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Fortified Sorghum as a Potential for Food Security in Rural Areas by Adaptation of Technology and Innovation in Sudan

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Abstract

Sorghum is the major food in Sudanese specially among poorer people, of low nutritional value; to achieve all the nutritional balance. While there are a highly nutritive value pods such like soybean, which contains high protein, fats and essential amino acids that important for human health. Nevertheless wheat has a physical improvement on sorghum cooked products. Moreover, there are many studies in and abroad investigating the nutritional value of soy and sorghum but the fortification is still below the needs. There this is a conceptual study to modify the previous technologies to safe foods by introducing rural technology considering all the production selectors such as; rural agricultural production, rural technology adaptation, rural processing and fortification. The produced fortified sorghum with wheat, soy bean with former fortification additives aimed to safe food and health by modifying local foods in rural and urban areas for pregnancies, infants, children and adults. It based on that presence of a bulk of food materials and capability to produce others, ability to formulate nutritive food and their production technology can access development of food security in rural areas. The methodology depends on the information's obtained from historical literature, historical surveys, proposed proper expected technology for fortification components through basal food quality control of sorghum production, soybean current and future production, technology transfer and adaptability of processing machines, screening and biometrical scientific researches, fortification expecting nutritional balance. Designing of local made machines for milling, boiling, roasting and packaging by transfer of technology and innovation adopted. Formulation of fortified sorghum. Also rural processing technology formulated. The analyzed results of literature, screening tests, survey and scientific results showed that rural production of soybean adaption can well be succeeded, rural manufacturing of the basic and fortified nutritional components can be done, systematic researches on some Sudanese diet such as fortified cooked sorghum soft sheets (*Kisra*), fortified thin porridge (*Madeda*), fortified thick porridge (*Logma or Asida*) with good protein, fats, minerals and fatty acids can be easily adopted. We come to conclude that the adaptation of fortified sorghum technology can be to produce different fortified sorghum products for different kinds of peoples; adults, children, infants and pregnancies. And the theories gave positive results through the analysis of different fortification components through simple technology. Finally tactics and strategies were designated for sorghum fortification.

Keywords: Food security; Nutritional elements; Amino acids; Sorghum; Fortification; Soybean; Porridge

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Introduction

The previous situation is to recover needs for fortifications is for protein-energy malnutrition which is one of the four major forms of malnutrition in developing countries that previously done by adding nutritive components to Sorghum flour. Soybeans is one of the world's most valuable oil seed legumes with tremendous potential for alleviating protein-based malnutrition and the demand for soybean is relatively high because of high cost of other sources of protein such as meat, eggs and even cowpeas [1] used to fortified wheat in many areas of the world. Protein in human diets is obtained from several sources that include cereals vegetables, legumes, meat, egg, milk, and fish, of all these sources from animals was regarded as the best because of its amino acid content [2]; however, the cost of animal protein is increasing every day. For most developing countries, unavailability has resulted in to looking for other alternatives protein sources. new technologies has helped to segregate the readily digestible fractions of foods from non-digestible fraction such as vegetable protein, this has changed the eating habits of many countries that only the digestible are consumed this gradual enriched of cereal based foods with oil seed proteins has receive and considerable attention there has been a trend to incorporate flour from various sources into cereal products such as Soy flour [3].

In Sudan, and other developing countries, shortage of wheat and hard currency to import adequate required quantities have resulted in the use of sorghum, millet and other local cereals for baked products. Sudanese food habit changed and wheat has becomes an essential grain crop and its production represents a special position in agricultural policies, for boosting domestic production and curbs wheat imports.

Food security a condition related to the supply of food, and individuals' access to it. Concerns over food security have existed throughout history. The final report of the 1996 World Food Summit states that food security "exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" Raj [4,5]. The goal of concept: Food insecurity, on the other hand, is a situation of "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways", according to the United States Department of Agriculture (USDA) [6]. Nevertheless also Food safety describing handling, preparation, and storage of food in ways that prevent food borne illness; include the origins of food including the practices relating to food labeling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food guidelines for the management of governmental import and export inspection and certification systems for foods associated with biotechnology and innovation.

Statement of the problem

The problem in Sudan and many African countries is using of low quality cereal crops such as sorghum grains that can lead to malnutrition among poorer peoples specially that affected by conflicts., and the need for fortification is a crucial issue to overcome the nutritional value balance.

The objective of the study

The objective of this study is to design strategies to produced fortified sorghum with wheat, bean and other natural additives aimed to safe food and health by modifying local foods in rural and urban areas for pregnancies, infants, children and adults trough fortifying cooked sorghum soft sheets (*Kisra*), fortified thin porridge (*Madeda*), fortified thick porridge (*Logma or Asida*) with good protein, fats, minerals and fatty acids. And the new product in spite of food security it can be modified as an international diet for native citizens or others. Fortifying sorghum to improve both physical and nutritional value of sorghum different diet through proposed nutritional components and conceptional plane to adopt strategic plane to keep food security, by improvement of traditional food through the following bands ideas and concepts; Food security, safety, biotechnology, Innovation and transmission of technology.

Hypothesis and assumption of the study

The study based on the theory that presence of a bulk of food materials and capability to produce others, ability to formulate nutritive food and their production technology can access development of food security in rural areas. And Food security for healthy food can be achieved through fortification of sorghum for poorer rural peoples. Food fortifications have a positive impact on in food safety and security. And the following assumptions were considered in this study:

1. As food fortified the quality of food improved.
2. Innovations and technology transfer push the development of food security.
3. Training and knowhow for new technology raise food security among poorer.

Methodology

The methodology depends on the previous studies and organoleptic screening, researches through the followings:

Processing technology

The research depends on historical literature, historical surveys, for fortification components through basal food quality control of sorghum production, soybean current and future production, technology transfer and adaptability of processing machines, screening and proposed fortification nutritional balance. And the technology required for designing of local made machines for milling, boiling, roasting and packaging by transfer of technology and innovation adopted. Formulation of fortified sorghum and rural processing technology formulated.

Formulation of fortified sorghum food

Calculation of proposed nutritional factors were carried out by calculation of each nutritional component in each gain and he sum of expected nutritional factors. The proposed nutritive value of 7.0: 2.0: 1.0 by taking 70% Sorghum, 20% soy and 10% wheat flour and mixed with each other to form the fortified flour for different Sudanese sorghum products.

