QUALITY EVALUATION OF SORGHUM *OGI* FORTIFIED WITH SOYBEAN FLOUR

ABSTRACT

This study investigated the quality of sorghum ogi fortified with soy-flour on its nutrient density. The fortified ogi produced from different formulations of Sorghum (ogi) and Soy-flour were: 100:0 (control), 90:10, 80:20, 70:30, 60:20 and 50:50 Sorghum (ogi) to Soy-flour respectively. The formulated products were subjected to proximate, minerals, functional, microbiological and sensory analysis. The results showed that proximate composition increased with increased addition of Soy-flour crude protein, fat content, crude fibre content, ash content, moisture content and carbohydrate ranged from (24.87 to 49.05%), (7.50 to 17.30%), (1.13 to 1.92%), (1.43 to 3.15%), (5.65 to 6.93%) and (22.93 to 58.14%). The mineral contents: calcium, iron, and magnesium ranged from (2.00 to 3.99mg/100g), (1.88 to 2.10mg/100g), (0.38 to 0.56mg/100g). The functional properties: bulk density, water absorption capacity and swelling capacity ranged from (0.98 to 0.73g/ml), (1.51 to 1.84g/ml) and (5.65 to 2.52g/ml). The microbiological count for Total bacteria ranged from (1.2×10^5 to 3.7×10^5); Total fungi count ranged from (0 to 1.5×10^5) and Total mold count ranged from (1.0×10^5 to 2.0×10^5). The sensory scores: taste, aroma, color, consistency and general acceptability ranged from (6.35 to 7.40%), (6.35 to 7.30%), (6.00 to 7.56%), (6.00 to 7.90%), and (6.30 to 7.60%). Sample 50:50 is considered best because of its high mineral contents for the development of infant and sample 80:20 is significantly high in proximate composition, and was considered best for infant. There is a significant difference ($p \leq 0.05$) in the analysis.

Keywords: ProximateComposition, Minerals, Functional, Microbiological and Sensory Analysis.

1. INTRODUCTION

“The period during which other foods or liquids are given to a young child along with breast milk is considered the period of complementary feeding and any nutrient containing foods or liquids other than breast milk provided for the child during this period are defined as complementary foods” (WHO,2003). “Thus, it is essential that infants receive appropriate, adequate and safe complementary food to ensure the right transition from breastfeeding to the full use of family foods. Lack of appropriate feeding can set up risk factors for ill health. The life–long impact may include poor school performance, reduced productivity, impaired intellectual and social development or chronic diseases” (Nestel *et al.,* 2003).

Awake (2003) reported that “Protein malnutrition is a major public health problem in some parts of the world, including Nigeria and the West African sub region. This is because diets in these areas are predominantly starchy, the major crops being cereals, roots and tubers”. “In developing countries, complementary foods are mainly based on starchy roots and tubers like cassava, cocoyam and sweet potato or on cereals like maize, rice, wheat, sorghum and millet. Little children are normally given these staples in the form of gruels that is mixed with boiled water or boiled with water”.[64-66]

“The traditional method of preparation involves steeping in water for one to three days, depending upon variety, urgency of need and the desired sourness, followed by milling and extraction. The soaking and extraction process that the grain is subjected to lowers the nutrient value of the product” (Osungbaro, 2009). Ogi is commonly reconstituted with boiling water to form akamu, or allowed to cool to form eko and consumed, either alone or with bean meal (moinmoin) or bean cake (akara) as accompaniment.

“Toasted soybean flour is usually added directly to food without undergoing heat treatment. In many developing countries, soybean flour is widely used as a good source of protein to fortify weaning food before feeding infants” (Athanase *et al.,* 2021). “A large population of pregnant

women and lactating mothers use soybean flour as a nutritional supplement" (Nwokocha*et al.*, 2016).

