countries in eastern and southern Africa.

At the margins, the grain processing industry may assist with the dissemination of seed and fertilizer to target groups of farmers. However, broader solutions are necessary to ensure a sustainable flow of these inputs to the majority of Tanzanian farmers. These include the need to reallocate a portion of the public research funding allocated to crop breeding to the maintenance of breeder and foundation seed. Breeders should be evaluated, in part, on the basis of variety adoption. Are farmers gaining access to the varieties breeders are developing and releasing? Fertility management scientists similarly need to concentrate on promoting better targeting of smaller quantities of chemical fertilizer, rather than on identifying 'ideal' application rates that small-scale farmers will never adopt.

The largest problem of crop input supply relates to distribution. Tax subsidies may encourage sustained private investments in seed production and marketing for secondary crops. Capital support, for example in the form of targeted loans, may be distributed to rural retailers willing to hold seed and fertilizer inventories. NGOs can be called upon to provide technical support to improve the efficiency of retail trade, for example assistance with the mechanics of book-keeping, inventory control, and calculation of trading margins.

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Annex 1. Area and production of sorghum, millet, and maize in Tanzania, 1990-98.

	Sorghum		Millet		Maize	
Production year	Area (´000 ha)	Production (´000 t)	Area (´000 ha)	Production (´000 t)	Area (´000 ha)	Production (´000 t)
1989/90	380	568	178	200	1631	2445
1990/91	600	750	256	200	1848	2331
1991/92	683	850	309	263	1908	2226
1992/93	642	719	325	210	1824	2282
1993/94	664	478	340	218	1629	2159
1994/95	690	839	376	411	1654	2567
1995/96	690	872	376	367	1646	2663
1996/97	623	499	354	347	1529	1832
1997/98	488	673	204	na	2028	2750
1998/99	na	na	na	na	na	na

na = data not available
Sources: Area data from FAO 1999, production data from Food Security Department, Ministry of Agriculture and Cooperatives

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.

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