International Academic Research Consortium Journals (IARCJ)
International Journal of Food Science, Tourism & Home Economics
ISSN: 2360-9317. Volume 8, Issue 4
PP 8-38, September, 2024
DOI: 427251-39265-0842
arcnjournals@gmail.com
https://arcnjournals.org

Effects of Combination of Soybean, Sorghum and Millet on the Mineral Contents of Ndaleyi: A Traditional Nigerian Food in Borno State

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***Abstract**: The purpose of this study is to determine the effects of dehulling and fermentation of millet, sorghum and defatted soybean flour as methods of processing of Ndaleyi a traditional Nigerian fermented food and to evaluate minerals, vitamins and copper composition of the raw materials and the finish products. The raw materials (millet, sorghum and soybeans) were purchased from Maiduguri Monday Market on 18th October, 2023 and transported to the Department of Food Science and technology, Ramat Polytechnic Maiduguri, Borno State, Nigeria for production and subsequent analysis. All the raw materials were purchased and stored in 25kg polythene bags at room temperature. 2kg of millet, sorghum and soybean were soaked for one week except soybean for three days, continuous addition of fresh water and removal of the older water was constantly maintained and allowed for fermentation. After fermentation and dehulling of millet, sorghum and soybean are allowed to dry and mixed sorghum, millet and soybean in ratio of dehulled and undehulled with defatted soybean at 75:25, 90:10 for both millet and sorghum with soybean respectively. The application of AOAC methods were adopted for the analysis which shows that the result of mineral content of millet, sorghum and soybean decreases after dehulling as shown in tables for the minerals Mg 47.70mg to 42.56mg, P, 391-35mg to 385.15mg, Ca 182.03mg to 175.33mg, K 260.71mg to 231.31mg, Fe 2.965mg to 2.65mg and zinc 1.97 mg o 1.89 mg respectively. The B-vitamins content decreased for thiamin from 0.46mg/100g to 0.43mg/100g for millet and 0.38mg/100 to 0.31mg/00 for sorghum upon dehulling. B2-vitamins increased dehulling from 0.33mg/100 to 0.31mg/100g in millet and decreased for sorghum form 0.2mg/100g to 0.27mg/100 respectively. Mineral copper was not detected in both millet and sorghum flour but found in soybean was increased from 0.62mg/100 to0.67mg/00g.*

Keywords: Effects, Combination, Soybean, Sorghum Millet, Mineral Contents, *Ndaleyi*

Introduction

Ndaleyi is basically a fermented sun-dried agglomerated powder made from millet or sorghum. It is a major traditional food of the Kanuri people of the Kanem Bornu Empire in Nigeria. The Kanuri people have an estimated population of over five million (2006 Nigerian Population

Census). Until recently, *Ndaleyi* was a food for members of the royal family and the affluent in society. It is consumed during Sallah, naming and marriage ceremonies. It is marketed in Saudi Arabia in packaged form most especially during the Hajj (Nkama, *et al*. 1994).

Pearl millet (*pennisefum americanum leeke*) is one of the two most popular staple cereals (the other being sorghum) grown in Northern Nigeria which is situated in the arid and semi-arid regions (SAR) of the tropics, Nkama *et al*. 1994. This is because the millet plant can withstand drought and acidity. Over three million metric tonnes of the grain were produced in Nigeria in 1984 which accounted for about 10% of the total world production.

In Nigeria, millet is consumed mainly as human food, in many forms, one of which is *Ndaleyi* is basically a fermented, sun-dried, agglomerated powder made from millet or sorghum. Production of millet in Nigeria was estimated to be two million metric tonnes. Between 2005 and 2020 the millet crop in the country decreased due to adverse effects. The largest drop in millet production was registered in 2011 when the crop volume experienced a decrease by 75% compare to 2010 going from 5.2 million metric tonnes to 1.3 million metric tonnes due to adverse weather conditions Varrella, et al. (2020).

Soybeans have been one of the five main plant foods of China along with rice; soybeans, wheat, barley and millet. Soybeans production was localized in China until after the Chinese-Japanese war of 1894-95 when Japanese began to import soya bean oil cake for use as fertilizer, shipments of soy beans were made to Europe about 1908 and the soybean attracted world attention. Europeans had been aware of soya beans as early as 1712 through the writing of a German botanist. The cereals and legumes are rich in carbohydrates and proteins and many other nutrients beneficial for health. These are known as poor man's meat and good sources of complex dietary carbohydrates (starch and dietary fiber), protein, minerals and B vitamin Sangeetha,etal.,(2017). The climate change and excessive use of chemical pesticides/fertilizers lead to concern over quality food production, Verma *et al.(* 2016).

Statement of the Problem

Protein energy malnutrition (PEM) has been identified as one of the most endemic notational problems in sub-saharan Africa including Nigeria. Attempts have been made to device certain strategies for combating this menace. Highly nutritious food rich in protein and high calorie value promoted this research. Cereal grain and legume complementation has been suggested. In Africa, traditional food with adequate nutritional value like *Ndaleyi* is recommended. Nutritional deficiency disease like kwashiorkor and marasmus can be equally controlled.

A healthy diet incorporates all nutrients in moderation. Low protein intake has several health consequences and a severe lack of protein in the diet causes death (UNICEF, 2008).

The common legumes such as soybean, mung bean, black bean, lentils and chick pea increase the protein content and improving protein quality of cereal-based complementary foods. Both legumes and cereals however are rich in phytic acid which is a potent inhibitor of mineral and trace element absorption. However, a combination of cereals, millet and oil seeds provides most of the amino acids which complement each other to provide better quality proteins.

Aims and Objectives

The aim of this research is to:

i. produce Ndaleyi from the blends of millet, sorghum and soybean
ii. evaluate mineral vitamins and copper composition of the raw materials and finish products

LITERATURE REVIEW

The mature millet grain consists of carbohydrates, proteins, lipids, minerals matter and water in addition to small amounts of vitamin and enzymes (Table 2). The carbohydrates are the most important constituent forming about 77-87% of the total dry matter, carbohydrates present in millet are starch, cellulose, hemicellelose, pentosans, dextrins and sugars. The protein content of pearl millet is from 8.6 to 17.4% depending in part on variety and class but more largely on environmental factors during growth. The removal of some of the outer layers of millet grain by dehulling lowers protein content but increases the digestibility of the dehulled product (Nkama and Ikwelle, 1997).

The protein content of pearl millet and foxtail millet is comparable with other cereal. Fearly, millet has higher protein content than sorghum or maize. Finger millet appears to be adequate in all the essential amino acids compared to sorghum which is deficient in lysine, tryptophan and sulphurcontaining amino acids.

Millet is rich in the B-complex vitamins with levels of thiamine, niacin, pantothenic acid and pyridoxine familiar to that of wheat. Finger millet is high in calcium (344mg/100g fresh basis). Millet has been shown to possess anti-pellagra properties. It has been observed that incidence of pellagra was lower in areas where millet are consumed than were maize is the sole cereal food (Kent, 1983, Nkama, 1994, Ahmed and Dominguez, *et al*. 1993).

Table 1: Proximate composition of pearl millet

	N	Mean (%)	Range (%)
Protein	2	12.11	8.6-17.4
Carbohydrate	11	69.4	16.5 – 89.1
Lipid	18	5.0	1.5-5.8
Fibre	11	2.4	1.5-5.9
Ash	16	2.3	1.6-3.8
Moisture Content	3	18.1	11.1-18.1

N = Number of individual studies

Source: Nkama and Ikwelle (1994)

Anti-nutritional Factors of Millet

Millet contains significant amounts of polyphenols (tanning and phytic acid). The occurrence, chemical nature and mechanism of anti-nutritional or toxic effect of such components are well documented. Phytate bind Cu, Zn, N, Co, Mn and Ca make them unavoidable. Therefore, their reduction or elimination becomes very important in millet based foods through suitable processing methods like fermentation, germination and dehulling which have been found to reduce the levels of phytic acid and tannins in food (Khetar, Paul and Chauhan, 1989; 1991 (a) and 1991 (b)).

Millet Legume Combination

The nutritional complementarity of cereals and legumes proteins seems well known in Africa. Millet or sorghum with cowpea or groundnut is used in the sahelian countries. Chemical analysis has shown that amino acids deficient in the millet are generally adequately compensated by the proteins of legumes and vice versa. The mutual compensation is closer to deal when the ratio by mass of cereal to legume is about 70:30 in which proportion each provides about equal part by mass of protein (Nkama, 1993; Amleida Dominguez, *et al*, 1993; Merero *et al*. 1988).

Processing and Food Uses of Millet

Nigeria uses million tonnes of pearl millet as staple food in many homes, especially among the poor, predominantly in Northern Nigeria (FAO, 2007). It is also used in making a popular fried cake known as "masa". Its flour is also used in prepaing "tuwo", a thick binding paste, also refered to as "toh" in northern Africa. It contains 18% protein, rich in Vitamin B especially niacin, B6 and folic acid. It is fitted for flat bread especially because it lacks gluten. It is an important food across the Sahel. It is particularly the main staple in a large region of northern Nigeria, Niger, Mali and Burkina Faso. It is often ground into flour, rolled into large balls, parboiled, liquefied into watery paste using fermented milk and then consumed as a beverage. This beverage called "fura" in Hausa or "tukura" in Marghi language is a popular drink in northern Nigeria and southern Niger. Pearl millet is an excellen forage crop because of its low hydrocyanine content (Green, 2012).

Millets are also used to prepae alcoholic beverages. Millets are traditionally important grains used in brewing millet beer in some cultures, for instance by the Tao people of Orchid Island and the Amisr Atayal of Taiwan. It is also the base ingredient for the distilled liquor rakshi in Nepal and the indigenous alcoholic drink of the Sherpa, Tamang, Ri and Limbu pepple, Tongba, in Eastern Nepal (Amadou, 2019).