Organoleptic screening

Organoleptic properties of fortified traditional sorghum meals namely; "*Kissra*"a, "*thin porridge*" and "*stiff porridge*". The sensory evaluation by 10 trained panelists; using scoring procedure according to the methods describe by Alabia and Announyle [2]. A numerical hedonic scale ranging is from 1 to 10 (1 is very bad and 10 for excellent) used in former studies for sensory evaluation according to Larmond [7]. Ten experienced judges participated in the evaluation test.

Histological Literature Review

Cereals grains

Starch is the main component in the carbohydrate fraction accounting for 65-75% of the grain dry weight of which wheat starch (29%) [8]. Starch is a carbohydrate primarily comprised of two polysaccharides, namely amylose and amylopectin [9,10].

Sorghum

Sorghum **(Figure 1)** is an important source of energy, protein, vitamins and minerals for millions of the poorest people in these regions. Sorghum and millets are grown in harsh environments where other crops grow or yield poorly. They are grown with limited water resources and usually without application of any fertilizers or other inputs by small-holder farmers in many countries. Therefore, and because they are mostly consumed by disadvantaged groups, they are often regarded to as "coarse grain" or "poor people's crops". They are not usually traded in the international markets or even in local markets in many countries. Sorghum is the one of the first crops in East Africa [11]. It has been important crop in the semi-arid tropics of Asia and Africa for centuries. All of the sorghum cultivars taken into cultivation are belong to *Sorghum bicolor* (L.) *Moench* sp. Which is commonly cultivated incorporated with animal husbandry. Sorghum is the more tolerance to drought and hot temperatures, diseases, pests various soil types and have higher water use efficiency, higher production capacity from unit area [12]. In addition to nutritive value was improved with recent breeding studies. Furthermore, Sorghum x Sudan grass cultivars is recently preferred to corn as summer crop in most regions of World due to global warming [13]. The main leading producers in the world are India, Nigeria, US, Sudan and Mexico **(Table 1)** [14,15].

Figure 1 Sorghum in Sudan.

In Sudan there are many sorghum verities released the most important ones are in **Table 2** [14].

Chemical composition of sorghum: He chemical composition depends on variety and seed parts; composition of some Sudanese varieties chemical composition illustrated in **Table 3**.

All data are expressed on a dry - matter basis [16].

Sudanese foods from sorghum: Sorghum was used to prepare different types of foods as shown in **Table 4**. Sudan one of the African countries in which sorghum represents the first consumed cereal crop. In Sudan, as in other developing countries, inadequate of wheat and hard currency to import sufficient quantities have resulted the needs for use of sorghum, millet and other local cereals for baked products. Therefore are many types of foods the most important ones are; "Fareek" roasted sorghum grains at milky stage [17], "Balila" (boiled sorghum grains) [18], "Kisra" (thin Sheet breads of sorghum) [17], "Accedah or logma" stuff porridge from sorghum flour [17], " Madida or Nasha" thin porridge from sorghum flour [17], "Holomore or abrey" Beverage from cooked [18], rooted fermented thick sheets of sorghum flour, "Bagania" alcoholic beverage from fermented dry "Kisra" [18], "Marisa" Sour opaque beers which is Alcoholic Beverage from fermented sorghum [18], "Aragi" alcoholic beverage from fermented sorghum flour [18]. But the most important ones for food diets are (*Kisra*), fortified thin porridge (*Madeda*), fortified thick porridge (*Logma or Asida*), as showed in Appendix 1-3 [17-19].

Wheat

In Sudan, with food habit change in the 1970s wheat has become an essential grain crop and occupied special position in agricultural policies, for boosting domestic production and curbs wheat imports. Wheat in Sudan ranks second after sorghum in terms of consumption. And there is a progressive increased in wheat products among urban areas. Sudan's wheat consumption per a year supposed to be 1 million tons [20]. Worldwide, wheat

Table 1: Leading sorghum producers, 1990.

Country	Area		Production	
	(10^3 ha)	(% total)	(10^3 ha)	(% total)
United States	3 674	8.3	14 516	25
India	15300	34.5	12500	21.5
Mexico	1 830	4.1	6 230	10.7
China	1900	4.3	5310	91
Nigeria	6 000	13.5	4 000	6.9
Argentina	688	1.6	2 016	3.5
Sudan	2 925	6.6	1 502	2.6
Ethiopia	870	2	1000	1.7
Australia	406	0.9	933	1.6
Burkina Faso	1 250	2.8	917	1.6
Total	34 843	78.6	48 924	84.1
World	44 352	1 00	58190	1 00

Table 2: Some important released Sudanese sorghum cultivars.

Cultivar	Year of release	Area to be sown	Varieties preferred by farmers
Dwarf white milo	1957	Irrigated and low rainfall areas	✓
Wad Akar	1967	Low to medium rainfall areas	✓
Tub 7 (UmBenein 7)	1971	Low to medium rainfall areas	
Tub 11 (UmBenein 11)	1971	Low to medium rainfall areas	
Tub 22 (UmBenein 22)	1971	Low to medium rainfall areas	
Dabar/1/1/1/1	1978	Irrigated and medium to high rainfall areas	✓
Gadam Alhamam	1978	Medium to high rainfall areas	
Hageen Dura-1	1983	Irrigated and medium to high rainfall areas	✓
Ingaz	1992	Irrigated and medium to high rainfall areas	
Sheikan	1992	Irrigated and medium to high rainfall areas	
Wad Ahmed	1992	Irrigated and medium to high rainfall areas	✓
Pioneer 877	1992	Irrigated and medium to high rainfall areas	✓
Hageen Rabih	1996	Irrigated and medium to high rainfall areas	
Tabat	1996	Irrigated and medium to high rainfall areas	✓
Aroseelrimal	2000	Low rainfall areas	
Yarwasha	2003	Low rainfall areas	
Bashayir	2008	Low rainfall areas	✓
Butana	2008	Low rainfall areas	✓

Table 3: Chemical composition of some sorghum grains in Sudan.

Varieties	Moisture (%) (% w/w)	Protein (%) (N×6.25)	Fat (%) (% w/w)	Fiber (%) (% w/w)	Ash (%) (% w/w)	Carbohydrates (%) (% w/w)
Daber	8	10-12.0	3.79	2.73	1.27-1.80	73.84
Safra	8.8	15.5	3.66	3.02	1.71	67.81
Fakki Mustahi	8	14.12	4.3	1.96	1.5	70.12
Feterita	8.8	12-15.6	3.3	1.33	1.3	73.27-69.67
Hageen	7.6	12.22	3.73	1.33	1.31	73.8
Tetron	7.87	11.1	3.34	1.63	1.54	76.16
Gadam Elhaman	7	11.15	3.5	2.15	1.56	74.64
Himasi	6.9	8.8	369	1.46	1.65	*
Karamaka	6.8	12.46	3.4	2.25	1.13	77.6
Tabat	8.65	9.83	2.23	2.94	1.15	73.96
Mayo	8.65	*	*	*	1.9	75.76
Wad Ahmed	7	14.01	3.79	2.18	2.1	*
Hyprid	6.01	12.22	3.85	2.3	1.76	76.16
Mogud	7.9	*	*	*	*	72.97

Table 4: Traditional foods made with sorghum.

