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Full Length Research Paper

Sorghum: Most under-utilized grain of the semi-arid Africa

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The review alluded to the fact that sorghum is the second most important grain in Africa and that its production has improved greatly over the past four decades. It maintained that about 300 million people from the developing countries rely on sorghum as a source of energy, and that the grain stands to contribute more to food supplies and food security of these countries if well explored. It showcases the nutritional credentials of sorghum, and reveals the potentials of sorghum as raw material for the Nigerian brewing, food, textile, and beauty industries. Furthermore, it gave the local recipes for some major sorghum foods. Conclusively, it recommended that there should be an increased research investment in sorghum, and that more needs to be done in the propagation, utilization, marketing and improvement of the marketing potentials of the grain in all its forms.

Key words: Nutrition, raw material, production, food security, grain.

INTRODUCTION

Sorghum (Sorghum L. Moench) also known as guinea corn in West Africa and locally called Okababa, Dawa, and Okili in Nigeria belongs to the tribe Andropogonae (FAO, 1995). It is the fifth most important cereal crop by acreage after wheat, rice, maize, and barley globally; it is cultivated on marginal, fragile drought-prone environments in the semi-arid tropics of Africa and Asia, and it is a crop genetically suited to hot and dry agro ecologies where it is difficult to grow other food grains (ICRISAT, 2004).

Sorghum has a fibrous root system that could penetrate up to 8 feet into the soil and that makes it one of the hardiest cereals.Sorghum is one of the oldest known grains of Africa and India where it is commonly used in a variety of foods. From tonnage perspective, sorghum is the second most important cereal in Africa; its production has increased significantly over the past 40 years from 10 million metric tonnes to 26 million metric tonnes (FAO, 1998). Nigeria and Sudan produces about 63% of Africa's total production (FAO, 1995).

Grain sorghum is the most commonly cultivated agronomic type of sorghum worldwide, and in Africa, it is a very important part of the diet which could be in the form of boiled porridge or gruel, unleavened bread, and rice-like products (Berenji and Dahlberg, 2004). Sorghum is one of the most important staples in the semi-arid tropics of Africa and Asia; it is the principal source of energy, protein, vitamins and minerals for millions of the poorest in these regions (FAO, 1995). However, human consumption is decreasing with enhanced socio-economic status of population in general and easy availability of much preferred cereals in abundance and at affordable prices (Sheorain et al., 2000).

Sorghum is a global crop; it is known as kafferkoren, soedangrass, and suikergient in the Netherlands, mtatam, shallu or feterita in East Africa, kaoliang in China, durra in Egypt, chicken corn or guinea corn in the United Kingdom, milo in Middle East Africa, jola, jowa, cholam, bisinga or durra in India, kaffir corn in South Africa, sorgo, milo or sudangrass in USA and guinea corn, feterita, sorghum, or sorgho in West Africa (Dicko et al., 2006).

The consumption trend of sorghum is very similar to

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Table 1. Chemical and biological data of sorghum on dry weight basis.

Parameter	Dry weight
Protein %	9.6
Fat %	4.5
Available carbohydrate	67.4
Crude fibre %	4.8
Ash %	3.0
Calories per 100g	447
Protein digestibility %	84.8
Net protein utilisation %	50
Utilizable protein %	4.8
Digestible energy %	79.9

Source: Khan and Eggum, 1978.

global pattern of output since most of the grain is consumed in countries where it is grown, like many lesser known grains sorghum is basically used as animal feed in the developed countries of the world (Mason, 2010). About 300 million people from the developing countries essentially rely on sorghum as a source of energy (Godwin and Garry, 2000). The grain stands to contribute more to food supplies and food security than at present, especially, for developing countries and others in dire need around the globe. African Agricultural Technology Foundation (AATF) (2010) maintained that the cereal accounts for 37% of the total food grain produced in drier regions of West Africa, and that its importance as food security crop became more pronounced when the Nigerian government banned the importation of barley in 1986.