Millet is processed for food in several ways depending upon need and local habits. The main objective of processing is to improve appearance, texture, culinary properties and palatability and alter the bioavailability of nutrients.

Millet grains, before consumption and for preparing of food are usually processed by commonly used traditional processing techniques include decorticating, malting, fermentation, roasting, flaking and grinding to improve their edible, nutritional and sensory properties. Millet can be used to make bread, bear, cereal and other dishes. Even today, millet is a staple food around the world in fact, millet is gaining renewed population because of how versatile and easy it is to grow (Merero *et al*. 1988).

The Stages of Processing of Millet

Cleaning

Cleaning involves the removal of stones, dust and chaff. Traditionally and in small scale processing units for millets, cleaning is mostly done by a hand winnower, which takes advantage of the wind.

Dehulling or peeling

The purpose of dehulling is to separate the fibrous pigmented outer skin and germ from the endosperm. It is important in determining the quality of the finished product. Traditionally, dehulling is accomplished by dampening the grain and pounding in a wooden mortar. To ease of manual removal is related to the various characteristics like pericarp thickness, grain size and shape.

Dry grinding

The dehulled grain is reduced to fine flour or coarse flour, the equipment commonly used as the stone quern, wooden pestle and mortar, disk attrition mills and hammer mills powered by diesel engine or electricity.

Wet grinding

In wet grinding the grain (dehulled or whole) is steeped in water for various lengths of time ranging from 12 hours to 7 days, depending on the products to be produced. Wet milling is used to prepare traditional products such as Ndelayi, Masa, Aryau, etc. The possibility of using pearl millet as raw material for wet milling to produce industrial starch has been investigated (Kent, 1983).

Nutritional Value of Millet

Millets are nutritonaly analogous to leading cereals and serve as an excellent source of protein and other micro-nutrients. While sorghum and most of the millets comprise about 10% protein and 3.5% lipids, finger millet contains 12-16% protein as well as 2.5% lipids.

Sorghum and millets are rich sources of micro nutrients that include vitamins and minerals. Millets have fewer cross-linked prolamins, which act as an additional factor contributing to a higher digestibility of millet proteins.

Millet is cultivated round the world to provide basic nutrition for many developing nations. Every 100 grams of millets contains 378 calories of energy, 4.2 grams of total fat out of which saturated fat is 0.7 grams, total carbohydrate content is 73 grams, dietary fibre is 8.5 grams, protein content is 11 grams, folate is 85 mcg, niacn is 4.720 mg, pantothenic acid is 0.848mg, riboflavin is 0.290 mg, thiamine is 0.421 mg, Vitamin B6 is 0.384 mg, Vitamin E 0.05 mg, Tocopherol alpha is 0.05 mg, Vitamin K is 0.9 mcg, Calcium is 1%, Iron content is 17%, Copper Is 38%, Magnesium is 28%, Manganese is 82%, Phosphorus is 28%, Potassium is 4%, Selenium is 4%, Zinc is 11%.

Nutritional facts per 100 grams
378 Calories
4.2g Total Fat
5mg Sodium
195mg Potasium
73g Total Carbohydrate
11g Protein
Vitamins and Minerals
16% Iron
20% Vitamin B-6
28% Magnesium

The beneficial effects of processing on the nutritive value of millet-based foods are envisaged on two areas.

(i) Improved bioavailability of nutrients
(ii) Partial or complete removal of anti-nutrients and toxic compounds. (FAO 1995)

Health Benefits of Millet

The health benefits of millets are such that it treats coronary artery disorder, helps in weight loss, reduces risk of colon cancer, helps to decrease high blood pressure, helps in preventing celiac disease, controls diabetes, good source of antioxidants, helps in slowing down muscle degradation, aids in sleep, helps n relieving menstrual cramps, aids breast milk production, improves skin elasticity.(FAO 2012).

Soybean

Soybeans originated in Southeast Asia and were first domesticated by the Chinese farmers around 1100BC. By the first century AD, soybeans were grown in Japan and many other countries. Former U.S. President Benjamin Franklin sent some soybean seeds to a friend to plant in his garden in 1770. In 1908, soybean was introduced to Nigeria and was cultivated as an export crop in a small area in Benue State, The crop is usually grown in small holdings in mixed cropping with sorghum or maize or as an intercrop in citrus orchards (Ezedinma, 1965).

Table 2: Energy and selected nutrients in legumes (composition per 100g edible portion of dried, mature whole seeds

	Water (%)	Energy (kcal)	Fat (g)	CHO (g)	Protein (g)	Crude Fibre (g)	Ash (g)	Calcium (g)	Iron (mg)	Thiamin (mg)	Riboflavin (mg)	Nicotinic acid (mg)
Adzuki bean	15.0	324	1.0	1	21.1	3.9	3.4	82	6.4	0.45	0.15	2.2
Bambara g/nut	10.1	370	1.0	59.5	16.0	ND	3.0	85	4.2	0.18	ND	ND
Black gram	10.6	344	6.0	65.0	21.0	4.4	3.4	110	8.4	0.58	0.20	2.3
Broad beans	13.8	328	1.6	63.4	25.0	5.1	3.1	104	4.2	0.45	0.19	2.4
Chickpeas	11.0	362	1.2	56.9	19.0	2.5	3.1	114	2.2	0.46	0.20	1.2
Cowpea	11.5	340	5.6	60.9	22.7	4.2	3.2	110	6.2	0.59	0.22	2.3
Groundnuts	7.3	548	1.6	61.0	23.4	2.1	2.4	58	2.2	1.00	0.13	16.8
Horse gram	9.0	354	45.3	21.6	28.9	ND	4.2	294	8.2	ND	ND	ND
Hyacinth beans	12.1	334	4.1	53.8	21.5	6.8	3.8	98	3.9	0.40	0.12	1.8
Jack beans	12.1	348	1.2	61.4	21.0	7.6	3.6	134	8.6	0.65	0.13	2.0
Kidney beans	10.0	336	3.2	61.0	20.3	4.8	3.6	86	6.9	0.46	0.18	22.1
Lathyrus peas	12.0	293	1.2	62.8	25.0	ND	3.0	110	5.6	0.10	0.40	ND
Lantils	12.0	340	1.0	61.0	20.2	ND	2.1	68	7.0	0.46	0.33	1.3
Lima beans	10.5	346	0.6	65.0	19.8	ND	3.0	90	5.6	0.46	0.21	1.4
Mung beans	10.6	341	1.3	65.4	22.9	4.4	3.5	105	7.1	0.53	0.26	2.5
Peas	13.6	330	1.2	61.8	22.2	6.0	2.0	54	4.4	0.77	0.18	3.1
Pigeon peas	11.5	339	1.4	60.1	20.41	4.4	3.5	103	4.9	0.49	0.21	2.2

FAO (2015)
ND = Not detected

Production of Sorghum in Nigeria

Sorghum is one of the crop priorities of the Nigerian government's Agricultural Transformation Agenda (Sorghum Transformation Plan) (FAO, 2013). Sorgum by far, is the largest staple cereal crop in the country (NAERLS, 1996); out of 8 million 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 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).

Nigeria is the largest sorghum producer in West Africa, accounting for about 71% of the total regional sorghum output (Ogbonna, 2011). Nigeria's sorghum production also account for 35% of the African production in 2007 (AATG, 2011). The country is the third largest world producer after the United States and India (FAOSTAT, 2012).

Nutritional Composition of Sorghum

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 (Jacob et al. 2013).
Sorghum is of a lower feed quality than corn (maize). It is high in carbohydrates with 10 percent and 3.4 percent fat, and contains calcium and small amounts of iron, vitamin B1 and niacin. For human consumption, the gluten-free grain is usually ground into a meal than is made into porridge, flatbreads and cakes. The characteristic strong flavour can be reduced by processing. The grain is also used in making edible oil, starch, dextrose (a sugar), paste and alcoholic beverages. The stalks are used as fodder and building materials. Sweet sorghum or sorgos, are grown mainly in the United States and Southern Africa for forage and for syrup manufacture and are sometimes used in the production of ethyl alcohol for biofuel.(Bhise etal 1988).
One cup serving (100 g) of sorghum contain 143g of carbohydrate and 326 calories most of which comes from carbohydrate, 12g of dietary fibre and would provide 47% of the recommended daily value for iron based on a 2,000 calorie intake (Thompson, 2010). 100g (one cup serving) of sorghum contains 325 calories and has 10.8mg of protein, 0 mg of sugar, 3.1mg of fat, 6.0mg of fibre and 0mg of cholesterol. Sorghum contains the following vitamins and minerals: vitamins B_1, B_2 and B_3, calcium (Ca), Potassium (K), Iron (Fe), Phosphorus (P) and Sodium (Na). 100g (one cup serving) woul 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. Although, the grain is low in sodium, it has a large amount of iron and a 100g serving would meet over 50% of the recommended intake of iron for men and 24% for women, there is more iron than that in equal amount of brown rice (Thompson, 2010).
Sorghum has been shown to be a power house in terms of nutrients. When included in the diet, it can provide vitamins like niacin, riboflavin and thiamin as well as high levels of magnesium, iron, copper, calcium, phosphorus and potassium, as well as nearly half of the daily required intake of protein and a very significant amount of dietary fibre (48% of the recommended intake). Sorghum germ is also rich in B-complex vitamins, while endosperm which is the largest part of the kernel is relatively poor in mineral matter (ash) and oil content. It is, however, a major contributor to the kernel's protein (80 percent), starch (94 percent) and B-complex vitamins 50 to 75 percent (Kent, 1983).
The proximate composition of sorghum varies due to environmental factors, especially since sorghum is grown under quite variable conditions. The pericarp is rich in fibre, whereas the germ is high in protein, fat and ash. The endosperm contains mostly starch, some protein and small amount of fat and fibre (pentasans, cellulose and hemicelluloses). Starch is the most abundant component while soluble sugars and fibre are low. Protein content varies due to agronomic condition (water availability, soil fertility, temperature and environmental conditions during grain development) and genotype. Sorghum proteins are located in the endosperm (80%), germ (16%) and pericarp (3%). Sorghum protein is deficient in lysine, an essential amino acid and protein quality is critically important in developing countries where human diets consist mainly of cereals (Kent, 1983).
Lipids are relatively minor constituents in sorghum; most of the lipids are located in the scuttle area of the germ. This lipid content is significantly reduced when the germ is removed during decortications or degermination. The typical fatty acid composition of sorghum oil is similar to that of maize oil and dominated by linoleic and oleic acids. The lipids can be sub-divided into polar, non-polar and non-saponifiable lipids. The most abundant by far are the non-polar lipds