Type of food	Common names	Countries
Unfermented bread	Roti, rotii	India
Fermented bread	Kisra, dose, dosai, galletes, injera	Africa, India
Thick porridge	Ugali, tuwo, saino, dalaki, aceda, atap, bogobe, ting, tutu kalo, karo, kwon, nshimba, nuchu, to, tuo, zaafi, asidah, mato, sadza, sangati	Africa, India
Thin porridge	Uji, ambali, edi, eko, kamo, nasha, bwa kal, obushera, Ogi, oko, akamu, kafa, koko, akasa	Africa,India Nigeria, Ghana
Sweet/sour opaque beers	Burukutu, dolo, pito, talla	West Africa
Sour opaque beers	Marisa, busaa, merissa, urwaga, mwenge, munkoyo, utshwala, utywala, ikigage	Sudan, southern Africa
Non-alcoholic beverages	Mehewu, amaheu, marewa, magou, feting, abrey, huswa	Africa

provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally [21]. The wheat flour containing large amount of protein and high quality of gluten is used for normal bread, whereas that of lower amount of protein is mostly used for confectionary or cakes [22]. Gluten in wheat is considered to flour quality preference, which is formed by interaction of two proteins, gluten in and glia din in association with lipids and pentosans during dough formation [23,24]. As a food, gluten is best known that gives characteristic porous of bread [25]. It is also used in breakfast cereals, as a meat and milk protein substitute for vegetarian products [25] and in fish food component [26].

Chemical composition of wheat: Bread wheat's (*Triticum aestivum* L.) one of the world's most important crops [27]. The wheat flour containing large amount of protein and high quality of gluten is used for normal bread, whereas that of lower amount of protein is mostly used for confectionary or cakes [22]. Sudanese Agricultural Corporation released many cultivars; the most important ones are Debaira, Wadi Elneel and Elneelain which adapted Sudan conditions **(Table 5)**. And among which cultivar Debaira gave the best flour quality for flat bread making compared with the other local cultivars investigated. This study revealed the ability of producing good flat bread from Sudanese cultivar [28].

Soybean

The soybean (Glycine max) is an industrial crop extensively cultivated for its oil and protein content. It is one of the families Leguminosae, subfamily Papilionoidae originated in Eastern Asia, probably in north and central China [29]. It is believed that cultivated varieties were introduced into Korea and later into Japan some 2000 years ago. Soybeans have been grown as a food crop since thousands of years ago in China and other countries in east and south East Asia as an important component in traditional popular diet [29].

In addition to its versatility, the soybean is a commodity of unique chemical composition. On a mean dry matter basis, soybeans contain about 40% protein and 20% oil. Soybeans contain the highest protein content among food crops; it is the second highest oil content with respect to all food legumes. Thus, the composition of soy products range in protein content from about 40% for full-fat flours to 95% or more for protein isolates [30]. The proximate composition of Soybean flour and wheat flour showed 3.6% and 9.0% moisture content respectively, 52.5% and 12.9% protein, 12.3% and 1.5% fat, 7.72% and 1.2 ashes, 15.36% and 76.4% carbohydrates, 10.36% and 3.2% fiber respectively [31]. Unlike proteins in cereals such as rice; soybeans contain a large number of proteins types with an important functional property [30]. In Sudan, as in other developing countries, shortage of wheat and hard currency to import adequate required quantities have resulted in the use of sorghum, millet and other local cereals for baked products. In Sudan, with food habit change wheat has become an essential grain crop and its production represents a special position in agricultural policies, for boosting domestic production and curbs wheat imports.

Soybean in Sudan: There are two soybean cultivars in Sudan obtained by breeding programmer namely Sudan one and Sudan two. Their evaluations showed good yield and good quality. The production of Sudanese hybrids starts to spread in Sudan, now it was well adapted to central Sudan mainly Gezira scheme. But the program must include all the Sudan states through seed multiplications. It will be suggested as an important crop in the few coming years.

Chemical composition of soybean: Soybean provides a cheap source of high quality oil and protein; these factors have led to soybean becoming a major industrial crop. However, soybean has also been cultivated and processed at household level in china for more than 2000 years and, throughout East Asia, soy bean used for many food products.

Soybeans contain the highest protein content among food crops; it is the second highest oil content with respect to all food legumes. Thus, the composition of soy products range in protein content from about 40% for full-fat flours to 95% or more for protein isolates [32]. Unlike proteins in cereals such as rice; soybeans contain a large number of proteins types with an important functional property [32].

Soy flour is often mixed with other flours to increase the protein content, and soymilk provides an alternative source of protein for people allergic to the protein in cow's milk [33].

Furthermore, on a mean dry matter basis, soybeans contain about 40% protein and 20% oil. Soybeans contain the highest protein content among food crops; represented the second highest oil content with respect to all food legumes. Thus, the composition of soy products range in protein content from about 40% for full-fat flours to 95% or more for protein isolates [30]. The proximate composition of Soybean flour compared to wheat flour showed 3.6% and 9.0% moisture content respectively, 52.5% and 12.9% protein, 12.3% and 1.5% fat, 7.72% and 1.2 ashes, 15.36% and 76.4% carbohydrates, 10.36% and 3.2% fiber respectively [31]. Unlike proteins in cereals such as rice; soybeans contain a large number of proteins types with an important functional property [30]. The production of flours from soy beans involves the removal of hulls to produce a full soy flours or removal of both hulls and oil fractions to produce defatted flour. Full- fat and defatted soy flours represent basic flours of soy protein that can be produced by simple, uncomplicated and low cost processes, and properly processed soy flours have excellent nutritional value.

Production of soybean in small farm holdings: In spite of scarcity of sustainable land and high cost of land preparation, other difficulties such as difficulty in obtaining certified viable grains and adaptable seeds, limited market disposal grains, inadequate awareness of soy bean as an important crop can be overcome by extension agencies and farmers can be easily adopt to different technical aspects.