"Sorghum (*sorghum bicolor*) is a cereal that is indigenous to the semi-arid tropics of Africa and has achieved the highest growth rate of any major food crops in Western Africa" (Delekan*et al.*, 2010). "It is believed to have the greatest potential among food crops for attaining technological breakthroughs that will improve food production in any region. In the semi-arid tropical region, sorghum is much better suited for cultivation than non-indigenous cereals, such as wheat. It can withstand both hot and dry conditions as well as heavy rainfall along with waterlogging.In fact; sorghum can consistently survive under the climatic conditions where other cereals fail to grow" (Ajanaku*et al*., 2013). "The only major problem identified with is the nutritional value of sorghum is that cooked sorghum has less digestible protein than that of other cooked cereals" (Ratnavathi, 2013).

"The grain is composed of three main parts: seed coat (pericarp-testa), germ (embryo) and endosperm (storage tissue). The seed coat contains copious amount of polyphenolic compounds that combine with other flavonoids (anthocyanins, anthocyanidins, etc.,) to give it varying colours" (Okrah, 2008). "The germ fraction of sorghum is rich in minerals (ash), little amount of protein and lipids as well as B-group vitamins: thiamine, niacin, and riboflavin that occur in the aleurone layer, while the endosperm consists mainly of starch granules, storage proteins and nutritionally deficient and organoleptically inferior as reported by (Elsheik*et al*., 2000). This is largely due cell-wall materials" (Ogbonna, 2011).

"Despite an impressive array of nutrients in sorghum grain, sorghum-based meal have continued to be to the presence of anti-nutritional factors (ANF) such as tannin, phytic acid, polyphenol and trypsin inhibitors that bind these food ingredients into complexes making them unavailable for human nutrition" (Makokha*et al*., 2002). "For instance, the presence of these anti-nutritional factors limits the digestibility of proteins and carbohydrates by inhibiting their respective proteolytic and amylolytic enzymes" (Mohammed *et al*., 2011).

1.1 POTENTIAL HEALTH BENEFITS OF SORGHUM GRAIN

“Phenolic compounds are naturally produced in sorghum and play an important role in plant defense against pathogens and pests. As food components, their health benefits to human have been widely investigated. Phenolic acids, flavonoids, and condensed tannins are the main phenolic compounds in sorghum with relatively high concentrations, providing an excellent source for human intakes. Besides different sorghum, varieties have a different phenolic profile and thus used for various purposes” (Girard, 2018).

1.1.1 Antioxidant activity

According to Awika*et al.* (2005), “the antioxidant activity of sorghum phenolic compounds seems to play a key role in the health promotion and disease prevention associated with sorghum consumption. Various methods have been used to measure the antioxidant activity of natural compounds, and these methods are almost exclusive based on the colorimetric methods using in vitro assays”.

“Oxygen radical absorbance capacity (ORAC), ferric reducing antioxidant power, and 2,2 -azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) and 1,1-diphenyl-2-picrylhydrazyl (DPPH) free radical scavenging methods are the current widely used in vitro methods for estimation of sorghum antioxidant activity” (Lee *et al*., 2011).

“The phenolic compounds extracted from sorghum grain exhibit the highest antioxidant activity among cereal grains of wheat, rice, and corn, and comparable to common fruits and vegetables” (Wu *et al.*, 2017). “The antioxidant activity is strongly related to the total phenolic contents, particularly the condensed tannin content in sorghum. Sorghums with condensed tannins (black and brown sorghums) have consistently demonstrated high antioxidant activity in vitro, especially in the bran where the phenolics are concentrated” (Awika*et al*., 2005).

1.1.2 Anti-inflammatory activity

“ Long-term oxidative stress can lead to chronic inflammation and consequently can result in various chronic diseases. During inflammation, a number of pro-inflammatory compounds such as interleukin (IL), cyclooxygenase, tumor necrosis factor (TNF)-α and prostaglandin (PG-E2) are generated” (Shim *et al.*, 2013). “Many phenolic compounds from sorghum grain have been demonstrated to inhibit the production of these pro-inflammatory compounds” (Makanjuola*et al*.,

2018). “For example, phenolic acids such as gallic acid and ferulic acids were reported to suppress the COX-2 enzyme and ferulic acid has been shown to inhibit the production of TNF-α” (Burdette, 2007). “Furthermore, the crude phenolic extract from sorghum bran, especially from black sorghum, has demonstrated strong inhibitory effects against COX-2, IL-1β, and TNF-α pro-inflammatory activity, and the effect is similar to the anti-inflammatory drug indomethacin” (Burdette *et al.*, 2010).