70% to 80%. Sorghum is an important source of minerals that are located in the pericarp, aleuronic layer and endosperm. Sorghum is good sources of potassium and adequate source of magnesium ion and copper but a poor source of calcium and sodium. Decorticated and degerminated sorghum products are part of these important nutrients. All cereals, except finger millet and teff are poor sources of dietary calcium. Phosphorus is the mineral found in greatest amount. Malting and fermentation significantly increase phosphorus availability due to phytase activity. These processes improve bioavailability of other minerals as well. Sorghum is an important source of vitamins except for vitamin B12 (Gazzaz et al., 1989). Dried matured kernels do not contain vitamin C. The B vitamins are concentrated in the aleurone layer and germ, removal of the tissues by decortications reduces the amounts. Niacin in cereals is found in free and bound forms and can be synthesized from tryptophan. Malting and germination increase the amount of B vitamins and their availability (Gazzaz et al., 1989).

Anti-nutritional Factor in Sorghum and its Impact on Utilization as Food

Several factors including the presence of anti-nutritional factors have been reported as one of the main factors limiting the uses of sorghum as food and feeds (Soetan and Oyewole, 2009). Anti-nutritional factors also known as secondary metabolites, are chemical compounds synthesized in natural food during the process of synthesizing primary metabolites and have been shown to be highly biologically active (Soetan and Oyewole, 2009). The presence of anti-nutritional factors in sorghum has been one of the major limiting factors for its wider utilization as they reduce nutritional utilization of available food compounds (Shantakumari et al., 2008). Though, anti-nutritional factors have been evolved by plants for their own defense, but they reduce the biological function of nutrients and the maximum utilization specially proteins, vitamins and minerals, thus preventing optimal exploitation of the nutrients present in a food and decreasing the nutritive value (Ugwu and Oranye, 2006).

Tannin

Tannins are better astringent plant polyphenols that either bind and precipitate or shrink proteins (Gee and Harolds, 2004). Tannins belong to the phenolic classical secondary plant metabolites and all phenolic compounds are formed via the shimic acid pathwy (Smith and swain, 1962). The astringency from tannins is responsible for dry and pucker feeling in the mouth following the consumption of wine strong tea or unripe fruits. Tannins can be said to be large polyphenolic compounds composed of sufficient hydroxyls and other suitable groups such as carboxyls which forms strong completes with proteins and other macromolecules. The molecular weight of tannins ranges from 500 – 3,000 (Tubacco et al., 2002). Tannins are commonly found in both gymnosperm as well as angiosperms and are located mainly in the surface of plant hence tannins does not interfere with plant metabolism (Heminway et al., 1989).

Phytic Acid

Phytic acid is primarily in the aleurone layer in photon bodies or aleurone layer and to a lesser extent in the germ of sorghum (Doherty et al., 1982). Phytic acid complexes with the essential dietary minerals (e.g. calcium, zinc, iron and magnesium) and therefore, phytates cause the minerals to be unavailable for absorption (Lasztity, 1990; Benito and Miller, 1998). The primary role of phytates may be to store phosphorus and inositol which are gradually utilized during germination. Activity of endosgenous phytases during germination or malting significantly reduces the amount of phytates. Abrasive decortications to remove the pericarp and aleurone layers and or milling into flour with separation of the bran reduces the phytate content from 50%

to 4%. Doherty *et al.* (1981) reported that enzyme methods of phytate removal using fermentation or malting were more effective than the physical extraction methods of milling, soaking and heating. Levels of phytate-phosphorus in 30 sorgum cultivars ranged from 0.17 to 0.38%, accounting for 80 to 87% of the phosphorus in the kernel (Doherty t al., 1981). Lakshmi and Sumathi (1997) reported that the levels of phytates phosphorus in sorghum are higher than those reported for wheat, barley and corn but are significantly lower than that of soybeans and other oilseeds. Sorghum bran contains the highest levels of phytates.

Phytates (myo-inositol hexaphosphate) are severe anti-nutrients present in seeds that binds minerals, especially calcium, iron, magnesium and zinc, making them unavailable for absorption, Svanberg et al. (1999). Attempts to remove it by the means of germination have been explored with a variety of grains and legumes (Egli et al, 2004). The results depend greatly on the species in question. For example, chick pea shows very little change, while the phytate content on rice decreased to about 30% of its original value during 72 hours of germination (Egli et al., 2004). Subsequent processing such as coking, soaking or fermentation may increase the phytate removal. Zinc abosprtion from breakfast porridge was doubled and iron absorption increased by 47% when oats were malted and soaked before use. Egli et al. (2004) achieved a 98% decrease in phytate that led to large increase in zinc and iron solubility in quinoa by germination and fermentation.

Production, Nutritional and Utilization of Grain Legumes

Grain Legumes

The grain legumes refers to edible seeds of leguminous family. They are extremely important plant food in those areas of the world where animal protein are scars and expensive where religious or cultural reasons dictate the avoidance of animal flesh foods, some of the grain legumes are cowpea, peas, lentils, groundnuts, soybean and bambara nuts (Langyintuo et al. 2003).

Soybeans and its Nutritional Significance

The use of soybeans at the household level has been limited to certain countries in Southeast Asia, where about 77g of soybeans are consumed per capita per day in addition both traditional and new soybean food products are marketed in Bangladesh, Malaysia, India andother countries of the East (Ngoddy, *et al*. 1985).

Soybean are first cooked and then fermented or processed by various forms of moist heating. Cooking improves texture and palatability and is required to improve nutritional quality. Five steam treatment, cooking, baking and other common means of food preparation are effective in eliminating the anti nutritional effects of raw soybeans.

Among the legumes, groundnuts and soybeans have exceptional high oil content, about 45% and 20% respectively of the edible portion of the feds. Both seeds, therefore, undergo similar processing which often includes oil extraction (Ngoddy, *et al*. 1985). Although, soybean butter is not as popular as groundnut butter, it is nevertheless a desirable end use.

The protein may be used by adding lecithin as an emulsifier. In such form it can be used as an extender in comminuted meat products, in blended foods and in baby foods. The defatted soybean extruded after heating may be extracted with water, aqueous alcohol or dilutes acid to dissolve and remove carbohydrates and other ingredients resulting in a product of higher protein content (about 60-70%). As such this material may be used in processed meat products, baked goods and breakfast cereals (Ngoddy, *et al*. 1985). A high protein soy concentrate (90-97%) may be obtained by extracting defatted soy flakes with water at isoelectric pH. This material is used in coffee whiteners, in bread spreads and in frozen desserts. Thermoplastic extrusion of defatted soybean flour together with water flavouring and colouring ingredient produces a product which can be used as an extender for meat products such as hamburgers.

In some Asian countries, soybeans milk is prepared by soaking the diced beans for a few hours in water, mashing the beans and boiling in water for 30 minutes, then straining out the solid particles. This soybeans milk may be made from whole or defatted beans. This milk may be sued as such or it may be treated, while hot, with calcium or magnesium salts, with rennet or with lactic acid to precipitate a curd which is then drained and pressed. The curd is eaten in different forms (Ngoddy, *et al*. 1985).

MATERIALS AND METHODS

The samples were purchased at the Maiduguri Monday Market and transported in polythene bags to the Department of Hospitality Management Technology Ramat Polytechnic, Maiduguri, Borno State, for the processing of 25kg millet, 25kg sorghum and 15kg soybean grains obtained and kept in the kitchen at room temperature.

Production of Flours

The cereal grains (millet) flours were processed according to the method demonstrated by Ihekoronye and (Ngoddy 1985). Essentially, the grains was clean to remove extraneous matters such as stones, chaffs, sands and broken grains conditioned to moisture content of 14% and mill with a hammer mill (Meadows Model 35). The flour was sieved using sieves of 315 microns to separate the bran from the endosperm to produce fine flour ready for use in composite blending and the soybean flour was steeped in water for some time.

The flours produce millet, sorghum and soybeans are package and stored at room temperature for both processing and laboratory analysis in the demonstration kitchen of the Department of Hospitality Management and Department of Food Science and technology, Ramat Polytechnic Maiduguri respectively.

Determination of Physical and Functional Properties of Millet

A portion of the millet sample (2kg) was placed in an earthen ware pot and about 2.5 litres of step water (fresh borehole water or kadal) added The sample was steeped for 6 days at room temperature (30$\pm$2^{o}C), then removed, washed with fresh water and briefly sun-dried for 1 hour to remove surface moisture.

Clean soybean grains was placed in an earthen ware pot measuring 500g of step water (fresh borehole water) was fermented for one week by steeping at room temperature then removed, washed with fresh water and briefly dried for 2 hours to remove surface moisture. The steeped millet and steep soybean were mixed in ratio of 4:1 and millet homogenous using a No.2A premier grinding mill (Christy Hunt Engineering Ltd, Atlas Wors Earls Colne, U.K.). A very thin slurry was prepared from the mixed millet and soybean by adding excess water (1:10w/v). This was then sieved using a very fine cheese cloth. The bran fraction (over tail or biria) was removed, sun-dried and reserved for analysis. The filtrate was transferred into a larger earthen ware pot. Vigorously stirred by hand and allowed to settle for two or three days. Excess water was removed and a portion of it reserved for analysis.