Table 5: Chemical composition of the flours of the three local wheat cultivars and Canadian wheat flour.

Cultivar	Canadian	Debaira	Wadi Elneel	Elneelain
Moisture (%)	10.4	12.07	11.5	12
Protein (%)	14.36	13.57	11.97	10.77
Ash (%)	0.35	0.55	0.41	0.5
Fat (%)	1.01	1.22	1.13	1.04

Adaptation of soybean technology: Agricultural technology generation is an institutional research system designed to improved technologies and knowledge for use in Agriculture. For a technology to make impact, it must provide several disadvantages, the most important being that the technology should be affordable to the client and show apparent returns on investment. To avoid rejection and faulty of technology farmers involved in the screening research technology, transfer and adaptation to achieve goals the technology must be:

1. Technologically feasible
2. Economically viable
3. Sociocultural compatible with the existing farming systems

Agricultural technology transfer can be conceptualized as the function designed to disseminate improved technologies to the end-users [33]. To be sustainable, the system must teach the farmers through an informal educational process that emphasizes ownership, and the need for self-reliance, and the encourages local leaderships.

Sorghum fortification

Sorghum is consumed in Sudan in fermented forms, mainly as Kisra (local thin bread), aceda (thick porridge) and nasha (thin porridge), but several studies have shown the possibility of incorporating it, both as whole and decorticated grain, in wheat flour at various levels to produce bread when wheat is in short supply [34] **(Figure 2)**.

Role of soybean to increase protein: Hegazy and Ibrahim [35], EL kalit and Tinay [36] they reported that substitution of wheat flour with soybean flour increased the protein content. Addition of soybean flour cause increase in protein [37]. The increase in ash content could be attributed to the higher level of ash content in the soybean and cocoyam flour than the wheat flour [38]. Dhingra and Jood [37] postulated that increase in fat and ash contents could be due to increase the level of added soybean flour. Apotiola and Fashakinly who found in a study of substitution of wheat flour with cocoyam and soybean flour increased the protein content [39]. Crude fiber measures the cellulose, hemicelluloses and lignin content of food; the crude fiber content of the wheat flour was the lowest while that of soybean flour was the highest [37-40], and Obasia explained that adding of soybean affected spread ratio [41].

Effect of fortification on changing in physical properties: There is a decrease in spread ratio factor of biscuits as an increase in thickness of biscuit which may be due to protein presence in the soybean flour; this because protein has more binding power and it blinds water and restricted the spread of the biscuits [42,43]. The values of the water absorption capacity was very high especially in soybean flour because protein consists of sub units structure and dissociates on heating and protein have more water binding site. Nevertheless wheat gives sheet breads elastic character and some nutritional elements.

Figure 2 Components of fortification Sorghum, Soybean and Wheat grains.

Effect of fortification on chemical compositions: The fortification using Sudanese Sorghum cultivars (Dabar), Sudanese Wheat cultivars (Debaira), and Sudanese Soybean hybrid (Sudan one), by 10% incorporated wheat for improving physical characteristics, 10, 15 or 20% soy bean to increase nutritive value of sorghum. The proposed new technology of improve protein, fat and ash contents [18] as shown in **Table 6**.

Food fortification or enrichment is the process of adding micronutrients (essential trace elements and vitamins) to food. Nutrient supplementation of foods was mentioned for the first time in the year 400 B.C. by the Persian physician Melanpus, who suggested adding iron filings to wine to increase soldiers' "potency" [44]**.** It may be a purely commercial choice to provide extra nutrients in a food, while other times it is a public health policy which aims to reduce the number of people with dietary deficiencies within a population. Diets that lack variety can be deficient in certain nutrients. Sometimes the staple foods of a region can lack particular nutrients, due to the soil of the region or because of the inherent inadequacy of the normal diet. Addition of micronutrients to staples and condiments can prevent large-scale deficiency diseases in these cases. While it is true that both fortification and enrichment refer to the addition of nutrients to food, the true definitions do slightly vary. As defined by the World Health Organization (WHO) and the Food and Agricultural Organization of the United Nations (FAO), fortification refers to "the practice of deliberately increasing the content of an essential micronutrient, i.e., vitamins and minerals (including trace elements) in a food irrespective of whether the nutrients were originally in the food before processing or not, so as to improve the nutritional quality of the food supply and to provide a public health benefit with minimal risk to health," whereas enrichment is defined as "synonymous with fortification and refers to the addition of micronutrients to a food which are lost during. For soybean fortification, portions of millet grains were replaced with separately weighed soybeans at 0, 10, 20, 30 and 40% replacement levels. The soybeans were pre-soaked in de-mineralized water for 2 hours and boiled for 20 min into inactivate trypsin inhibitor activity and reduce be any flavor [45].

Table 6: Comparative nutritional values of soybean proposed fortification.

Sorghum components	Moisture content	Protein content	Fat content	Ash content
Sudanese sorghum flour 100%	6.62	11.6	4	1.68
Sudanese wheat flour 100%	12.07	13.57	1.22	0.55
Sudanese soybean flour 100 %	3.6	42.5	22.3	7.72
Mixed sorghum wheat flour	7.165	11.797	3.722	1.567
Fortification of Sorghum, wheat and soy:				
10% soy fortification	6.863	14.887	5.552	2.171
15 % soy fortification	6.712	16.432	6.467	2.213
20 % soy fortification	6.561	17.977	7.382	2.54

Focusing nutritional significance of soy products in the human diet reclaimed that Soybeans are unique among the legumes because they are a concentrated source of is flavones. A nutrient profile and phytochemical contributions of Soy's nutritionists focused in enhancing people consume more beans in general and more soy foods in particular [46].

