SORGHUM: AN ENVIRONMENTALLY-FRIENDLY FOOD AND INDUSTRIAL GRAIN IN NIGERIA

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INTRODUCTION

Sorghum (*Sorghum bicolor* (L) Moench), locally called guinea-corn, is the most extensively grown cereal grain in the country (Aba *et al*., 2004). The crop is environmentally-friendly as it is water-efficient, requires little or no fertilizers or pesticides and is biodegradable (FAO, 1995). In the savanna and the semi-arid regions of Nigeria, millions of people consume sorghum in their daily diets as staple foods (Obilana, 1981). These foods are high in energy and nutrition and are therefore recommended for the infants, pregnant and lactating mothers, the elderly and the convalescents (Obilana, 2005). Sorghum is also used as a raw material for lager beer brewing (Aisien & Muts, 1987). In Nigeria, the most widely used varieties for this purpose are: SK5912, KSV8 and ICSV400 (Ogbonna, 2002). Large-scale beer production with these varieties was however hampered due to some biochemical problems including inadequate proteolysis resulting in low FAN and low extract yields. Our research efforts with these varieties have recorded: greater proteolysis, increased FAN and extract yields as well as a better understanding of the physico-chemical, catalytic and molecular properties of the sorghum malt proteases (Ogbonna *et al*., 2003a&b; 2004a&b; Ogbonna & Okolo, 2005; Ogbonna, 2007a&b). In this paper, sorghum is presented as an environmentally-friendly food and industrial grain in Nigeria. The highlights are on its cultivation, adaptation, breeding & selection, processing & utilization and application in malting and beer brewing.

SORGHUM CULTIVATION IN NIGERIA

About 50% of the total area devoted to cereal crops in Nigeria is occupied by sorghum. The area estimated at 6.86 million hectares extends north-wards from latitude 8^0N to latitude 14^0N (Aba, *et al.*, 2004). In 1978, the total sorghum production in Nigeria was estimated at 4.8 million tonnes (Obilana, 1981). This figure has risen to about 7.0 million tonnes annually (Obilana, 2005). Consequently, Nigeria becomes the highest sorghum producer in the West African sub-region, accounting for 71% of the regional total sorghum output. Globally also, the country leads in sorghum production for human consumption and has risen from its fifth position in 1995 (FAO, 1995) to be the third largest producer of sorghum in the world after the USA and India where more than 90% of their sorghum harvest is used for animal feed (Obilana, 2005).

ADAPTATION TO ENVIRONMENTAL CONDITIONS

Sorghum is adapted to a wide range of environmental conditions, particularly, drought. Hence, it is widely grown in different ecological zones of Nigeria (Showemimo *et al*. 2000). It has a number of morphological and physiological characteristics that contribute to its adaptation to dry conditions. These include: an extensive root system, waxy bloom on the leaves that reduces water loss, ability to stop growth in periods of drought and resume when conditions are favourable as well as tolerance to waterlogging (FAO, 1995). The crop equally grows on a wide range of soils: sand, loam, sandy loam, saline and alkaline soils with a pH range of 4.0-8.5 (Aba *et al*., 2004).

SORGHUM BREEDING & SELECTION

The most common landraces of sorghum in Nigeria are: Kaura, Farafara and Guinea (Curtis, 1967). They are variously tolerant to striga (a parasitic weed) in all the savanna zones and are agronomically alike. Sorghum improvement by breeding started in Nigeria in 1956, however, years of selection at the Institute of Agricultural Research (IAR), Samaru, Nigeria, have resulted in the development and release of sorghum varieties suited to specific ecological zones (Aba *et al*. 2004). Varieties have equally been developed with suitable qualities for industrial uses. The best performing and highest yielding among these are listed in Table 1.

SORGHUM PROCESSING & UTILIZATION

Processing

Sorghum is the most amenable cereal grain to different processing technologies including: primary, secondary and tertiary methods (Obilana, 2005). Primary processing involves: fermentation, malting, wet & dry milling, boiling, roasting and popping. Secondary processing involves; brewing, beverage & drinks production, baking and confectionery making, steaming, extrusion (for pastes & noodles), while tertiary processing involves: composite flours (mixing of cereal/cereal flours, cereal/legume flours, cereal/cassava flours), biofortification and chemical fortification with additives. The different processing levels and their technologies are achieved using different agro-industrial equipments and machinery. These result in diversified end-products for foods, feeds, beverages, alcoholic and non-alcoholic drinks.