The top-lighter layer Chir was carefully removed and placed on a mater in thin sheets and the bottom denser layer *Ndaleyi* was then recovered and placed on another mat. Both samples (*Ndaleyi* and Chir) were sun-dried for 6 to 8 hours.

Determination of Ndaleyi and by-product (Chir and bran). Each of these was expressed as a percentage of dry matter content of cleaned dried mixed of millet and soybean grain (Nkama *et al*. 1994).

Physical Analysis of Millet, sorghum and Soybeans Flours

The moisture content, crude protein (m x 6.25), crude fat and ash content of millet and soybean grain, *Ndaleyi*, Chir, millet and soybean mixed ogi and bran was determined using relevant AOAC methods. Tetratable acidity (TA) and pH of millet grain and soybean grain during steeping, the steep liquor, *Ndaleyi*, Chir and millet and soybean ogi mix wasdetermined according to AOAC methods. Reducing sugars in raw millet grain, soybean *Ndaleyi*, Chir and millet ogi were determined according to Lane and Erynon method as described by (Pearson and Nkama, 1994).

Chemical Methods

Crude Protein Determination

Principle

In Kjeldahl procedure, proteins and other organic food components in a sample are digested with sulphuric acid in the presence of catalysts. The total organic nitrogen is converted to ammonium sulphate. The digest was neutralised with alkali and distilled into a boric acid solution. The borate anions formed are titrated with standardized acid which was converted to nitrogen in the sample. The result of analysis represents the crude proteins content of the food since nitrogen also come from non-protein components.

Titration

The distillate in the conical flask was titrated with standard solution of hydrochloric acid (Hcl) to the end point. The titre volume was recorded, that is, volume of Hcl that exchanged with the indicator and percentage crude protein was calculated.

$$\%\ \text{Crude Protein} = \frac{A \times C \times 100 \times 1 \times 6.25}{B \times D \times 100 \times E}$$

Where :

A = Volume of solution of standard HCL (titre value)

B = Volume of Sample solution taken from distillation

C = Volume of sample made after digestion

D = weight of sample taken for distillation

E = acid factor

Oven Drying Methods

In oven drying methods, the sample was heated under specified conditions and the loss of weight was used to calculate the moisture content of the sample. The moisture content value obtained was highly dependent on the type of oven used, conditions in the oven and the time and temperature of drying. Various drying oven methods are AOAC approved for many food products. The methods are simple, and many ovens allow for simultaneous analysis of large numbers of samples. The time required may be from a few minutes to 24 hours.

Calculation of moisture and total solid contents of foods

Moisture and total solids contents of foods can be calculated as follows using oven drying procedure:

$$\%\ \text{moisture} = \frac{w_t H_2O\ in\ sample}{wt.of\ wet\ sample} \times 100$$

$$\%\ \text{moisture} = \frac{wt.of\ wet\ sample = wt.of\ dry\ sample}{wt.of\ wet\ sample} \times 100$$

$$\% \text{ total solids (wt/wt)} = \frac{wt.of\ dry\ sample}{wt.of\ wet\ sample} \times 100$$

(ii) $\frac{proein\ content\ analysis}{(kjeldahl\ method}$ (AOAC 1991).

Principle

In the Kjeldahl procedure, proteins and other organic food components in a sample are digested with sulphuric acid in the presence of catalysts. The total organic nitrogen was converted to ammonium sulphate. The digest was neutralized with alkali and distilled into a boric acid solution. The borate anions formed were titrated with standardized acid which is converted to nitrogen in the sample. The result of the analysis represents the crude protein content of the sample of the food since nitrogen also comes from non-protein components.

Defatted Sample of Soybean

The samples were defatted using chloroform and methanol (solvents) mixed in the ratio of 2;1 and 4g of each of the samples were placed in extraction thimble for 15 hours defatting in Soxhlet extraction apparatus (AOAC, 2006).

Ash Content Analysis

The Association of Official Analytical Chemists (AOAC) international has several dry ashing procedures (e.g. AOAC methods) for certain individual foodstuffs

The general procedure includes the following steps:

i. The sample were weighed in a 5g sample into a tarred crucible pre-dry if the sample is very moist and crucibles was placed in cool muffle furnace use tongs gloves and protective eye ware if the muffle furnace is warm.
ii. The muffle furnace was turned off and waits to open it until the temperature has dropped to at least 250^{o}C preferably lower. Open door carefully to avoid losing ash that may be fluty.
iii. A safely tongs was used to quickly transfer crucibles to a desiccator with a porcelain plate and desiccant. Cover crucibles, close desiccator and allow crucibles to cool prior to weighing.

The ash content is calculated as follows:

$$\% \text{ ash} = \frac{\text{wt. after ashing – tare wt of crucible}}{\text{Original sample wt x dry matter coefficient}}$$

Where: dry matter coefficient = % solids/100

Crude Fat Analysis (Continuous Solvent Extract Methods)

For continuous extraction, sample was put in an extraction ceramic thimble and the solvent is added into the boiling flask. The continuous method gives faster more efficient extraction than semi-continuous extraction methods. However, they may cause channeling which results in incomplete extraction. The Wiley under writers and goldfish tests are examples of continuous lipid extraction methods.

Soxhlet method – procedures – preparation of sample: If the sample contains more than 10% H_2O dry the sample to constant weight at 95-100% under pressure ≤ 1000mmHg for about 5 hours (AOAC method).

Soxhlet method procedure

i. The samples were weighed to the nearest mg, about 2g. Pre-dried sample into a pre-dried extraction thimble, with porosity permitting a rapid flow of ethyl ether, cover sample in thimble with glass wool; it was weighed pre-dried in a boiling flask.
ii. The samples were put anhydrous ether in boiling flask. Note: the anhydrous ether was prepared by washing commercial ethyl ether with two or three portions of H_2O adding NaOH or KOH and letting stand until most of H_2O is absorbed from the ether. Add small pieces of metallic Na and let hydrogen evolution cease (AOAC Method). Petroleum ether may be used instead of anhydrous ether (AOAC method).
iii. The samples were assembled in boiling flask Soxhlet flask and condenser. The sample was extracted in a Soxhlet extractor at a rate of 5 or 6 drops per second condensation for about 4 hours or for 16 hrs. at a rate of 2 or 3 drops per second by heating solvent in boiling flask.
iv. The sample were dry boiled in a flask with the extracted fat in an air oven at 100°C for 30 mins, cool in desiccator and weigh.
Calculation

$$\frac{\text{fat on dry weigh basis} \quad = \quad \text{\%fats in sample}}{\text{(dried sample)} \times 100}$$

Dietary Fibre Analysis

Dietary fibre was estimated by two basic approaches i.e. gravimetrically or chemically. In the first approach, digestible carbohydrate, lipids and proteins are selectively solubilized by chemicals and/or enzymes. Indigestible materials are then collected by filtration and the fibre residue is quantitated gravimetrically. In the second approach, digestible carbohydrates are removed by enzymatic digestion, fibre components are hydrolyzed by acid and monosaccharide are measured, sum of monosaccharide in the acid hydrolyzed represents fibre.

Carbohydrate Content Determination

The available percentage of carbohydrates in the sample was determined by difference i.e. (100% -moisture + protein + ash + fibre) as described by Chibuzo and Ali (1994; 1995) and Asma et al. 2006).

Total Caloric Value

The total caloric value or energy value was estimated by using the A+ water factor as reported by Chibuzo and Ali (1994-95).

Determination of Mineral in samples

The minerals analyses of the samples were determined with the Atomic Absorption spectrophotometer (AAS) as described by (AOAC 2000). The minerals that were analyzed are calcium, iron, zinc, sodium, magnesium, potassium, phosphorus, copper and manganese.

Procedure

About five grams of the formulated flours and fortificant was weighed into a clean dry porcelain crucible. It was shed in muffle furnace for two to. Hours at 475 to 500°C, cooled and dissolved in five mills of 20% Hcl. It was filtered into fifty mills volumetric flask after thorough acid wash. It was diluted with distilled water. Iron was determined by wavelength of 248.3nM. Zinc at 213.9πM, sodium and potassium was determined with flame photometer calorimetric method.

Preparation of Millet Fermented to Flour

Millet was cleaned from dirt, washed and soaked for at least 12hour then washed with clean water, sun-dried for 3-4 hours. The millet was milled into flour and sieve to obtain fine flour, and the fine flour were packaged.

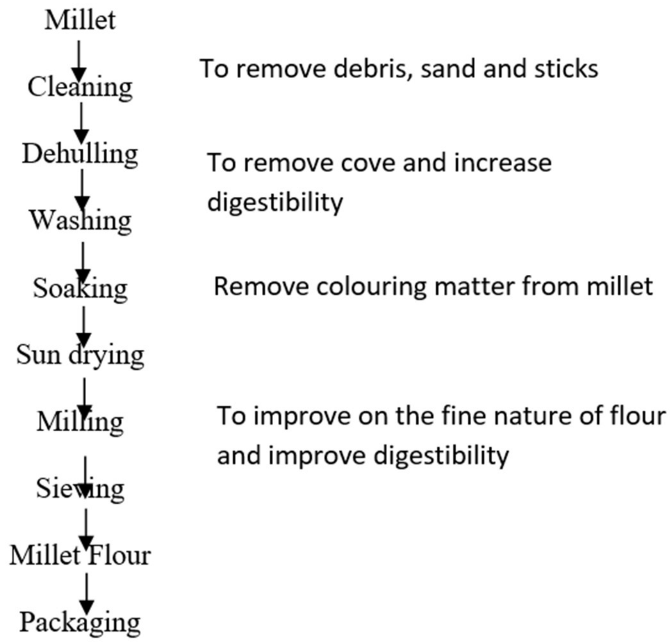

Fig. 3.1: Flow chart for the production of millet flour (Nkama *et al*., 1994)

Method of Preparation of Soybeans Fermented to Flour

Soybeans were cleaned from dirt, washed and soaked for at least 12 hours then washed with clean water, sun-dried (for at least 3-4 hours). The soybean was milled into flour and sieved to obtain fine flour were packaged.