Soybean subjected to soaking, blanching, roasting, dehulling, drying and milling reduced anti-nutritional factors such ashaem agglutinin from 2560 in unprocessed to 10 soy; and trypsin inhibitor from 40.2 mg/g to low levels in most processed soy. Soybean fortification in the ratio 1:3 improved the ash content of pap 8-11 fold; protein, 4-5 folds and fat, about 2 fold. Combination of soaking and roasting are recommended for promotion among rural dwellers because of the relative cheapness and reasonable organoleptic acceptability levels [47]. Subjecting of 22 to 28 years old mans to incorporation of rice with soybean diets for 11 days; linear regression of protein means levels was 93.35 mgN/kg body weight/day. The digested means were 78.8%, 82.4% and 81.4%, and net protein consumed was 57.1%, 59.3% and 64.8% consequently, showing that good protein incorporated with soy have high nutritive value compare to pure local one [48]. Adding soybean to Hausa koko by fortified with soybean up to 40% using analysis of Variance and Turkey testing for the separation of means ($p<0.05$); replacement level to improve the protein quality on acceptability, and found that a general increase in acidity with increasing percentage of soybean in the mixture. Lactic acid bacteria growth was accelerated with the addition of soybean from 106 to 109 cfu/ g after 12 h of fermentation. Taste, odor and overall acceptability were significantly and negatively affected above 40% soybean content. Color significantly improved upon addition of soybeans whereas texture was not noticeably affected [49]. Fermented two cassava cultivars for 3 days with the incorporation of soybean residue or full-fat flour at 25% (w/w) to produce **gari**., resulted in that water activity of incorporated cassava -soybean **gari** was <0.7, the swelling capacity was 2.5 to 3.3, pH was 5.1 ± 0.2, total cyanide was 0.8 to 1.3 mg/100 g and crude protein was 8 to 12% (w/w) greater than the 1 to 2% (w/w) of the unfortified **gari [50].** As outlined by the FAO, the most common fortified foods are:

Cereals and cereal based products

Milk and milk products

Fats and oils

Accessory food items

Tea and other beverages

Infant formulas.

The four main methods of food fortification (named as to indicate the procedure that is used in order to fortify the food):

1. Bio fortification (i.e., breeding crops to increase their nutritional value, which can include both conventional selective breeding, and modern genetic modification)
2. Synthetic biology (i.e., addition of probiotic bacteria to foods)
3. Commercial and industrial fortification (i.e., flour, rice, oils (common cooking foods))
4. Home fortification (e.g., vitamin D drops) *[51].*

Food supplements

There are several main groups of food supplements like:

- Vitamins and co-vitamins
- Essential minerals
- Essential fatty acids
- Essential amino acids
- Phytonutrients
- Enzymes

In most countries, sugar fulfills the criteria listed by the Council of Food and Nutrition of the National Academy of Sciences of the United States as a good vehicle for fortification with specific nutrients [52,53]. In most countries, sugar is widely consumed by the population in quantities that show little daily variation, thus facilitating decisions about fortification levels. The retail price range of sugar generally places it within reach of the lower socio-economic end of a given population, and in most countries sugar production is centralized, which permits easier control and regulation of the fortification process.

Fortification for body building

Despite having some scientific basis, but with controversial ethics, is the science of using foods and food supplements to achieve a defined health goal. A common example of this use of food supplements is the extent to which body builders will use amino acid mixtures, vitamins and phytochemicals to enhance natural hormone production, increase muscle and reduce fat. The literature is not concrete on an appropriate method for use of fortification for body builders and therefore may not be recommended due to safety concerns *[54].*

For programmers of fortification in developing countries, some additional factors have to be considered:

- The food vehicle should be consumed by practically all the population;
- The daily intake of the carrier food should be essentially constant;
- Fortification should not alter the organoleptic characteristics of the vehicle;
- Production and processing of the food vehicle should be centralized;
- The cost of the fortification should be economical.

Organoleptic acceptance of fortified soybean in some Sudanese diet: Organoleptic researches conducted in Sudan for introducing of Soy in diet showed positive results. Addition and 10 and 15% soy to wheat flour yielded acceptable baked bread and other types of cakes. Also Mohammed et al. [18] used soy with wheat for making biscuits improve nutritional values with top scores.

Addition of 10, 15% soy and 10% soy and 10% wheat to Sheet bread “Kisra” top scored, while the scoring reduced from 20 to 25% of soy due to the new taste of soy in Sudan. But in the near future the acceptance will gain high score with an increasing in soy percentage can be achieved. Also an experiment used to investigate 10 and 15% in thin porridge also showed high scores. From these experiments of using Sudan I variety of soy with Sudanese wheat and Sorghum promote the fortification in Sudan for sorghum fortification and just few organoleptic tests are recommended for different states.

Food security

Food security conditions related to the supply of food, and individuals' access to it. Concerns over food security have existed throughout history. The final report of the 1996 World Food Summit states that food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life “Raj [4, 55]. Household food security exists when all members, at all times, have access to enough food for an active, healthy life [56]. Individuals who are food secure do not live in hunger or fear of starvation [57]. The WHO states that there are three pillars that determine food security: food availability, food access, and food use [58]. The FAO adds a fourth pillar: the stability of the first three dimensions of food security over time [57]. In 2009, the World Summit on Food Security stated that the "four pillars of food security are availability, access, utilization, and stability" [59]. As of 2015 the concept of food security has mostly focused on food calories rather than the quality and nutrition of food. The concept of nutrition security evolved over time. In 1995, it has been defined as "adequate nutritional status in terms of protein, energy, vitamins, and minerals for all household members at all times".

The goal of soybean fortification with respect to food insecurity, is reclaimable approach to food insecurity such as a situation of "limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways", according to the United States Department of Agriculture (USDA) [60].

World Summit on Food Security: The Food and Agriculture Organization of the United Nations (FAO) called the summit in response to widespread under-nutrition and growing concern about the capacity of agriculture to meet future food needs. The conference produced two key documents, the Rome Declaration on World Food Security and the World Food Summit Plan of Action [55,61].

Food safety

Food safety is a scientific discipline describing handling, preparation, and storage of food in ways that prevent food borne illness. This includes a number of routines that should be followed to avoid potentially severe health hazards. In this way food safety often overlaps with food defense to prevent harm to consumers. The tracks within this line of thought are safety between industry and the market and then between the market and the consumer. In considering industry to market practices, food safety considerations include the origins of food including the practices relating to food labeling, food hygiene, food additives and pesticide residues, as well as policies on biotechnology and food and guidelines for the management of governmental import and export inspection and certification systems for foods. In considering market to consumer practices, the usual thought is that food ought to be safe in the market and the concern is safe delivery and preparation of the food for the consumer.

Food can transmit disease from person to person as well as serve as a growth medium for bacteria that can cause food poisoning. In developed countries there are intricate standards for food preparation, whereas in lesser developed countries the main issue is simply the availability of adequate safe water, which is usually a critical item. In theory, food poisoning is 100% preventable.