Sorghum originated and was domesticated around 5000 to 8000 years ago in north eastern Africa or at the Egyptian-Sudanese border (Wendorf et al., 1992). Damania (2002) holds a contrary view and maintained that sorghum originated in the Indian subcontinent. The sorghum kernel varies in colour from white through shades of red and brown to pale yellow to deep purple-brown, however, the most common colours are white, bronze and brown. Sorghum grain is basically spherical, they vary in size with various flavours associated with each (Purseglove, 1972).

A 1000-kernel weight has a range of value from 3 to 80 g, but in most varieties, it is between 25 and 30 g (FAO, 1995). Sorghum is the fifth most important cereal crop in the world; only rice, wheat, maize, and potatoes are more highly consumed than sorghum (Dahlberg et al., 2011) and it is the most important cereal crop in Nigeria (Agboola, 1979). While the total food consumption of all cereals have risen greatly in the past 35 years, the global food consumption of sorghum has remained stagnant and this can be tied to it being seen as an inferior grain by most people (FAO, 1995).

Sorghum plant is a potentially attractive raw material for food, feed, fuel and industry (Hallgren et al.,1992). Grain sorghum is the most commonly cultivated agronomic type of sorghum worldwide (Berenji and Dahlberg, 2004). In 2009, 82% of harvested area of sorghum was within Africa and Asia (FAO, 2011). Sorghum can be classified into four main groups depending on their production characteristics: grain sorghum, forage sorghum, high-tonnage sorghum, and sweet sorghum (Shoemaker and Bransby, 2010). The most common cultivars in West Africa is the S35, ICSV 111, and ICSV 400 (ICRISAT, 2004), while the most common in Nigeria is the KSV3-SK5912, KSV8, and ICSV400 (AATF, 2010). Global production of sorghum is currently estimated at 57.6 million tons (Rao et al., 2005), and Nigeria produces about 8 million tonnes of sorghum.

Sorghum is one of the crop priorities of the Nigerian government's Agricultural Transformation Agenda (Sorghum Transformation Plan) (FMI, 2013). Sorghum by far, is the largest staple cereal crop in the country (NAERLS, 1996); out of 8million tonnes of sorghum produced in the country only 120,000 tonnes are utilized by industries (Murty et al., 1996).

The bulk of sorghum grown in Nigeria is grown in the Northern Guinea and Sudan/Sahel ecologies in the following states of Nigeria: Kaduna, Kano, Jigawa, Borno, Plateau, Bauchi, Adamawa, Gombe (Aba et al., 2005). Development of commercial sorghum offers substantial benefits to Nigerian farmers and National food security. Sorghum displays a unique agricultural adaptability to a world in ever increasing need for more food (Koleoso and Olatunji, 1992); it assumes greater importance in the economies of several African countries whose farmers are largely having limited resources and who are at subsistence level (ICRISAT, 2004).

On the health parlance, sorghum has strong anti-proliferative activity against colon cancer cells (Yang et al., 2009) and its bran may protect against diabetes and insulin resistance (Farrar et al., 2008). It is safe for people who react to gluten proteins found in wheat, barley and rye (Ciacci et al., 2007); it could be used as food ingredients or dietary supplement to control cholest-

Table 2. Essential amino acid composition of sorghum (g/16 g N).

Amino acids	Composition
Lysine	2.7
Tryptophan	1.0
Threonine	3.3
Isoleucine	3.6
Leucine	11.2
Tryosine	3.6
Phenylalanine	4.4
Histidine	2.2
Methionine	2.3
Cystine	2.2
Valine	4.7

Source: Khan and Eggum, 1978.

Table 3. Percentage of protein fractions in sorghum protein.

Sorghum protein	Percentage of protein fractions
Albumins	11.2
Globulins	9.7
Prolamines	7.6
Glutelins	18.9
Residual	52.7
Total protein extracted	47.4

Source: Pushpamma, 1968.

