TRADITIONAL AFRICAN CEREAL GRAINS - OVERVIEW

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INTRODUCTION

Africa is the centre of origin and still today the major producing area for several cereal crops, notably sorghum, pearl millet, finger millet, teff, fonio and African rice. These traditional African cereals are sometimes called "Orphan Crops", or even "Lost Crops" (National Research Council, 1996). This is despite the fact that they are staple foods for millions of people in the semi-arid regions of the world, particularly in Africa and India, and especially particularly those who live by subsistence farming. Table 1 lists most of these African cereal grains, although the list is certainly incomplete, as others such as Ethiopian barley and oats are cultivated on a very limited scale and some are simply collected as wild seeds (National Research Council, 1996).

Table 1. The major African cereal grains

Generally used English name	**Other common vernacular names used in English**	**Proper name**
Sorghum	Grain sorghum, Milo	*Sorghum bicolor* (L.) Moench
Finger millet	Ragi, Wimbi	*Eleucine coracana* L. Gaertn.
Teff	Tef, Teff grass, Abyssinian lovegrass	*Eragrostis tef* (Zuccagni) Trotter
White fonio	Fonio, Acha, Fonio millet, Hungry rice	*Digitaria exilis* (Kippist) Stapf
Black fonio	Black acha, Hungry rice	*Digitaria iburua* Stapf
Kodo millet	Creeping paspalum Ditch millet Indian paspalum Water couch	*Paspalum scrobiculatum* L.
Pearl millet	Bulrush millet, Cattail millet, Babala, Bajra/Bajira	*Pennisetum glaucum* (L.) R. Br.
Guinea millet	False signal grass	*Urochloa deflexa* (Schumach.) H. Scholz
African rice		*Oryza glaberrima* Steud.

Information mainly from the USDA Germplasm Resources Information Network (GRIN) (GRIN, 2007)

This paper gives an overview of the production and cultivation of these African cereal grains, their nutrient composition, traditional foods and beverages made from them and looks at some new developments. The paper also identifies problem areas with respect to these grains which impact negatively on food security and economic development of people in the developing world.

PRODUCTION AND CULTIVATION

Table 2 shows that sorghum, pearl millet and finger millet are widely grown grains, both in Africa and elsewhere. In contrast, the production of the other African cereals is very limited

both in quantity and distribution. Teff is almost entirely limited to Ethiopia, fonio to the Sahel region and African rice to marshlands of West Africa (National Research Council, 1996).

Table 2. Production of the most important African cereal grains (thousands of metric tons).

Grain	World production	African production	Major producing countries (in descending order)
Sorghum	58,700	23,282	USA, Nigeria, India, Mexico
Millets (total)	29,295	9,557	India, Nigeria, China, Niger
Pearl millet	13,351	7,330	Nigeria, Niger, Burkina Faso
Finger millet	3,763	855	India, China, Uganda, Nepal
Teff	Very low	1,063	Ethiopia, South Africa, Australia
Fonio	309	309	Mali, Burkina Faso, Guinea, Nigeria

Data mainly from FAOSTAT (2004), ICRISAT/FAO (1996) and Obilana and Manyasa (2002)

With regard to sorghum, in Africa, sorghum is the second most important cereal after maize, accounting for some 17% of cereal production (FAOSTAT, 2004). Worldwide it is the fifth most important cereal after wheat, maize, rice and barley, but only 8-9% of the level of the each of the first three and 37% of barley. Pearl millet is by far the most important millet produced both in Africa and worldwide (ICRISAT/FAO, 1996). All the other millets only account for about 1% of world food grain production (House, 1995). However, mere total world production is not necessarily a guide to the traditional African cereals. In resource-poor developing countries, they play a critical role in food security on account of their agronomic characteristics. The most important of these are drought-tolerance and the ability to grow in low rainfall regions. This can be seen clearly from their distribution of production. Sorghum production is concentrated in areas where the rainfall is less than 500 mm on account of its drought-tolerance, i.e. the northern parts, dry parts of the countries of west Africa, the semi-arid parts of East Africa and dry western parts of southern Africa, in particular Botswana (ICRISAT/FAO, 1996). The situation is even more extreme with pearl millet as it will grow in areas with rainfall as little as 250 mm, it is cultivated in the desert margin areas of the Sahel region of west Africa, and northern Namibia/southern Angola. Fonio is cultivated in the Sahel region at the end of the crop rotation period and during famine, when the land is not even suitable for pearl millet (Smith, 1996); hence its common name of Hungry Rice.