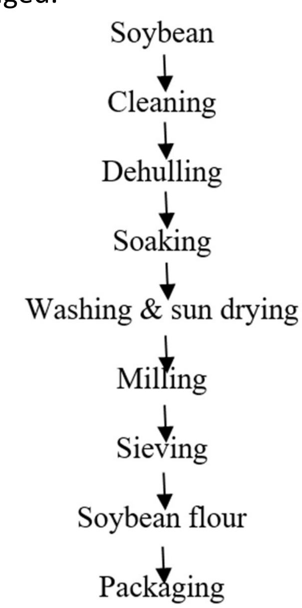

Fig.3.2: The flowchart for the preparation of soybean flour (Ngoddy *et al.,* 1985).

Production of Fermented Sorghum Flour

The sorghum seeds are fermented after cleaning, dehulling and undehulled seeds are grinded into fine particles by the attrition and pass through a 0.8mm mesh size sieve and packaged in transparent plastic buckets and store until when needed for use (Badau *et al*. 2006).

Flow chart to produce Fermented Sorghum

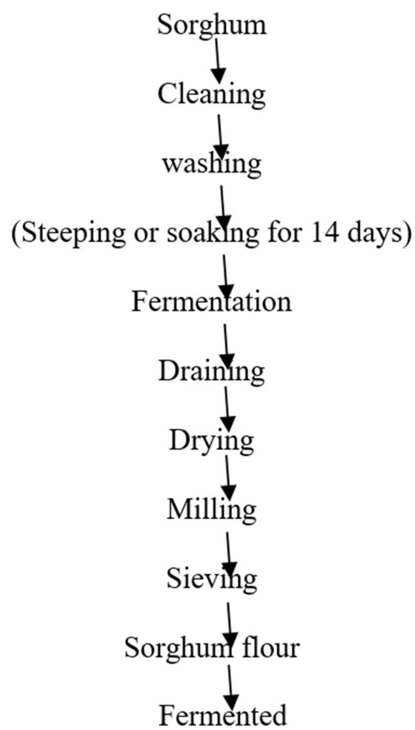

Fig. 3.3

Steps Involved in Production of Ndaleyi from Millet

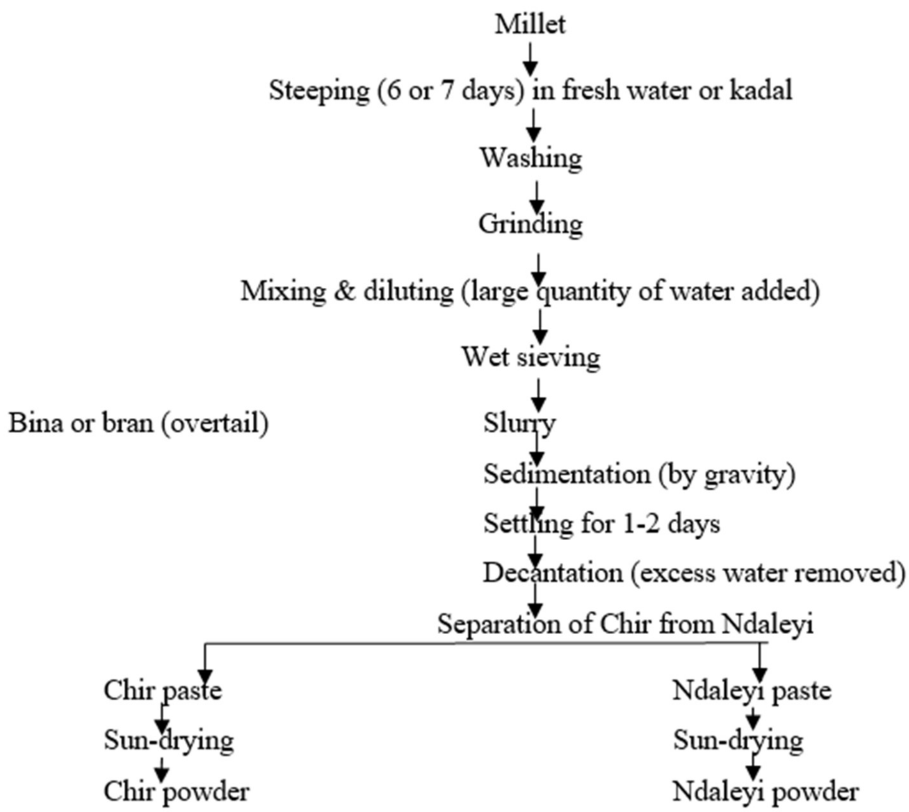

Fig. 3.4 Nkama *et al* 1994

RESULTS AND DISCUSSION

Effects of Dehulling on Millet, Sorghum and Soybean Flours

The result of the mineral elements composition in the dehulled and undehulled samples were potassium (231.31mg, 50.79mg) for millet, (3911.11mg), (384.32mg) for sorghum and (675.12mg; 682.84mg) for soybeans respectively in which were higher in potassium content.

The magnesium content for dehulled and undehulled sample were (42.55mg, 47.70mg) for millet, (37.34mg, 38.13mg) for sorghum and (65.65mg, 74.59mg) for soybean respectively. The magnesium content of sample is also high. Calcium, phosphorus and sodium content of the sample were at the high side. The concentration of zinc, iron and manganese content of the sample were low in dehulled and undehulled millet, sorghum and soybean respectively.

The results obtained show the negative decline in mineral concentration in favour of undehulled samples of millet, sorghum and soybean than the dehulled samples. This is due to the reduction of the pericarp, endosperm, bran and other anti-nutritional factors e.g. oxalates, tannins, etc. during dehulling but improves the bioavailability and palatable content of the food sample (Joseph, *et al*. 2021).

The high iron content of the soybean sample for both dehulled and undehulled samples at 12.35mg to 13.26mg as a remedy for iron deficiency disease, that is anemia. Generally, in refining grain, the bran is separated, resulting in the loss of dietary fibre, vitamins, minerals, lignans, phytoestrogen, phenolic compounds and phytate diets (Oghbaei & Prakash, 2016). The result revealed a clear negative effect of dehulling on the concentration of Fe, Zn and Mg. In all the grains studied, Fe, Zn and Mg decreased in the experimental sample when compared to the whole undehulled control samples. The decrease in the levels of these micronutrients was statistically significant ($P \leq 0.05$) when compared with the control samples. In real terms, this represents 40-44% decrease in the levels of iron, zinc and magnesium from 2.96mg to 2.65mg, 1.80mg to 1.96mg and 47.70mg to 42.56mg respectively for millet and 4.92mg to 4.65mg, 1.96 mg to 1.85mg and 38.11mg to 37.30mg respectively for sorghum.

Although, dehulling in grains reduced the levels of anti-nutrients, it inevitably and negatively affects the levels of desirable nutrients which are mostly located on the outer parts of the grains. The practice of dehulling cereals to improve palatability and organoleptic qualities, most times unwittingly leads to severe reduction or total loss of valuable micronutrients. The findings in this research indicates that Fe, Zn and Mg are substantially lost when millet, sorghum and soybean are decorticated, a practice aimed at producing better products but unfortunately does more harm than good, by removing germ and bran that contains this mineral (Nkama and Ikwelle 1997).

Table 3: Effect of Dehulling on the Mineral content of samples (Mg/100g)

	Minerals (mg/100g)[1]							
Sample (Code)[2]	Mg	P	Ca	Mn	K	Na	Fe	Zn
DMF	$42.56^{d}\pm0.01$	$385.15^{b}\pm0.01$	$175.33^{d}\pm0.01$	$11.23^{f}\pm1.00E.02$	$231.31^{f}\pm0.01$	$41.60^{d}\pm0.470$	$2.65^{f}\pm0.01$	$1.88^{e}\pm0.02$
UMF	$47.70^{c}\pm4.3E.04$	$391.35^{a}\pm0.01$	$182.03^{c}\pm1.0E.02$	$18.82^{e}\pm0.02$	$260.71^{e}\pm0.01$	$47.13^{c}\pm0.02$	$2.97^{e}\pm5.84E.03$	$1.97^{c}\pm5.84E.03$
DSF	$37.34^{f}\pm0.01$	$265.62^{c}\pm0.02$	$141.21^{e}\pm0.01$	$20.735^{d}\pm1.0e.02$	$391.11^{c}\pm1.0e.02$	$31.51^{f}\pm0.02$	$4.65^{d}\pm5.7E.03$	$1,85^{e}\pm0.01$
USf	$38.11^{e}\pm1.0E.02$	$265.33^{c}\pm0.01$	$124.62^{f}\pm0.02$	$21.11^{c}\pm5.774E.03$	$384.33^{d}\pm1.000E.02$	$37.83^{e}\pm1.0E.02$	$4.92^{c}\pm0.01$	$1.88^{d}\pm1.0E.02$
DSOF	$675.12^{b}\pm0.02$	$137.34^{e}\pm0.02$	$335.84^{a}\pm0.01$	$53.66^{b}\pm5.8E.03$	$675.12^{b}\pm0.00$	$64.30^{a}\pm0.01$	$12.35^{b}\pm1.0E.04$	$4.55^{b}\pm5.584E.03$
USOF	$74.61^{a}\pm0.040$	$154.32^{d}\pm0.02$	$310.01^{b}\pm0.02$	$58.613^{a}\pm0.02$	$682.83^{a}\pm0.02$	$62.44^{b}\pm1.E.02$	$13.23^{a}\pm0.01$	$4.64^{a}\pm0.02$