1.1.3 Cancer Prevention

“The phenolic compounds from sorghum have shown anticancer activity, and consumption of sorghum whole grain can reduce the risk of developing certain cancers” (Isaacson, 2005). “The anticancer activity of sorghum may be attributed to the potent antioxidant activity and phase II enzyme induction of its phenolic compounds” (Awika*et al.,* 2009).Among the sorghum phenolic compounds; 3-deoxyanthocyanidins have received the most attention.

“Both 3-deoxyanthocyanidins and 3-deoxyanthocyanidin-rich sorghum extract have been demonstrated to be effective against the growth of various cancer cells, including colon, hepatoma, esophageal, intestinal epithelial, leukemia, breast, and stomach cancer cells; these compounds act directly against cancer by inducing cell apoptosis and inhibiting the proliferation and metastasis of cancer cells” (Massey *et al*.,2014). “It should be noted that 3-deoxyanthocyanidins are more effective than their anthocyanidin analogs on this property”(Yang *et al.,* 2009).

1.2 FUNCTIONAL PROPERTIES OF SORGHUM-BASED OGI

According to Akubor (2009), “functionality is regarded as any physicochemical property that affects processing and the behavior of the component in the food product”. “Functional characteristics play an important role in the determination of the acceptability of flour, protein or paste as an ingredient in preparing foods” (Charles *et al.,* 2005). “They however depend on some parameters that interact between salts, acids, gums, carbohydrate, fat etc., which affects the final products. Some of the functional properties or characteristics are; water absorption capcapacity, oil absorption capacity, bulk density, loose density, swelling capacity/index, gelation time, gelation temperature, emulsion capacity etc”. (Oladunmoye*et al.,* 2014). “Sorghum products exhibits several functional properties, the acidity of fermented ogi has been found to be caused

by the synthesis of lactates, acetates and some volatile organic acids" (Adebowale *et al*., 2005). The acid formation during fermentation contributes to the desirable sourness of ogi and an indication of the duration and effectiveness of the fermentation step in the ogi processing.

"Pasting and crystalline characteristics are important in starch applications and for any successful utilization in food products; the protein should possess a high degree of functionality" (Charles *et al.*, 2005; Zeeman, 2002). "Some factors such as Genotype, growth season, and growth location all affected the pasting behavior of flour especially sorghum flour" (Zeeman, 2002). "The pasting behavior of all flours have been seen in research to be influenced by genotype and environmental factors that brought about subtle changes in the source materials such as grains, as well as tubers" (Maziya-Dixon *et al*., 2005). "Final viscosity of flour samples is important in determining the ability of a sample to form a gel during processing" (Adebowale *et al.*, 2005). "Final viscosity is an indication of whether the starch material forms a gel or a paste on cooling and indicates the strength of cooked paste" (Ofegbayo*et al.,* 2006). "Setback is an index of the tendency of the cooked flour to harden on cooling due to amylase retrogradation" (Adeniji*et al*., 2010).

1.3 BRIEF HISTORY OF SOYBEAN

"Soya beans (Glycine max) have recently become popular in the West African sub-region due to their high protein content. It is an annual leguminous crop and is grown to provide food for humans, feed for animals and raw materials for industry" (Abbey *et al*., 2001). "Soya bean is an excellent source of protein (45-48%). The soya bean seed is the richest in food value of all plant foods consumed in the world. It is used in the production of different products as composite flour" (Dhingra, 2002; Basman*et al*., 2003). For soybeans to be used effectively to improve the nutrition status of people there is the need for thorough research into the process characteristics, nutritional quality and consumer acceptability of soya beans and blends into which soya bean flour has been incorporated.

"Toasted soybean flour is usually added directly to food without undergoing heat treatment. In many developing countries, soybean flour is widely used as a good source of protein to fortify weaning food before feeding infants" (Athanase*et al.,* 2021). "A large population of pregnant

women and lactating mothers use soybean flour as a nutritional supplement" (Nwokocha*et al*., 2016).