Table 4. Amino acid composition of sorghum flour and sorghum bread (g/16 g N).

Amino acid	Sorghum flour	Sorghum bread
Valine	4.7	4.7
Isoleucine	3.6	3.6
Leucine	11.2	11.1
Tyrosine	3.6	3.5
Phenylalanine	4.4	4.4
Lysine	2.7	2.5
Histidine	2.2	2.0
Arginine	4.6	4.0
Methionine	2.3	2.3
Cystine	2.2	2.3
Tryptophan	1.0	1.0

Source: Khan and Eggum, 1978.

-erol levels in humans (Carr et al., 2005); has higher antioxidants compared to other grains and fruits (Awika and Rooney, 2004), and slows the growth of cancer generally in human (Gomez et al., 2001).

Sorghum, though, seen as food security crop in many parlances, it is also a source of income for many African households (Anglami, 1998). Awareness about the crop and its often not known uses would in the long run bring the crop out of its seeming obscurity, and will ultimately lead to increase in its demand and production. This would not only raise farmer's income but would be good for the balance of trade of the country; surplus productions is exported, or and sorghum flour is used in place of wheat-flour domestically.

Promotion of and the consumption of sorghum which is among the objectives of this review would also impact

Table 5. Chemical composition (dry basis) of sorghum flour and sorghum bread.

Parameter	Protein (N × 5.7)	Fat	Available carbohydrate	Crude fibre	Total	Metabolizable	Ca	P	S	Fe
	g/ 16 g N		Cal/ 100 g			mg/ 100 g				
Sorghum flour	6.9	4.5	67.4	4.8	447	425	44.8	313.9	25.9	10.1
Sorghum bread	6.9	4.9	64.8	4.8	446	424	53.9	323.9	35.6	10.7

Source: Khan and Eggum (1978).

positively on the health of Africans in general, and Nigerians in particular. Again, a review of this nature would lead to much needed dissemination of information about the nutritional value of the crop. Furthermore, lasting food security would be elusive in the developing countries, especially, the West African countries where sorghum account for 50% of the total cereal crop land area without a significant improvement not only in the production of the crop, but also in its uses (Dicko et al., 2006), which also is one of the key issues in the review.

SORGHUM AND NUTRITION

Sorghum grain has 95 to 98% of the nutritional value of maize; vitamin content for corn and sorghum is similar but sorghum has a higher mineral content than maize (Balota, 2012). Sorghum grain has a lot of nutritional benefits due to its rich antioxidant properties (Green, 2012). It is higher in protein (11.5 to 16.5%) and calories than several other grains (Martin and MacMasters, 1950). One cup serving (100 g) of sorghum contain 143 g of carbohydrate and 326 calories most of which comes from carbohydrate, 12 g of dietary fibre, and would provide 47% of the recommended daily value for iron based on a 2,000 calorie intake (Thompson, 2010). 100 g (one cup serving) of sorghum contains 325 calories and has 10.8 mg of protein, 0 mg of sugar, 3.1 mg of fat, 6.0 mg of fibre and 0 mg of cholesterol. Sorghum contains the following vitamins and minerals: vitamins B_1, B_2 and B_3, calcium (Ca), potassium (K), iron (Fe), phosphorous (P), and sodium (Na). 100 g (one cup serving) would provide 55% Recommended Dietary Allowance (RDA) of phosphorus, 19% RDA of potassium, 47% RDA of iron, 5.4% RDA of calcium and 0.5% RDA of sodium. Tables 1 – 6 provide in-depth explanations of the many positive attributes of sorghum and its products.