(1) Triplicate determination in any column means bearing similar superscripts are not significantly different ($P \geq 0.05$)

(2) DMF = Dehulled Millet Flour; UMF = Undehulled Millet Flour; DSF = Dehulled Sorghum Flour; USF = Undehulled Sorghum Flour

DSOF = Dehulled Soybean Flour; USOF = Undehulled Soybean Flour

Effects of Dehulling on the Vitamin and Copper Composition of Millet, Sorghum and Soybean Flour

The results of the findings in terms of vitamins and copper contents of millet, sorghum and soybean flour, there is high amount of thiamin (B1) vitamins in millet than sorghum flour from (0.38mg/100g to 0.29mg/100g) after dehulling, there is also a decrease in vitamin B1(thiamin) contents for sorghum flour. B2 (Riboflavin) decreases from (0.26mg/100g to 0.37) contents for undehulled sorghum to undehulled millet flour. The copper content of millet and sorghum was not detected while dehulled and undehulled samples of soybean has a little amount of copper which is less than one mg in 100mg of the sample as it was reported by (Fardet, 2010) previously. B-vitamins are known to increase with fermentation and dehulling with cereals. The result shows increase in the Thiamin (B1) content of the dehulled millet from 0.43mg/100g to 0.46mg/100g and also the dehulled sorghum respectively. The results of the undehulled sorghum flour shows decrease in the riboflavin (B_2), increase of thiamine (B1) vitamin for c the dehulled millet flour from 0.37mg/100g to 0.32mg/100g respectively, whereas there is increase in riboflavin (B_2) for dehulled sorghum from 0.23mg/100g to 0.29mg/100 respectively. The Niacin (B_3) contents of the dehulled and undehulled millet flours almost the same at 1.46mg/100g but increase for dehulled sorghum flour from 1.16mg/100g to 1.23mg/100g. Millet has higher B-complex vitamins than sorghum. Greater levels of thiamine, niacin, pantothenic acid and pyridoxine similar to that of wheat as shown on table 4.4 in conformity with results obtained by (Kent 1983, Nkama 1983, Ahmed and Dominguez et al., 1993.) B-complex vitamins was not detected in both dehulled and undehulled soybean flours during the research as shown the table 4.4. However, the copper compositions for both dehulled and undehulled soybean flours are low, less than one gram in 100g per sample.

Table 4: Effects of Dehulling on the Vitamins and Copper Composition of Millet, Sorghum and Soybean Flour

	Parameters (Mg/100g)			
Samples (CODE)	Thiamin (B1)	Riboflavin (B2)	Niacin B3	Copper
DMF	$0.46^{a}\pm5.4.03$	$0.32^{b}\pm0.01$	1.4167b±0.02	ND*
UMF	$0.43^{b}\pm5.4e.03$	$0.37^{a}\pm0.01$	1.46a±0.01	ND*
DSF	$0.38^{c}\pm0.01$	$0.29^{c}\pm0.02$	1.24c±0.02	ND*
USF	$0.31^{d}\pm0.01$	$0.27^{d}\pm0.02$	1.16cd±0.01	ND*
DSOF	ND*	ND*	ND*	$0.63^{b}\pm0.02$
USOF	ND*	ND*	ND*	$0.68^{b}\pm0.02$

1. Values are means ± standard deviations of triplicate determination, in any column, means bearing similar superscript are not significantly different (P≥0.05)
2. DMF = Dehulled MIllet Flour; UMF = Undehulled Millet Flour; DSF = Dehulled Sorghum Flour; USF = Undehulled Sorghum Flour
   DSOF = Dehulled Soybean Flour; USOF = Undehulled Soybean Flour
3. ND* = Not detected

Table 5: Effects of Fermentation on the Mineral Content of Millet, Sorghum and soybean Flours

The results of the mineral content of the fermented samples of dehulled and undehulled millet, sorghum and soybean flour were determined. Generally, natural cereal grain fermentation result in a decrease in mineral concentration as shown on table 4.5, there is also decrease in iron concentration for the samples of millet and sorghum for both dehulled and undehulled samples. (6.83mg/100g to 6.55mg/100g) and (7.43mg/100g to 7.13mg/100g) for millet and sorghum grains while iron concentration for soybean is a bit high (16.42mg/100g to 18.00mg/100g) for both dehulled and undehulled sample. There is also low concentration of zinc and sodium for all fermented samples except undehulled soybean flour shows 18.00mg/100g. Because of the removal of germ, pericarp polyphenolic compounds, and bran during processing. (Oghbaie and Prakash 2016).

The results of the fermented sample of millet, sorghum and the soybean for both dehulled and undehulled samples are very high in magnesium (mg), phosphorus (p), calcium (ca) and potassium (k), content of the sample under investigation as shown on Table 4. 5. The sample also shows that the manganese (Mn) concentration of the sample of both dehulled and undehulled soybean flours is also high in comparison to the fermented dehulled and undehulled millet and sorghum flour samples respectively. These is due to high bran and germ content of soybean than in millet and sorghum flours. As reported by (Merero etal., 1988).

Fermentation offers suitable pH environments for enzymatic degradation of phytates present in cereals forming complexes with minerals (iron, zinc, calcium, magnesium and similar proteins.

Similarly, decrease in phytates during fermentation and processing may boost the quantity of soluble minerals Iron, zinc and calcium) to several folds (Haard et al. 1999).
Fermented soybean flours for both dehulled and undehulled shows an increases of magnesium,(84.88mg/100g to 88.71mg/100g) phosphorus, (195.92mg/100g to311,04mg/100g) calcium(475.75mg/100g to 435.26mg/100g) respectively. These is due to removal of the outer covering of the seeds during dehulling and fermentation. (Merero etal 1988.,)

Table 6: Effects of Fermentation on the Mineral content of Millet, Sorghum and Soybean Flours

	Minerals (Mg/100g)							
Sample (Code)	Mg	P	Ca	Mn	K	Na	Fe	Zn
FDMF	$64.77^{d}\pm0.56$	$421.94^{b}\pm0.12$	$231.53^{e}\pm0.06$	$22.01^{f}\pm0.02$	$261.62^{f}\pm1.E.02$	$43.16^{f}\pm0.01$	$6.82^{e}\pm0.02$	$3.17^{f}\pm0.01$
FUMF	$68.82^{c}\pm0.05$	$442.13^{a}\pm0.02$	$260.85^{c}\pm0.02$	$28.74^{e}\pm0.06$	$265.13^{e}\pm1.02$	$45.90^{e}\pm2.33$	$6.66^{f}\pm0.02$	$3.33^{e}\pm0.02$
FDSF	$41.55^{f}\pm0.02$	$283.66^{f}\pm0.01$	$191.74^{f}\pm0.01$	$32.95^{c}\pm5..03$	$362.24^{d}\pm0.01$	$53.42^{c}\pm0.02$	$7.42^{c}\pm0.02$	$3.65^{d}\pm0.02$
FUSF	$46.65^{c}\pm5..03$	$311.04^{c}\pm0.01$	$236.01^{d}\pm0.01$	$33.15^{d}\pm1..02$	$371.84^{c}\pm0.01$	$53.939^{d}\pm0.02$	$7.13^{d}\pm1..02$	$4.033^{c}\pm0.0$ 2
FDSOF	84.88b±1..0 2	$195.92^{f}\pm0.02$	$435.26^{b}\pm0.02$	$61.54^{b}\pm0.02$	$681.28^{b}\pm0.02$	$68.12^{b}\pm0.02$	$16.42^{b}\pm1.0$ 2	$8.93^{b}\pm0.03$
FUSOF	$88.71^{a\pm}1.02$	$213.86^{e\pm}0.02$	$472.75^{a}\pm0.03$	$64.15^{a}\pm0.03$	$692.83^{a}\pm0.02$	$74.34^{a}\pm1.02$	$18.00^{a}\pm0.0$ 2	$9.85^{a}\pm0.01$

1. Values are means ± standard deviation of tri[pilicate determination, in any column, means bearing similar superscripts are not significantly different (P≥0.05)
2. FDMF = Fermented Dehulled Millet Flour; FUMF = Fermented Undehulled Millet Flour
   FDSF = Fermented Dehulled Sorghum Flour; FDSOF = Fermented Dehulled Soybean Flour
   FUSOF = Fermented Undehulled Soybean Flour

Effects of Fermentation on the Vitamins and Copper Composition of Millet, Sorghum and Soybean

The results of vitamins and copper composition of the sample; B_1 vitamin (Thiamin) is high in fermented dehulled millet sample than undehulled millet from (0.50mg/100g to 0.47mg/100g). There is also high concentration of B3 (Niacin) in all fermented millet and sorghum flour with no or little in soybean flour. Copper minerals are not found in any millet and sorghum flour but found in small quantity in soybean flour from (0.90mg/100 to 0.83mg/100g) from dehulled to undehulled soybean flour. (Ahmed and Dominguez etal 1993).

The B-complex vitamins are very necessary in red blood cell formation with the help of enzymes. B vitamins are also significant in releasing energy from carbohydrate. Fats and proteins. The fermented samples of dehulled and undehulled samples of millet and sorghum flour is rich in B_1 (Thiamin) but low in B_2 (Riboflavin) vitamins as shown on the table (Fardet, 2010).

The results of the B1 (thiamin) content of the fermented and dehulled millet sample increases from 0.48mg/100g to 0.50mg/100g while B2 (riboflavin) content of the same milt decrease from 0.41mg/100g to 0.38mg/100g. Also, the fermented dehulled millet sample decreases in B3 (Biacin) content from 1.65mg/100g to 1.57mg/100g, the same result shows for fermented and dehulled sorghum flour in respect of B3 (Niacin) contents. Thiamine (B1) content of the fermented and dehulled sorghum also witness a decreased from 0.46mg/100g to 0.47mg/100g. No result was found for copper content in both fermented undehulled millet and sorghum flour, but was found for fermented and dehulled soybean flour decreases from 0.90mg/100g to 0.83mg/100g. Cereals and legumes are known as poor man's meat and a good sources of complex dietary carbohydrates (starch and dietary fibre) proteins, and minerals B-complex vitamins (Kumari and Sangeetha 2017).