Biotechnology

Biotechnology is the use of living systems and organisms to develop or make products, or "any technological application that uses biological systems, living organisms or derivatives thereof, to make or modify products or processes for specific use" (UN Convention on Biological Diversity, Art. 2). Depending on the tools and applications, it often overlaps with the fields of bioengineering, biomedical engineering, bio manufacturing, molecular engineering, etc. For thousands of years, humankind has used biotechnology in agriculture, food production, and medicine [2]. The term is largely believed to have been coined in 1919 by Hungarian engineer Károly Ereky. In the late 20th and early 21st century, biotechnology has expanded to include new and diverse sciences such as genomics, recombinant gene techniques, applied immunology, and development of pharmaceutical therapies and diagnostic tests. Biotechnology in Sudan was practiced on breeding of soybeans; but there were much good technical traditional knowledge reported; and they provide good knowledge which can modify biotechnology for production of fermented foods incorporated with soybean, beside more development of breeding of soy.

Innovation and technology transfer

Innovation: Is defined simply as a "new idea, device, or method" [62]. However, innovation is often also viewed as the application of better solutions that meet new requirements, unarticulated needs, or existing market needs [63]. The term "innovation" can be defined as something original and more effective and, as a consequence, new, that "breaks into" the market or society [64]. It is related to, but not the same as, invention [65]. In industrial economics, innovations are created and found empirically from services to meet the growing consumer demand [66,67].

Drucker identified seven sources of opportunity that will ultimately drive innovation, they are:

1. The organizations own unexpected successes and failures, and also those of the competition.
2. Incongruities, especially those in a process, such as production, distribution, or incongruities in customer behavior.

3. Process needs.
4. Changes in industry and market structures.
5. Changes in demographics.
6. Changes in meaning and perception.
7. New knowledge [68]

According to Drucker, there are three conditions that must be met for an innovation to be successful including:

1. Innovation is work. It requires knowledge, ingenuity, creativity, etc. Plus, innovators rarely work in more than one area, be it finance, healthcare, retail or whatever. This work requires diligence, perseverance and commitment.
2. To succeed, innovators must build on their own strengths. They must look at opportunities over a wide range, and then ask which of the opportunities fits me, fits this company. There must be a temperamental fit with the practitioner and a link to business strategy.
3. Innovation is an effect in economy and society, a change in the behavior of customers, of teachers, of farmers, of doctors, of people in general. Or, it is a change in a process, in how people work and produce something. Innovation must always be close to the market, focused on the market, and market driven [68].

Sources of innovation and goal achievement: To achieve the goals of innovation the Original model of three phases of the process of Technological Change that depends on invention, innovation and diffusion of technology as shown in **Figure 3.**

However, innovation processes usually involve: identifying customer needs, macro and meso-trends, developing competences, and finding financial support.

Technology generation (innovation) and transfer: Agricultural scientists are typically trained to manage agricultural innovation as a process of vertical transfer, i.e., bring in foreign technologies and adapting and transferring them to farmers through best farmers, headmen's of societies and systematic governmental experts.

In order to access these resources, a participatory and interactive process needs to be adopted through which farmers; ideas and needs can be directly involved with scientists in developing food recipes and prototype technologies.

Government policies in innovation: Given the noticeable effects on efficiency, quality of life, and productive growth, innovation is a key factor in society and economy. Consequently, policymakers have long worked to develop environments that will foster innovation and its resulting positive benefits, from funding Research and Development to supporting regulatory change, funding the development of innovation clusters, and using public purchasing and standardization to 'pull' innovation through.

Innovation for soybean production in Sudan: Innovation must be adapted to raise breeding for soybean as a national flora. On the manufacturing roasting and milling equipment's innovation governmental institutes have vital and crucial impact to access protection soybean products formulations and technology for poorer peoples.

Technology generation (innovation) and transfer: Agricultural scientists are typically trained to manage agricultural innovation as a process of vertical transfer, i.e., bring in foreign technologies and adapting and transferring them to farmers through best farmers, headmen's of societies and systematic governmental experts. In order to access these resources, a participatory and interactive process needs to be adopted through which farmers; ideas and needs can be directly involved with scientists in developing food recipes and prototype technologies. The technology can be transfer house (**Figures 4-8**) machines to meet rural and sun urban areas.

Integration of Innovation and technology transfer in sorghum food security fortification

Food security to improve nutritional value of sorghum can be achieved by small number of major crops, e.g., Soybean; have formed an increasing share of the food energy, protein, fat, and food weight eaten by the world's population over the past 50 years [69]. Since 1961, human diets across the world have become more diverse in the consumption of major commodity

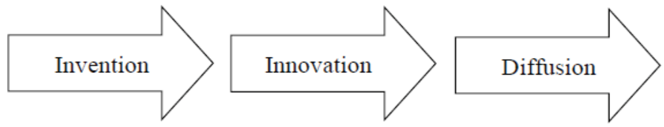

Figure 3 Original model of three phases.

Figure 4 Minor house hold hand milling.

staple crops, with a corollary decline in consumption of local or regionally important crops, and thus have become more homogeneous globally [69].

Processing of fortification components

Dough: Dough has been described as the most complicated rheological material at present known to man (M. Reiner) because the rheological properties of dough are closely connected with baking characteristics of flour; tests had to be developed long before viscos-elastic measurement was properly understood. Hence, these tests were empirical and used at that time on a very large scale because nothing better is available [70]. The desirable rheological characteristics of dough (stickiness, mixing requirement, water absorbance) together with the color and appearance of loaf are of importance as well [71].

Milling techniques: Different milling processes (hand pounding, roller milling, and abrasive decortication-hammer milling) [72]. Selected milling processes A weakness in this study was that hand pounding and brasive decortication-hammer milling, which have been perfected over time on the basis of feedback from consumers, were compared with two-stage roller milling, a process which is at an early development stage for sorghum milling. Thus, roller milling, as was applied to sorghum in this study, may not have been satisfactorily optimized, and hence, its performance was probably unfairly compared to those of the other proven milling processes [72].

Small-scale service and/or semi-commercial milling: While a diverse choice of small abrasive decorticators exists [73], only the RIIC/PRL type dehuller will be considered here. This dehuller is perhaps the most suitable for most sorghum processors as it seems to be the most 150 affordable in terms of capital and maintenance costs, when compared to other available decorticators, such as the PeriTech [72].

Comparative performance of the milling processes extraction rates

The most notable observation concerning performance of the three processes was that on average roller milling gave much higher meal extraction of approximately 11% (84 g/100 g) more than hand pounding (74 g/100 g) and abrasive decortication-hammer milling (76 g/100 g). The latter two processes gave essentially the same extraction rate. Extraction rate in this case was determined as the level of yield at which the meal was considered acceptable in quality, which was practically judged subjectively [72] **(Table 7)**.

The 8 min cycle is derived from the observed practical maximum residence time for decorticating 10 kg sorghum batches by the commercial mill engaged in this study.