Although, the grain is low in sodium, it has a large amount of iron and a 100 g serving would meet over 50% of the recommended intake of iron for men and 24% for women; this is more iron than that in equal amount of brown rice (Thompson, 2010). Protein is one of the major components of sorghum; the primary function of dietaryprotein is to satisfy the body's need for nitrogen and essential amino acid (FAO, 1995). The average starch content of sorghum is 69.5% (Jambunathan and Subramanian, 1988), and the crude fat content is 3% which is higher than wheat and rice (FAO, 1995). It contains no cholesterol, and like all other grains, has a fairly good amount of carbohydrates that could meet a good deal of recommended daily intake (Thompson, 2010).

Sorghum strengthens the immune system, helps in the elimination of toxic waste from the body, increases endurance, assists in blood cell building, boost appetite, relieves diarrhoea, aids rapid recovery, stimulates cardio-vascular system, stimulates free flow of blood, and lowers cholesterol levels. Sorghum consumption reduces the risk of certain types of cancer in humans (Gomez-Cordoves et al., 2001; Yang et al., 2009). The tannin content of sorghum especially, the brown grain could make it difficult for the human body to absorb other nutrients (Awika and Roonney, 2004), and this makes sorghum the grain of choice for those battling obesity.

In addition, sorghum helps to manage cholesterol; grain sorghum could be used as food ingredients or dietary supplement to control cholesterol levels in humans (Carr et al., 2005), and the bran of the grain may also help protect against diabetes and insulin resistance (Farrar et al., 2008). Sorghum is deficient in lysine, threonine and tryptophan, and the presence of some anti-nutritional factors such as tannins and phytate that interact with proteins, vitamins and minerals reduces the bio-availability of the grain (Ahmed et al., 1996). However, malting, fermentation, and cooking are known to improve the protein digestibility of sorghum by reducing its tannin and phytate content (Okafor, 1981).

Sorghum as raw material for industries

Sorghum is increasingly becoming the basis for a successful food and beverage industries in Nigeria. Industries in Nigeria use about 200,000 metric tonnes of sorghum annually; about a meagre 5% of the total sorghum marketed is channelled to industries as raw material (Sanni et

Table 6. Comparison of composition of sorghum and maize (content %).

Component	Sorghum	Maize
Starch	63 - 68	60 - 64
Moisture	9 -13	8 - 11
Proteins	9 -11	9 - 11
Fat and oils	1 - 1.5	3 -5
Crude fibre	1.5 - 2	1.5 -2
Ash	1 -2	1 - 2
Other organics	8 - 12	7 - 9

Source: Sheorain et al. (2000).

al., 2003). Sorghum flour has been incorporated in wheat flours at various levels to produce cakes, cookies and bread (Abdelghafor et al., 2011). The flour can be blended with other flours and can consist of up to 50% of the flour bread. Consumer acceptance trials in Nigeria of bread made with 0% sorghum flour was akin to 100% wheat flour bread (Aluko and Olugbemi, 1989; Olatunji et al., 1989). A similar study conducted in Sudan reveals that bread made with composite flour of 70% wheat and 30% sorghum flour were accepted (FAO, 1995).Baking has no effect on proximate, fatty acid and amino composition of sorghum flour bread (Khalil et al., 1984); bread made from wholly sorghum flour can be used as a gluten-free replacement for wheat, however, due to the lack of gluten, sorghum bread are generally unleavened (USDA and NRCS, 2006).

Sorghum offers great advantages in the brewing industries (Middleman, 1986), it provides extract at a lower cost than is available from malted barley and it is readily available (Ogbeide, 2011). It is increasingly being used as a substitute for more expensive and important raw material in the Nigerian brewing sector and most of the very successful breweries in the country use sorghum in beer production (Momoh, 2012); its grits are currently used as adjuncts in majority of breweries in Nigeria (Koleoso and Olatunji, 1992). The Federal ministry of science and Technology in conjunction with the Federal Institute of Industrial Research (FIRO) has developed using 50% sorghum malt and 50% barley malt to produce beer; this invention have paved the way for the optimal utilization of sorghum in the brewing sector in the country (Oni, 2013). Again, sorghum malt is being used wholly or partly as a substitute for barley in the production of non-alcoholic malt drink in Nigeria (Eleke, 2011).