Utilization

The uses of sorghum in Nigeria can be grouped into two: traditional and industrial. The traditional uses include a variety of traditional foods, beverages and drinks while its non-food traditional uses include: thatching of roofs and fencing of compounds. Sorghum consumption for food is mainly in the form of flour or paste processed into two main dishes: “OGI” or “AKAMU”, a thin porridge and “TUWO”, a thick porridge. Other dishes that are sometimes made from sorghum include a number of deep fried snacks, steamed dumplings, etc (Obilana, 1981). Of all the cereal crops, sorghum contributes about 50% of the calories in Nigeria generally and about 73% in the savanna regions of the country in particular (Simons, 1976). Sorghum foods are also high in minerals, vitamins and some essential amino acids which are further enhanced through biofortification thus, making them superior to other cereal foods. They contribute more energy and digestible protein in the diets of the majority of the people in the sub-saharan regions than those obtained from root and tuber crops (Aba et al. 2004). In addition, its polyphenol (mostly tannin) contents are used as antioxidants just as the slow digestibility of sorghum starch and protein makes its foods useful in diabetic treatments.

MALTING AND BREWING WITH SORGHUM

The malting/brewing properties of the three improved Nigerian sorghum varieties are comparable with those of barley malt (Table 2).

Inadequate proteolysis, low wort FAN and low extract yields, have been tackled through the use of cysteine hydrochloride (Cyst.HCl) as an extractant. Consequently, carboxypeptidase and proteinase enzyme activities in the three sorghum malts (Ogbonna *et al*. 2003a), extract yields (Ogbonna, 2007a) and FAN development (Ogbonna *et al*. 2003b; 2004a) were greatly optimized. Our studies (Figure 1) also revealed that sorghum malt variety KSV8 contains two distinct proteases: a cysteine protease with relative molecular weight of 16KDa (Ogbonna *et al*. 2003c) and a metalloprotease with relative molecular weight of 35 KDa (Ogbonna & Okolo, 2005).

Sorghum variety SK5912, contains two cysteine proteinase enzyme isoforms with relative molecular weights of 55 and 62KDa, respectively (Ogbonna *et al*. 2004a) just as sorghum variety ICSV400 equally contains two serine protease isoforms with relative molecular weights of 59 and 63 KDa, respectively (Ogbonna, 2007b). Incidentally, the optimum temperatures (50^0C) and pH (5.0 – 6.0) of activities of these enzymes are similar to the conditions in a brewery mash tun making their participation in protein degradation very imperative.

Table 1: Improved early-maturing, medium-maturing and late-maturing sorghum varieties released by the IAR, Samaru, Nigeria, for different ecological zones