Table 7: Effects of Fermentation on the Vitamins and Copper Composition of Millet, Sorghum and Soybean flours

Parameters (Mg/100gm) (1)				
Sample (Code)(2)	Thiamin (B_1) (mg/100g)	Riboflavin B_2 (mg/100g)	Niacin B_3 (mg/100g)	Copper (Mg/100g)
FDMF	$0.50^a \pm 0.02$	$0.38^b \pm 0.02$	$1.57^b \pm 0.02$	ND*
FUMF	$0.48^b \pm 0.0153$	$0.41^a \pm 0.02$	$1.65^a \pm 0.02$	ND*
FDSF	$0.43^c \pm 0.01$	$0.35^d \pm 0.02$	$1.34^d \pm 0.01$	ND*
FUSF	$0.46^c \pm 0.02$	$0.36^b \pm 0.02$	$1.49^c \pm 0.02$	ND*
FDSOF	ND*	ND*	ND*	$0.83^b \pm 0.01$
FDSOF	ND*	ND*	ND*	$0.90^a \pm 0.02$

1. Values are means ± standard deviations of triplicate determination, in any column, means bearing similar superscripts re not significantly different (P≥0.05)
2. FDMF = Fermented Dehulled Millet Flour; FUMF = Fermented Undehulled Millet Flour
FDSF = Fermented Dehulled Sorghum Flour; FDSOF = Fermented Dehulled Soybean Flour
FUSOF = Fermented Undehulled Soybean Flour
3. ND* = Not Detected

Mineral Content of Sample of Traditional *Ndaleyi*, Chir and Bran for both Millet and sorghum Flour

The results of the *Ndaleyi*, Chir and bran shows that Chir, the gluten concentration of the millet(Chir) sample is high in calcium, phosphorus and potassium (78.55mg/100g, 65,53mg/100g and 73.08mg/100g) while low in zinc, iron and magnesium (0.13mg/100g, 0.10mg/100g and 3.52mg/100g) respectively. Millet *Ndaleyi* flour with greater percentage of minerals but less in manganese and sodium. (2.31mg/100g and 10.32mg/100g) respectively. These may be due to removal of bran, pericarp and germ during processing.

Increase in minerals like calcium, phosphorus and potassium in the millet Chir from (80.77mg, 22.65mg and 92.92mg) and millet *Ndaleyi (72.42mg, 42.64mg and 61.86mg) respectively* was as a result of high percentage of these minerals in millet as it was reported in other literature. The Chir and Ndaleye composition of the mineral content of the sample were higher in sorghum than the millet based on this finding. The mentioned minerals like calcium, phosphorus and potassium have high concentration in sorghum Chir flour and sorghum*Ndaleyi flour*. From (80.77mg/100g, 22.65mg/100g and 92.92mg/100g), than millet Chir flour (78.55mg/100g, 65.53mg/100g and 73.08mg/100g respectively, as was reported by (Nkama and Ikwelle 1997).

The bran or overtail flour of the sample of both millet and sorghum are greater or higher in mineral composition of calcium, phosphorus, potassium and manganese than *Ndaleyi* and Chir of both millet and sorghum. The bran is recommended for animal feeds because of the available nutrients. These results have high nutritional benefit as it is rich in nutrients for human consumption as well (Prakash, 2007). Sorghum bran and millet Ndaleyi flour are almost same in magnesium, manganese and sodium content at (7.81mg /100g, 3.70mg/100g and 12.32mg/100g) respectively which is vital for animal feeds.

Table 8: Mineral Content of Sample of Traditional Ndaleyi Chir and Bran from both Millet and Sorghum Flour

	Minerals (Mg/100g)							
Sample Code	Mg	P	Ca	Mn	K	Na	Fe	Zn
MNF	$2.23^a\pm0.02$	$42.65^b\pm0.03$	$72.42^e\pm0.02$	$2.32^f\pm0.02$	$61.86^f\pm0.03$	$10.32^d\pm0.03$	$0.24^e\pm0.02$	$0.13^a\pm0.02$
MCF	$3.52^b\pm0.01$	$65.53^a\pm0.02$	$78.55^d\pm0.02$	$4.36^d\pm0.03$	$73.08^d\pm0.05$	$10.24^d\pm0.03$	$0.10^e\pm0.17$	$0.12^a\pm0.02$
MBF	$7.61^b\pm0.02$	$36.81^c\pm0.02$	$96.60^a\pm0.03$	$3.45^c\pm0.03$	$82.61^c\pm0.02$	$11.16^c\pm0.02$	$0.44^c\pm0.03$	$0.12^a\pm0.02$
SNF	$2.69^b\pm0.05$	$32.35^d\pm0.03$	$61.58^f\pm0.05$	$2.66^e\pm0.02$	$63.04^e\pm0.04$	$13.77^a\pm0.05$	$0.35^d\pm0.03$	$0.14^a\pm0.03$
SCF	$2.83^b\pm0.01$	$22.65^f\pm0.04$	$80.77^c\pm0.02$	$3.36^d\pm0.01$	$92.92^b\pm0.02$	$10.20^b\pm0.02$	$0.63^b\pm0.02$	$0.23^a\pm0.02$
SBF	$7.80^b\pm0.02$	$24.85^e\pm0.02$	$87.89^b\pm0.06$	$3.76b^{\pm}0.02$	$112.34^a\pm0.02$	$12.32^b\pm1.E-02$	$0.80^a\pm0.02$	$0.30^a\pm0.02$

1. Values are means to standard deviations of triplicate determinations, in any column, means bearing similar superscripts are not significantly different (P≥0.05)
2. MNF = Millet *Ndaleyi* Flour; MCF = Millet Chir Flour; MBF = Millet Bran Flour; SNF = Sorghum *Ndaleyi* Flour; SCF = Sorghum Chir Flour; SBF = Sorghum Bran Flour
3.

Effects of Fermentation on the vitamin and copper Composition of Samples of Ndaleyi, Chir and Bran Flours. **T**he results of the effects of fermentation on the B_1 vitamin (Thiamin) is high in fermented dehulled millet Ndaleye flour sample than undehulled millet Chir flour(0.01mg/100g). There is also high concentration of B_3 (Niacin) in all fermented millet and sorghum Ndaleyi(.0.39mg/100g) flour with no or little in soybean flour. Copper minerals are not found in any millet and sorghumNdaleye and millet Ndaleyi and Chir flours respectively but found in small quantity in soybean flour with about (0.07mg/100g and 0.05mg/100g).

The B-complex vitamins are very necessary in red blood cell formation with the help of enzymes. B vitamins are also significant in releasing energy from carbohydrate. Fats and proteins. The fermented samples of dehulled and undehulled samples of millet and sorghum Ndaleyi and their respective Chir flours is rich in B_1 (Thiamin) but low in B_2 (Riboflavin) vitamins as shown on the table 4.12 and is the same work done by (Fardet *et al* 2010).

The copper content in millet Ndaleyi, millet Chir, millet bran and sorghum Ndaleyi flours have not been detected, but the copper content of sorghum Chir flour and sorghum bran flour is found at 0.74mg/100g and 0.05mg/100g. The thiamin (B_1), riboflavin (B_2) and niacin content are not detected in sorghum Chir and sorghum bran flours respectively. Millet has higher protein than sorghum or maize and also rich in the B-complex vitamins with greater levels of thiamine, niacin, pantothenic acid and pyridoxine similar to that of wheat as shown on the result table 4.12 in conformity with the research conducted by (Kent 1983, Nkama 1983, Ahmed and Dominguez *et al* 1993). Millet bran flour is rich in all the B- complex vitamins ie thiamine, riboflavin and niacin with 0.0203mg/100g, 0.01mg/100g and 0.06mg/100g) respectively, than sorghum bran flour in which the result was not detected.

Table4. 9: Effects of Fermentation on the Vitamins and Copper samples of Ndaleyi Chir and Bran

	Parameter (Mg/100g) (1)			
Sample (Code) (2)	Thiamin (B_1)	Riboflavin B_2	Niacin B_3	Copper
MNF	$0.02^b \pm 2.2E\text{-}02$	$0.02^b \pm 1.527E\text{-}03$	$0.04^d \pm 2.02E\text{-}03$	ND*
MCF	$0.014^b \pm 1.5E\text{-}03$	$0.02^a \pm 1.0E\text{-}03$	$0.39^c \pm 1.7E\text{-}03$	ND*
MBF	$0.02^a \pm z2.2E\text{-}03$	$0.01^c \pm 1.527E\text{-}03$	$0.07^a \pm 1.0E\text{-}03$	ND*
SNF	$0.02^b \pm 2.082E\text{-}03$	$0.02^a \pm 1.4E\text{-}03$	$0.07^b \pm 1.0E\text{-}03$	ND*
SCF	ND*	ND*	ND*	$0.07^b \pm 2.2E\text{-}06$
SBF	ND*	ND*	ND*	$0.05^a \pm 1.7E\text{-}03$

1. Values are means ± standard deviation of triplicates determination in any column, means bearing similar superscripts are not significantly dfferent (P≥0.05)
2. MNF = Millet *Ndaleyi* Flour; MCF = Millet Chir Flour; MBF = Millet Bran Flour
   SNF = Sorghum *Ndaleyi* Fllour; SCF = Sorghum Chir Flour; SBF = Sorghum Bran Flour
3. ND* = Not Detected

Effects of Fortification on the Mineral Content of the Fortified Ndaleyi Sample

The results of mineral content of dehulled Ndaleyi millet flour at ratios (75:25) is (215.87mg/100g, 372.73mg/100g and 321.52mg/100g rich in calcium, phosphorus and potassium respectively, but less in magnesium, manganese and iron (78.76mg/100g, 36.76mg/100g and 5.25mg/100g) respectively, but deficient in zinc, with about(3.05mg/100g). This mineral content of the fortified cereals with legumes after dehulling will increases as it was reported by Fardet (2010). However, the mineral concentration of dehulled and undehulled sorghum with soybean in ratios (90:10) and (75:25) is equally rich in potassium, calcium and phosphorus which is in conformity of the already available literatures by (Ogbhaei and Prakash, 2016).