Despite the relative importance of some of these cereals, inter country trade in them is very limited, for example with sorghum and almost non-existent in the case of millets. With sorghum a major problem is that grain quality standards are not well developed (Niernberger and Taylor, 2001). With the millets, the problem is more fundamental in that there is scarcely any commercial production. These factors contribute to food insecurity in sub-Saharan Africa and hamper development of processing industries based on these grains. A related problem is the very low yields of these grains obtained. For sorghum the average yield in Africa is <0.8 tons/ha and for millets it is <0.7 tons/ha (FAOSTAT, 2004). This can be attributed to poor farming practices; including use of unimproved landraces, low or no fertilizer addition, poor soil fertility, poor soil moisture management, lack of weeding, bird predation and grain moulds (ICRISAT/FAO, 1996). The impact of mechanised, high input agriculture can be seen from data from South Africa and the USA where hybrid sorghum is cultivated, the yields are 3.5 and 4.4 tons/ha, respectively (FAOSTAT, 2004).

NUTRITIONAL VALUE

Table 3 shows that basic nutrient contents of the African cereal grains are generally typical of cereals. The protein content appears to be lower than that of wheat. However, this is merely a reflection of the fact that this particular type of wheat has a high protein content. What is not shown is that the African cereals do not contain gluten-forming proteins. In fact they can be safely consumed by people suffering from coeliac disease, or who allergic or intolerant to wheat, rye and barley (Taylor et al, 2006). Of the African cereals, pearl millet probably has the best nutrient composition. As can be seen it has the highest protein, fat and energy contents, and its protein is relatively rich in the essential amino acid lysine. The good nutritional value of pearl millet is due to the fact that it has proportionally large germ that is rich in high quality protein and oil.

A major issue is that there is a lack of accurate nutritional data on African cereal grains, as reflected by the obviously too high values for calcium in finger millet and teff. In fact, much of the available nutritional data on millets does not even identify which millet species was analysed, for example in the Encyclopedia of Grain Science (Schakel et al., 2004). Even worse, this may be compounded by meaningless statements, for example "Millet is a high-energy, nutritious food, especially recommended for child, convalescents and the elderly" (ICRISAT/FAO, 1996).

Table 3. Typical nutrient values of African cereal grains compared to wheat (data expressed on a 12% moisture basis)

Nutrient	Sorghum[1]	Pearl millet[2]	Finger millet[2]	Teff[2]	Fonio[2]	African rice[2]	Wheat (hard red spring)[1]
Protein (%, N x 6.25)	11.6	11.5	7.3	9.5	9.0	7.1	15.9
Carbohydrate (%)	77	70	74	72	75	75	69
Fat (%)	3.4	4.7	1.3	2.0	1.8	1.8	1.9
Dietary fibre (%)	9.1-11.5	9.7	11.7	-[3]	-	-	12.3
Ash (%)	1.6	2.3	2.6	2.9	3.4	3.5	1.9
Calcium (mg/100 g)	29	36	358[4]	157[4]	44	23	25
Iron (mg/100 g)	4.5	9.6	9.9	5.7	8.5	1.9	3.6
Energy (kJ/100 g)	1374	1443	1396	1390	1503[4]	1392	1389
Vitamin A (µg Retinol equivalents)	10-20	22	6	8	-	-	3
Lysine (g/100 g protein)	2.0	3.1	2.5	2.3	2.5	4.1	2.6

[1]USDA (2007), [2]Values from National Research Council (1996), unless otherwise specified
[3] - = value not reported, [4]Value questionable

Concerning grain components not shown in the table, some varieties of sorghum and finger millet contain substantial amounts of condensed tannins (procyanidins or proanthocyanidins). Up until recently, these have been regarded as antinutrients due to their interaction with dietary protein and other nutrients. However, there is increasing evidence that their health-promoting properties resulting from their very high antioxidant activity outweigh these

negative aspects (Dykes and Rooney, 2006). It is important to note most varieties of sorghum and certainly some varieties of finger millet do not contain tannins. However, most African cereal grains contain substantial amounts of non-tannin phenolics, which also have high antioxidant activity.

PROCESSING TECHNOLOGIES AND FOODS

There is steady development in processing technologies for these traditional grains. Milling using the combination of dehuller and hammer mill has been widely adopted across Africa (Bassey and Schmidt, 1989). A dehuller has even been developed for the very small grains like fonio (Smith, 1996). African cereal grains are extremely versatile foodstuffs and are processed into a very wide range of traditional food and beverage products, as shown in Table 4. By far the most common products are porridges and gruels which come in a bewildering range of consistencies and flavours, from alkaline to sour. However, large-scale commercial production of the African cereal grain food products is still rather limited; opaque beer (sorghum beer) brewing in southern Africa being a notable exception. Also of concern is that maize and to a lesser extent wheat are steadily displacing the use of traditional African cereals in many of these products. This is probably taking place simply because these commercially produced grains are more readily available.