Energy efficiency: The roller mill used in this study was driven by two 3-phase motors of 7.5 kW and 5.5 kW. Thus, in an hour this mill would use 13.0 kWh of energy to produce 418 kg of meal, expending on average 1 kWh for every 32.2 kg of meal produced. In comparison, the dehuller and hammer mill were driven by two 3-phase motors of 5.5 kW each. On average these motors would expend 11 kWh of energy to yield 142 kg of meal. Thus 12.9 kg of meal was produced per kWh of energy. These energy estimates demonstrate that the roller mill is superior to abrasive decortication-hammer milling (when applied in the batch mode) in energy efficiency. Much of the energy wastage with the abrasive decortication-hammer milling is 141probably associated with the loading and unloading stages. As such, for commercial production of sorghum meal with the abrasive decortication-hammer mill, a switch to the continuous process mode is probably necessary to minimize energy losses [72].

The Milling Process: As Pomeranz determine milling process by which wheat is ground into flour. Separating the wheat grain into its constituents (bran, germ and endosperm) involves the following processes [74]:

Storing

As wheat arrives in the mill it is passed through a cleaning process to remove coarse impurities and is then stored according to its quality. This is mainly determined by the hardness, protein content and gluten quality of the wheat.

Cleaning

Cleaning begins with screening to remove coarse and fine materials and the grain is separated by size, shape and weight. The finished product, whole pure wheat, is then passed into conditioning bins.

Conditioning

Conditioning takes place before milling to produce uniform moisture content throughout the grain. Moistening helps to prevent break- up of the bran (hard outer layer) during milling and improves separation from the floury endosperm (the mass that forms the white flour of the grain).

Gristing

After conditioning, different batches of wheat are blended together (gristed) to make a mix capable of producing the required flour quality.

Table 7: Effect of the Milling Process on the Sorghum Meal Output.

Milling Process	Grain throughput	Measured meal extraction rate	Meal per h
Abrasive Decortication	188 kg/h (25 kg per batch at 8 min per cycle; loading, decortication and unloading)	757 g /kg	142 kg
Hammer Milling1		836 g /kg	
Roller Milling	500 kg/h		418 kg
Difference in meal output			276 kg
Percent gain in meal output due to Roller Milling			194%

Milling

Essentially this is the separation of the bran and germ from the endosperm and the reduction of the endosperm to a uniform particle size (flour). This is done by a sequence of breaking, grinding and separating operations. The quality of the wheat going into the mill, e.g. protein content, will determine the types of flour to be produced. By blending together the many different flour streams produced by the mill, a miller can create further variations in features such as flour color. For example, very white flours would come from the early streams only, while brown flours involve using most streams. Whole meal flour is produced when all the streams, bran, germ and flours are blended back together with nothing removed.

Suggested improvements for Soy-sorghum milling processes: The biggest challenges in sorghum milling are associated with the difficulty to remove the pericarp and the germ from the endosperm [74]. Thus modification of hammer mill using Sudanese local materials is the challenged for modification of soybean milling machines to provide fortified sorghum. It is not impossible but special considerations must add to domestication and innovations in milling technology. The improvement can be achieved through:

1. In spite of hammer miller milling capacity lower than hammer but using hammer milling the recommended to have fine product of soy and sorghum.
2. Manufacturing of hammer mills in Industrial research and consultancy Center is recommended using innovation to produce hammer mails that suite Sudan situation since materials for manufacturing hammer mill is available due to previous studies.
3. Using diesel or Biodiesel motors in the very far areas from general Sudanese electricity networks.

Type of processing machines: There are many types of milling and roasting equipment's from house style to small-scale and medium scale machines. They can be closed according to the area, feasibility study and infrastructure availability (**Figures 4-8**).

Figure 5 Small-scale soybean machines.

Figure 6 Hammer mill.

Figure 7 Small-scale soybean machines.

Treatment of anti-nutrition's

There are many anti-nutritional compounds such as Tannins, Phytohaemagglutinins, Protease inhibitor, Estrogenic factors, Phytic acid, Dihydroxyphenylalanine, Amylase inhibitor, Cyanogen's, Phytohaemagglutinins, Flatulence factor, Glucosinolates and Anti-vitamin D factor found in the three crops (Soy, Sorghum and wheat) [75]. Treatment of soy, sorghum and wheat anti-nutritional factors can treated by many methods such as; Heat treatment, Autoclaving (121°C:15-30 min), Fermentation, Roasting at 100°C or higher, Steam autoclaving (120°C:2 h), Micronizing, Aqueous heat treatment, (100°C:10 min), Solvent extraction with hexane, Aqueous extraction (18 h), Soaking in water, Microwaving and Soaking in copper sulfate solution.

Conclusion

We come to conclude that:

Figure 8 Sorghum mill.

1. The adaptation of fortified sorghum technology can be adopted in agric. production of soybean and sorghum, formulation, quality control analysis, designing of machines to produce different fortified sorghum products for different kinds of peoples; adults, children, infants and pregnancies. And the theory gives positive results through the analysis of different fortification tools components through simple technology as a result of technology transfer and innovation.
2. The analysis of literature and scientific results showed that rural production of soybean adaption can well be succeeded, rural manufacturing of the basic and fortified nutritional components is a simple technology, systematic researches on some Sudanese diet such as fortified cooked sorghum soft sheets (*Kisra*), fortified thin porridge (*Madeda*), fortified thick porridge (*Logma or Asida*) with good protein, fats, minerals and fatty acids can be easily adopted. And incorporation of 10%, 15% and 20% soy are preferable now in Sudan, but 25% gain low scores of organoleptic acceptance gained by biotechnology, innovations and technology transfer.
3. Production and technology of soy house and small scale by manufacturing tools and machines for roasting, boiling and fermentation can be easily adopted
4. Incorporation of Sorghum, wheat and soy in Sudanese foods; bread sheets "*Kisra*", "Thin porridge" and "Thick porridge" improved physical and nutritional values and consequently achieved food security and food safety to access human right for nutritive and healthy food.
5. Governmental policies were succeeded in biotechnology for releasing new soy cultivars; Sudan one and Sudan two; and fortified foods.
6. The multidiscipline system including adapted cereals and soy to Sudan condition with and integration with the principals of food security, food safety, biotechnology, innovations, technology transfer and governmental and organizational policies can form a homogenous flow with in this integrated system.
7. Finally decision making strategies were designated for development of the sorghum fortification for analytical results and proper expected technology, tactic and strategies of fortification.