Release Name	New Name	Characteristics	Ecological zone
KSV4(BES)	SAMSORG-3	Short season type: maturity period = 95-105 days; seed colour: cream; potential yield: 1.5-2.5 ton ha^{-1}.	Sudan Savanna Ecology
KSV11	SAMSORG-5	Short season type: maturity period = 95-105 days; seed colour: white; potential yield: 1.5-2.5 ton. ha^{-1}	
KSV12	SAMSORG-6	Short season type: maturity period = 95-105 days; seed colour: cream; potential yield: 1.5-2.5 ton. ha^{-1}	
ICSV400	SAMSORG-40	Short season type: maturity period = 95-100 days; seed colour: cream; potential yield: 2.5-3.5 ton. ha^{-1}; used for malting and brewing.	
ICSV111	SAMSORG-41	Short season type: maturity period = 95-100 days; potential yield: 2.5-3.5 ton. ha^{-1}.	
NR71176	SAMSORG-38	Short season type: maturity period = 95-105 days; seed colour: cream; potential yield: 1.5-2.5 ton. ha^{-1}.	
NR71182	SAMSORG-39	Short season type: maturity period = 95-105 days; potential yield: 1.5-2.5 ton. ha^{-1}.	
KSV7	SAMSORG-13	Medium season: maturity period = 130-145 days; seed colour: cream; potential yield: 1.5-2.5 ton. ha^{-1}.	Northern Guinea Savanna Ecology
KSV8	SAMSORG-14	Medium season: maturity period = 130-140 days; seed colour: white; potential yield: 2.5-3.0 ton. ha^{-1}, used for malting and brewing.	
SSV7 (L.1499)	SAMSORG-21	Medium season: maturity period = 150-160 days; seed colour: white; potential yield: 3.0-3.5 ton. ha^{-1}.	
SSV9 (L.243)	SAMSORG-23	Medium season: maturity period = 150-160 days; seed colour: cream; potential yield: 2.5-3.5 ton. ha^{-1}.	
SSV10 (L.533)	SAMSORG-24	Medium season: maturity period = 150-160 days; seed colour: cream; potential yield: 2.5-3.5 ton. ha^{-1}.	
KSV3 (SK.5912)	SAMSORG-17	Long season: maturity period = 165-175 days; seed colour: yellow; potential yield: 2.5-3.5 ton. ha^{-1}; used for malting and brewing, livestock and confectionary.	Southern Guinea Ecology
SSV2 (FBL)	SAMSORG-16	Long season: maturity period = 165-175 days; seed colour: white; potential yield: 2.5-3.5 ton. ha^{-1}; used for malting and brewing.	

Sources: Adapted and modified from Aba *et al*. 2004

Table 2: Malting and brewing properties of some sorghum varieties

Malting/Brewing property	Sorghum malt variety			Barley malt
	SK5912	KSV8	ICSV400	
Protein (Nx6.25 %)	10.20	10.0	11.0	11.0
Germinative energy (%)	96.0	97.0	96.0	>95
Germinative capacity (%)	96.5	90.5	95.5	96.0
Optimum steeping time (h)	40.0	45.0	40.0	Variable
Optimum germination time (days)	5.0	5.0	5.0	5.0
Malting loss (%)	19.0	18.0	20.0	7.0
CWE (%)	38.0	43.0	43.0	20
HWE (L^0/Kg)	261.0	359.0	354.0	303.0
FAN (mg/L)	145.0	167.0	172.0	259.0

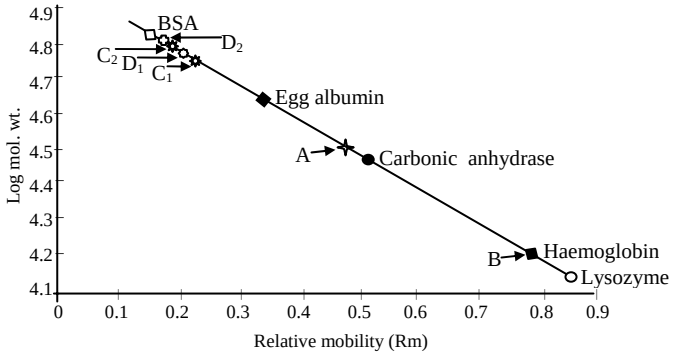

Figure 1: Estimation of molecular weights of purified sorghum malt proteases using SDS-PAGE. Marker proteins used were:BSA (66KDa); Egg albumin (45KDa), Carbonic anhydrase (31KDa); Haemoglobin (16KDa); lysozyme (14.6KDa); A = metalloprotease from sorghum malt variety KSV8-1 (35KDa); B = cysteine proteinase from sorghum malt variety KSV8-1 (16KDa); C_1 & C_2 = a cysteine proteinase from sorghum malt variety SK 5912 (55KDa & 62KDa respectively); D_1 & D_2 = a serine protease from sorghum malt variety ICSV 400 (59KDa & 63KDa respectively).

CONCLUSIONS

Relative to other cereal grains, sorghum is the most widely cultivated and most widely utilized food and industrial raw material in Nigeria. The significant increases recorded in some of its malting and brewing properties using cysteine hydrochloride (Cyst.HCl) as extractant suggests that other such properties could equally be higher than those of barley malt if proper extraction procedures are adopted.

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