Table 4. Food and beverage products made from African cereal grains

Category of product	**Specific type**	**Examples**[1]
Whole grain foods	Rice type	African rice (Nigeria)
		Pearl durra (sorghum, Sudan)
	Popped and puffed grains	Kollo (popped sorghum, Ethiopia)
		Popped finger millet (India)
Food from meal and flour	Fermented flatbreads	Injera (teff, finger millet) Ethiopia)
		Kisra (sorghum, Sudan)
	Unfermented flatbreads	Roti (sorghum, India)
		Kitta (sorghum, Ethiopia)
	Couscous	Pearl millet, sorghum, Mali
	Dumplings and doughs	Dinkgwa (sorghum, South Africa
		Maasa (sorghum, west Africa)
	Stiff porridges	Ting (sorghum, fermented porridge, Botswana)
		Tô (pearl millet, sorghum, alkali porridge, Mali)
	Thin porridges and gruels	Uji (finger millet, alkali porridge, Kenya)
		Atmit (sorghum, unfermented, Ethiopia)
Beverages	Non-alcoholic beverages	Oshikundu (pearl millet, fermented, Namibia)
		Kunun zaki (pearl millet, white fonio, Nigeria)
	Beers	opaque beer (sorghum, southern Africa)
		Tella (teff/finger millet, Ethiopia)
	Spirits	sorghum (China)
		Katikalla (teff, Ethiopia)

[1]Information from many sources, particularly personal communications

NEW DEVELOPMENTS

Fortunately, there are a number of positive developments taking place with regard to the production and utilisation of traditional African cereals. Probably the most fundamental new development is that of NERICA, the new rice for Africa. NERICA is a cross between African rice and common rice (*Oryza sativa* (L.)) (WARDA, 2007). It combines the high yield potential of common rice with African rice's resistance to the biotic stresses in tropical Africa. NERICA has been highly successful in West Africa for where it was originally bred and is now being evaluated in east Africa.

Recombinant DNA technology has not been applied to traditional African cereals to any great extent (O'Kennedy et al., 2006). This is probably because there is little financial incentive for seed companies because of the fact that these grains are mostly cultivated by small-scale farmers. One exception is the Africa Biofortified Sorghum (ABS) project (Supersorghum, 2007). The ABS project is using genetic engineering to develop a sorghum line with improved nutrient composition, including improved protein quality and digestibility, elevated levels of vitamins A and E, and improved iron and zinc bioavailability.

Regarding manufacture of foods from traditional African cereal grains, in recent years there have been many successes, especially in the area of convenience-type foods aimed at the rapidly growing middle-class urban population. In South Africa, there are several instant sorghum-based porridge products. The sorghum flour is pre-cooked so that to make a porridge it is only necessary to stir the flour into boiling water. In east Africa there are many protein- and micronutrient-enriched finger millet- and sorghum-based flours on the market. What characterises these products is that they are based on traditional foods, normally porridges, and often they are acidified with fruit acid to mimic the natural lactic acid fermentation flavour.

A more radical development is the brewing of lager beers and stouts from sorghum. This started in Nigeria in the 1980s when the government of that country banned the importation of barley malt in order to save foreign exchange. Although the ban has long since been rescinded, sorghum is still the grain of choice for brewing. More recently, sorghum lager brewing has started in east and southern Africa (Mackintosh & Higgins, 2004). Apart from sorghum's intrinsically good brewing quality, what is driving this brewing revolution is economics. It is far cheaper to use locally grown sorghum. A further important advantage is that brewing with sorghum provides a guaranteed market for local farmers.

CONCLUSIONS

Notwithstanding these important developments, traditional African cereal grains are still chronically underutilized, to the detriment of the wellbeing of the people of Africa and elsewhere. In fact, of the seven cereal species listed by the Global Facilitation Unit for Underutilized Species five are African cereals (GFU, 2007). A major reason for their underutilization is that they are under-researched. For example, Food Science and Technology Abstracts finds 13,919 publications with the word wheat in the title but only 1,975 and 670 featuring sorghum and millet(s), respectively (FSTA, 2007). Obviously, the danger is that traditional African cereals will fall further and further behind the so-called major cereals if this knowledge gap continues to increase. Thus, the challenge for researchers working on traditional African cereals is to think and act smarter, hence this workshop.

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