1.3.1 Potential Health Benefits of Soybean

Wide-scale soybean creation will not just guarantee manageable supply of crude material to sustain industry, yet in addition enhances financial conditions and occupation of ranchers. According to Haris*et al.* (2017), "it would additionally urge the agriculturists to develop soybean and increment neighborhood creation". "The consumption of soybeans have the following advantages: impact on malignancy, prevention of chronic kidney disease, fight against osteoporosis and menopause, reduces hypotensive action, useful impact on hypercholesterolemia and cardiovascular maladies, aid in circulatory strain and endothelial capacity, helps in insulin emission and vitality digestion, prevention of diabetes and impacts on platelet accumulation, Aid in fibrinolytic movement, soybean helps relieve sleep disorders" (Bolla, 2015).

"Soy flour helps in preventing High Cholesterol, High Blood Pressure and Preventing Diseases of the Heart and Blood Vessels". (Siulapwa, 2014). "It is likewise utilized for type 2 diabetes, asthma, lung function, all kinds of cancers (lung cancer, endometrial cancer, prostate cancer and thyroid cancer) and additionally preventing weak bones (osteoporosis), moderating the progression of kidney diseases. Other utilize incorporates treating Constipation and Diarrhea, and in addition Decreasing Protein in the Urine of individuals with Kidney Disease, Improving Memory and Treating Muscle Soreness caused by exercise. Ladies utilize soy meal for Breast Pain, Preventing Breast Cancer, and Preventing Hot Flashes for Breast Cancer, Menopausal Symptoms and Premenstrual Syndrome" (Bolla, 2015).

1.3.2Nutritional Importance of Soybean

Soybean supper is for most part viewed as the best of plant protein source regarding its dietary benefit.

According to Siulapwa*et al*. (2014), "it has a reciprocal association with oat grains in meeting the amino acids (AA) necessities of ranch creatures. Thusly, other plant protein sources are looked to the standard. Soybeans give an amazing wellspring of both vitality and protein for

poultry and swine. Likewise, with any fixing, their use rate relies on financial aspects, in spite of the fact that because of soybeans such financial aspects identify with the general cost of soybean supper and of supplemental fats".

According to Dourado*et al*. (2011), "soy items are not just advantageous to devour, they are a decent wellspring of supplements are additionally used to make meat analogues. Whenever utilized as a staple, utilization of one serving of soy items gives an admission of isoflavones proportionate to around 25-40 mg/day".

"Soybean has been prepared into a wide assortment of sustenance items, including soy oil, tofu, soymilk, tempeh, miso, soy sauce, lecithin, soy flour, texturized soy protein, soy protein focus and secludes, soy flour and soy protein-based newborn child recipe" (P. Vera *et al*., 2013). "The soybean seeds contain 13-25% oil, 45-48% protein, and 14-24% starches. The significant unsaturated fats are linoleic corrosive (55%) trailed by oleic corrosive (21%), palmitic corrosive (9%), stearic corrosive (6%) and other unsaturated fats (9%). The proportion of polyunsaturated, unsaturated fat to soaked unsaturated fat is 82:18. Soy protein contains all the basic amino acids, most, which are available in sum, that intently coordinate with those required for people" (Bisla, *et al*., 2012).

1.3.3 Anti-Nutritional Factors in Soybean

"The anti-nutritional factors present in raw and processed soybean are protease inhibitors 45-60mg/g CP and 4-8 mg/g CP;Lectins 50-200 mg/g and 50-200 mg/g; Glycine 150-200 mg/g and 40-70 mg/g; β-conglycin 50-100 mg/g and 10-40 mg/g; Saponins 0.5% and 0.6%; Oligosaccharides 14% and 15%; Phytic acid 0.6% and 0.6%" (Van Eys*et al*., 2004).

1.3.3.1 Trypsin inhibitors

"Trypsin inhibitors are sensitive to denaturation by heat treatment. The vast majority of soybean products used for livestock feeds are heat-treated in order to eliminate any anti-nutritional effects associated with feeding raw soybeans. The activity of these inhibitors in soybean products may be decrease by toasted or heated processes. The right warming up of soybean and its products eliminate above 90% of antitrypsin activity" (Livingstone *et al*., 2007).