Sorghum can also be useful in the production of ethanol and other bio-industrial products such as bio-plastic, especially, in dry areas where other crops cannot be easily grown (McLaren et al., 2003). The cellulose content in sorghum stalk is as high as 48% of dry weight and these stalks can be used industrially to produce sorghum ply board that are much better and lighter than shaving ply board; by using stalks which are mere by-product of sorghum in this way farmers can earn extra money, and the use of wood materials would also be reduced (Zou and Shi, 1999). Furthermore, sorghum pigments are used as dye in the textile industry, as natural colorant in the food industry, and in different fields in the beauty and medical industry (Guang and Guang, 2007).

SOME SORGHUM RECIPES

Food from sorghum can be grouped into two categories, traditional products and non-traditional products. The following are some traditional Nigerian sorghum food recipes:

Thin porridge (Ogi)

Ingredients: De-hulled sorghum grains, water, sugar or salt to taste.
Preparation/method: (1) Soak de-hulled grains in cold water for 18 to 48 h to soften and ferment grains; (2) wash the grains and ground to a coarse paste; (3) screen the slurry through a muslin cloth and discard the coarse particles remaining on the muslin; (4) let the strained slurry stand for 5 to 6 h and pour off the excess water leaving just enough to cover the settled paste; (5) bring water to boil; (6) pour the paste in boiling water (two table spoons for every 6 cups of water) and stir vigorously until paste gelatinizes; (7) cover the bowl and cook for another 2 to 3 min; and (8) serve the thin, hot porridge as it is or add sugar or salt to taste (FAO, 1995).

Stiff porridge (Tuwo)

Ingredients: Flour of whole or de-hulled sorghum.
Preparation/method: (1) Bring water to boil; (2) prepare paste of flour in cold water; (3) add the paste in small amounts to the boiling water and stir vigorously to prevent lump formation; (4) cool the thick porridge; and (5) serve with soup (FAO, 1995).

De-hulled cracked sorghum meal (pate)

Ingredients: Coarsely, ground whole de-hulled sorghum,

spinach, tomato, onion, locust bean cake and chilli. Preparation/method: (1) Bring water to boil; (2) add locust bean cake, onion, chilli, salt to boiling water; (3) add spinach and continue to cook for another 2 min; and (4) serve hot (FAO, 1995).

Fura

Ingredients: Sorghum flour (sifted), hot spice, water, nunu (fermented milk), yoghurt or sour milk.
Preparation/method: (1) Mix flour, water and spice; (2) prepare small round balls (2 to 3 cm in diameter); (3) drop them in boiling water and cook for 30 min; (4) pound cooked balls with water and spice until a smooth elastic and cohesive lump is formed; (5) again, prepare small balls, rolling between the palms of the hands or on a wooden board dusted with dry flour and (6) serve as it is or with nunu, yoghurt or soured milk (FAO, 1995).

Beer (burukutu)

Ingredients: Sorghum grains and pure yeast culture.
Preparation/method: (1) Soak sorghum grain in water overnight; (2) malt for four days; (3) sun-dry the malt; (4) grind the sun-dry malt; (5) mash and sieve; (6) boil mash for 30 min; (7) add old brew or pure yeast culture; (8) ferment for 48 h (2 days) at room temperature; (9) boil to stop fermentation; (10) allow to mature for two days and (11) serve burukutu (Mbajiuka et al., 2010).

CONCLUSION AND RECOMMENDATION

There has to be an increased research investment in sorghum, and more has to be done in the propagation and utilization of the grain; the public and private sector, and international research bodies have a great role to play in this regard (Mason, 2010). Conclusively, more efforts should be channelled to marketing and improvement of the market potentials of sorghum in all its forms; this will make it to survive as a commodity crop or develop into an important value added speciality crop.

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