The zinc content of (75:25) ratios of the sorghum and soybean fortificant is higher with (8.29mg/100mg) of the sample, when compared to zinc content of dehulled (90:10) millet fortified with soybean at (3.05mg/100g) of the sample. Also, the calcium content of the undehulled sorghum in Ndaleyi with the soybean with (75:25) fortification ratio is high than both dehulled and undehlled millet at (75:25) fortification ratios at 215.80mg/100g (90:10) with 184.50mg/100g of the sample respectively. These may be due to processing techniques in removing the bran husk and the covering membrane of the grain during dehulling which substantially contains calcium. The potassium content of the undehulled sorghum fortificant at (75:25) ratios is higher at 624.17mg/100g when compared to all the other samples of millet both dehulled and undehulled ratios respectively. These is attributed to the loss of some important minerals during dehulling (Ogbhaei and Prakash, 2016). The removal of some of the outer layers of millet, sorghum and soybean grain during processing of Ndaleyi reduces the protein content but increases digestability of the dehulled and fermented products (Nkama and Ikwelle 1997).

Table 10: Effects of Fortification on the Mineral Content of Samples (Mg) (100g)

	Minerals (mg/100g) (1)							
Sample Code (2)	Mg	P	Ca	Mn	K	Na	Fe	Zn
MNSO Dehulled (90:10)	71.67^{b}±0.57	344.86^{c}±0.02	187.82^{d}±5.4E-03	34.05^{d}±0.64	264.91^{c}±0.51	34.29^{ab}±1.0E-02	4.95^{e}±0.02	3.86^{b}±0.03
MNSO (undehulled (75:25)	78.77^{a}±0.15	372.73^{b}±0.02	215.87^{c}±0.02	36.76^{b}±0.03	321.52^{d}±0.02	28.26^{e}±0.02	5.25^{d}±0.02	3.06^{bc}±0.56
SNSO Dehulled (90:10)	62.93^{b}±0.04	341.56^{d}±0.02	184.53^{e}±0.02	31.85^{e}±0.02	383.54^{b}±0.03	31.26^{c}±0.04	6.84^{b}±0.0265	2.19^{c}±1.14
SNSO (undehulled) (75:25)	83.14^{a}±0.03	313.61^{e}±5.4E-03	257.12^{b}±0.02	34.22^{e}±0.02	311.20^{e}±0.01	29.51^{d}±5.4E-03	5.32^{c}±0.01	3.61^{b}±5.4E-03
DSOF	61.53^{b}±0.02	462.80^{a}±0.01	478.13^{a}±0.01	73.14^{a}±0.02	624.15a±0.03	74.14a±0.02	15.45^{a}±0.000	8.79^{a}±0.02

1. Values are means ± standard deviation of triplicates determination in any column, means bearing similar superscripts are not significantly dfferent (P≥0.05)
2. MNSO = Millet Ndaleyi and Soybean (90:10) dehulled
   MNSO = Millet Ndaleyi and Soybean (75:25) undehulled
   SNSO = Sorghum Ndaleyi and Soybean (0:10) dehulled
   SNSO = Sorghum Ndaleyi and soybean (75:25) undehulled
   DSOF = Defatted Soybean Flour

Effects of Fortification on Vitamins and Copper Composition of Fortified Ndaleyi wth Defatted Soybean Flour

The results of the Effects of vitamins and copper composition on the fortified Ndaleyi samples, shows that the Vitamins are essential micro-nutrients for growth, metabolism, reproduction and general well-being (Oghbai *et al.* 2016). This study show increase in vitamin B3 (Niacin) for the fortified samples from undehulled to dehulled *Ndaleyi* powder from 1.26mg/100g to 1.31mg/100g and from 1.46mg/100g to 1.62mg/100g respectively. B_2 vitamins concentrations in the sample are almost the same with the B_1 vitamins. The copper content of the fortified sample are also low less than 1% of all the samples of the fortified mix.

The copper contents of the millet Ndaleyi dehulled sample fortified with the soybean at (90:10) ratio shows superiority than all other fortificants in the experiment. B-vitamins are water soluble vitamins and hence are found in fruits and vegetables at a very high amount when compared to cereals and legumes that are low in water contents except the fresh cereals and legumes that may contain certain proportion of the B-vitamin composition. Dehulling cereals and legumes also reduce the number of water-soluble vitamins like B_1, B_2, B_3, B_6 B_{12} and Ascorbic acid content (Chavan, 2016). During dehulling and processing, most vitamins get lost just like the minerals e.g. calcium, magnesium, zinc, etc. The study reveals low content of the B-vitamin especially B_1 and B_2 vitamins which is less than 1mg/100g except for Niacin with more than 1mg/100g of the fortified samples of both dehulled and undehulled millet, sorghum and soybean fortificants. Millet is higher in protein than sorghum and maize and also rich in the B-complex vitamins with greater levels of thiamine, niacin, pantothenic acid and pyridoxine similar to that of wheat as shown on these result sheet as corroborated by (Kent 1983, Nkama 1983, Ahmed and Dominguez *et al,.* 1993).

Table 11: Effects of fortification on the Vitamins and Copper Composition of Fortified *Ndaleyi* Samples

	Parameters (Mg/100g)(1)			
Sample (Code) (2)	Thiamin (B1) (mg/100g)	Riboflavin B2 (mg/100g)	Niacin B3 (mg/100g)	Copper (Mg) (100g)
MNSO Dehulled (90:10)	$0.32^{b}\pm0.02$	$0.32^{c}\pm0.02$	$1.24^{e}\pm0.03$	$5.44^{a}\pm0.53$
MNSO (undehulled (75:25)	$0.32^{b}\pm0.01$	$0.38^{b}\pm0.01$	$1.34^{d}\pm0.03$	$0.14^{a}\pm0.01$
SNSO Dehulled (90:10)	$0.30^{b}\pm0.02$	$0.32^{c}\pm0.34$	$1.44^{c}\pm0.03$	$0.13^{a}\pm0.01$
SNSO (undehulled) (75:25)	$0.22^{c}\pm0.01$	$0.31^{d}\pm0.01$	$1.62^{b}\pm0.01$	$0.16^{a}\pm0.03$
DSOF	$0.53^{c}\pm0.01$	$0.44^{a}\pm0.03$	$2.74^{a}\pm0.03$	$0.22^{a}\pm0.01$

1. Values are means ± standard deviation of triplicates determination in any column, means bearing similar superscripts are not significantly dfferent (P≥0.05)
2. MNSO = Millet Ndaleyi and Soybean (90:10) dehulled
   MNSO = Millet Ndaleyi and Soybean (75:25) undehulled
   SNSO = Sorghum Ndaleyi and Soybean (90:10) dehulled
   SNSO = Sorghum Ndaleyi and soybean (75:25) undehulled
   DSOF = Defatted Soybean Flour

CONCLUSION AND RECOMMENDATIONS

Conclusion

The results of the effect of dehulled cereals, that is, millet, sorghum and soybean flours showed that mineral contents of calcium, potassium and phosphorus increases on dehulling cereals and legume as indicated on the results sheets Table 4.1. Also, other minerals like magnesium, sodium, iron and zinc also increase on dehulling cereals but decreases in sodium and iron of the legume soybean. These decreases some minerals is due to the removal of bran and germ due to the processing. The effects of dehulling on the proximate composition of the millet and sorghum flour also shown on the results of protein, fats, crude fibre, total ash content and the moisture content all increases on dehulling while carbohydrate decrease in content. The effects of functional properties of dehulled millet, sorghum and soybeans also increases, oil absorption capacity, bulk density, oil absorption capacity, swelling capacity, gelatinization capacity and

viscosity all increases on dehulling due to the removal of outer covering of bran of both millet and sorghum. But the oil absorption capacity, bulk density, water absorption, foaming capacity, emulsion capacity and viscosity of the soybean flour on dehulling increases in all the aforementioned parameters. The effect of vitamins and copper content of the dehulled cereal decreases while soybean increases with the exception of copper which was not detected in cereals but was found in soybean in traceable amount. The thiamin (B_1), Riboflavin (B_2) and Niacin (B_3) are all decreases on dehulling except riboflavin content which increases on dehulling.
The effects of fermentation on the mineral content of cereals and legumes reveal that high amount of calcium, phosphorus and potassium in mg/100g. There is also increase in magnesium, manganese, sodium, iron and zinc as a result of fermentation and dehulling of cereals. There are also increases in mineral content of fermented and dehulled soybean flour in favour of magnesium, phosphorus, calcium, manganese, potassium, sodium but decreases in iron and zinc content of fermented and dehulled soybean flour.

Recommendations

1. Dehulling of cereals and legumes reduces the number of micronutrients e.g. magnesium, phosphorus, calcium, potassium, sodium, iron and zinc. Dehulling of cereals and legumes should be discouraged in *Ndaleyi* processing.
2. Undehulled cereals and legumes contains high amount of protein, fats, crude fibre, ash and carbohydrates than the dehulled samples, it is also recommended that dehulling of cereals and legumes should be discourage in order to safeguard the availability of this essential nutrients in *Ndaleyi* processing.
3. Naleyi food product is highly recommended for a patient of celiac disease (protein intolerance) because of its lower protein content

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