Recommendations

From the above technical information we can concluded the following tactic and strategies for fortification of sorghum as food security rights:

1. Designing of national project for sorghum fortification with special emphasis in rural areas.
2. The announcement and call for right of rural Sudanese peoples to have healthy and nutritive foods to overcome the malnutrition that appears in some far rural areas with arrangements coordination with regional and international organizations to improve the rural statements.
3. Good articulation between the governmental Institutes such as research institutes, states, localities and extension service with stakeholders in rural areas under the umbrella of national project.
4. The priority of socioeconomic stakeholders synchronized with organoleptic studies to study and promotes the idea and their proportional uptake preference for evaluation of each locality suitable technology.
5. Investigation of all technological equipment concerning fortification components.
6. Designing of different models such as house hold, small and medium scale. And registration of new technology targeting the beneficiary groups in target areas, for protection of mongolisms by other competent.
7. Development of more advanced breeding programmed to release more high yielding varieties with high protein and other essential nutrients to completing as far as possible complete nutritional status when comported with sorghum and wheat.
8. Development of efficient seed multiplication system to produce and distribute certified seeds.
9. Establishment of efficient training system to cover all fortification steps; good cultural practices, good manufacturing hygiene (house or small-scale).
10. Establishment of marketing polices and hazard control system with good insurance system to protect rural communities from risks and hazards.
11. Establishment of good records system, with good back feed system to manipulate the situation for consistency, evaluation and corrections.
12. A multi-sectorial approach in the establishment of any food fortification programme must be adopted, sharing participation of relied governmental organizations, Target groups, academic and research institutes.

13. All efforts should consider harmonizing national and international legislation concerning fortified foods, with the international standards of the Codex Aliment Arius.
14. International guidelines accepted for safe fortification practices should be recognized.
15. Levels of fortification should be investigated and corrected according to bioavailability of the nutritional value of target populations.
16. Local food industries potential evaluation is important to be involved in high quality fortified food products.
17. HACCP principles and risk-based inspection method and internationally accepted analytical procedure required to developed and support of fortification programmes.
18. The impact of food fortification on the nutritional requirement of target groups should be monitored according to appropriate corrective action.
19. Local areas fortified food should be made knowledge of existing mechanisms for requesting fortified food products according to local requirements.
20. Determination of the current and potential capacity of regional processing industries to fortify food commodities.
21. Establishment, at national level, of required list of nutrients to be in food fortification.
22. Supplementation of additional regulations, at the national level to fortified foods according to specific national and local situations.
23. Labeling needs and allowable claims to obtain fortified foods according to the Codex work on Nutrition and Health.

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Appendices

Appendix I: How to prepare thin pancake-type leavened bread Sudanese “*Kisra”* (Bread Fermented bread)

Method

1. In an earthenware container, mix flour, starter and enough water to form a paste.
2. Allow to ferment overnight, i.e. about 18 hours.
3. Thin dough to the consistency of a batter.
4. Spread about 100 ml of the batter on a hot iron plate, using a rectangular spatula (15 x 5 cm) to form a very thin layer.
5. Bake for about half a minute.
6. Remove and store in a container one on top of the other.
7. Cover with a cloth and store for use on the same or next day.
8. Serve with vegetables, legumes, meat stew or soup.

Notes: A soft, thin, slightly moist and flexible product is preferred, with uniformly distributed "eyes" or perforations and a slightly sour taste.

Ingredients

- 9 parts sorghum flour, generally white variety
- 2 parts water
- 1 part starter (yeast inoculum from a previously fermented batch of kisra batter)

Appendix II: How to prepare OGI (Thin porridge) Sudanese “Nasha”

Method

1. Soak dehulled grains in cold water for 18 to 48 hours to soften and ferment the grains.
2. Wash the grains and ground to a coarse paste using a grinding stone.
3. Screen the slurry through muslin cloth and discard the bran and coarse particles remaining on the cloth.
4. Let the strained slurry stand for 5 to 6 hours and pour off the excess water, leaving just enough to cover the settled paste.
5. Bring water to boil.
6. Pour the paste in the boiling water (2 tablespoons for every 6 cups water) and stir vigorously until the paste gelatinizes.
7. Cover the bowl and cook for another 2 to 3 minutes.
8. Serve the thin, hot porridge as it is or add sugar or salt to taste.

Notes: The product should be light in color, either white or creamy. Traditionally ogi is not stored. *Kafer, eko or ogide*, thicker versions of ogi, are stored. Change in flavour, texture or aroma is unacceptable.

Appendix III (a): How to prepare Stiff porridge Sudanese “Asida”

Method

1. Bring water to boil (in a clay pot).

2. Sprinkle a small amount of flour on the surface of the water. Continue heating.
3. As soon as water begins to boil again, add remaining flour in small amounts. Stir constantly to avoid lump formation.
4. Allow to cook for 2 minutes and remove about half of the hot slurry to another container.
5. Vigorously mix the remaining slurry in the pot using a wooden stick with a flattened cylindrical handle.
6. Add the set-aside slurry and continue boiling until the right consistency is obtained.
7. Continue cooking on a reduced fire for about 4 to 5 minutes.
8. Remove the ugali to a basket made for this purpose. The whole process of ugali preparation takes 15 to 20 minutes.
9. Serve with meat or vegetable sauce or stew, or green vegetables. Serves 2-3.

Notes: Ugali should be light in color. It should not be sticky when eaten and should maintain the same characteristics in storage for 24 hours.

Appendix III (b): How to prepare Stiff porridge "ALKALI TÔ" Sudanese "Asida"

Method

1. Boil about 4 liters water in a metal pot.
2. Mix 10 9 wood ash in 650 ml water.
3. Add about 500 g sorghum flour and stir to form a homogeneous paste.
4. Swirl the paste in the boiling water.
5. Stir the boiling mixture about 8 minutes. (Sometimes this mixture is consumed as thin porridge.)
6. Reduce the heat under the pot. Take out approximately one-third of the mixture and set it aside in a separate bowl.
7. Keep the mixture in the pot boiling and add, in small lots, the remaining sorghum flour.
8. After each addition beat the mixture vigorously with a flat wooden spoon. When the paste thickens too much to beat, add some of the thinner porridge that was kept aside. Again add flour and beat. Continue this cycle until all the flour and set-aside porridge is mixed in the boiling pot to form a homogeneous, thick paste.
9. Reduce heat, cover the pot and allow the paste to cook over low heat for about 12 minutes.
10. Remove the content from the fire, cool for about an hour and serve.