1.3.3.2 Lectins

“Lectins are glycoproteins capable to agglutinate erythrocytes and bind sugar components. Lectins are not broken down in the gut, attach to mucosa cells damaging the intestinal wall and reducing the absorption of nutrients. Lectins are heat sensitive and are therefore only present at residual levels in soybean products. Heat treatment to inactivate anti-nutritional factors in soy products is less efficient for antigen than for trypsin inhibitors or lectins. The level of soy lectins can be estimated by measuring the hemagglutination activity” (Van Eys*et al.*, 2004).

1.3.3.3 Goitrogenic factors

These, similarly, are glycosides belonging to the isoflavinic group, some of which like genistin; have goitrogenic activity resulting in enlargement of the thyroid gland and a reduction in the activity of thyroxine secreted by the thyroid itself.

1.3.3.4 Phytic acid

Phytic acid complexes with certain minerals - such as calcium, phosphorus, magnesium, copper, iron and zinc - reducing their bioavailability. Levels of phytate in soybeans range from 1.0 - 2.3 percent. Phytates and oligosaccharides are not destroyed by the heat treatment.

1.4 MICROORGANISMS ASSOCIATED WITH OGI

According to Teniola and Odunfa (2000), “the changes during the fermentation of ogi, a cereal-based traditional lactic acid-fermented weaning food up to the spoilage stage includes; Ogi off-odor, off-taste and off-color. The bacteria that are associated with ogi are *Corynebacterium spp., Lactobacillus plantarum, Lactobacillus fermentum, Leuconostocmesenteroides, Clostridium bifermentans and Staphylococcus aureus Pediococcuspentosaceus, Bacillus subtilis, Brevibacterium linens and yeast like Candida valida, C. krusei, and Geotrichumcandidum”*.

By the research of Ijabadeniyi, (2007), “during the secondary fermentation, the microorganisms are reduced to *Lactobacillus plantarum*, *Lactobacillus fermentum* and yeast, *Saccharomyces cerevisiae.Lactobacillus spp*. and *Saccharomyces cerevisiae* are responsible for the quality characteristics of ogi while brevibacteria contributed most significantly to ogi off-odour”. “However, microbial quality of the soy-ogi blend is not a priority to most of the producers and handlers mainly because of lack of awareness” (Okwori*et al*., 2010). “Although flour is generally regarded as safe due to its low water activity, contamination of the product with pathogenic and

non-pathogenic microorganisms could occur during processing which render the product unsafe for human consumption. Foodborne outbreaks due to consumption of flour-based products is not common because they are subjected to kill step such as baking or cooking and drying known to eliminate most microorganisms present in the product" (Agwa, 2016).

1.5 EFFECT OF DRYING ON THE QUALITY OF OGI POWDER

Increase in water absorption and swelling capacities of ogi is based on drying. In addition, protein, ash, crude fiber and carbohydrate contents of the wet ogi may slightly increase following drying, on the contrary, bulk density, reconstitution ratio and gelation capacity seems to decreases as well (Akubor, 2009). However, the fat and moisture contents decrease with drying temperature. This agreed with the report of Akubor (2009) that drying has significant effect on the quality of ogi powder. The sensory scores for colour, flavour and overall acceptability may decrease with increase in drying temperature and however, scores for flavour and overall acceptability of ogi dried at either 50°C or 60°C will not significantly different ($p>0.05$) from those of fresh ogi which may serve as the control. Finally, acceptable ogi powder could be produced by drying wet ogi at a temperature of 50°C for at least 6 hours (Akubor, 2009).

1.6 USEFULNESS OF LEGUMES (SOYBEAN) FORTIFICATION WITH SORGHUM OGI

Among infant, ogi generally have been implicated for kwashiorkor (Akanbi*et al*., 2003) and this has led many researcher to attempt fortifying it with plant protein especially soybean (Nnam, 2000) and cowpea (Sanni*et al*., 2001), to improve its nutritional values. Fortification of cereals with legumes especially soybean has been reported to improve protein from 1.4 % to 13 % in fortified preparation and increase lysine to about 50% when soybean is present (Egounlety*et al.*, 2002).

1.7 SUN DRYING

"Drying is a type of food preservation method and one of the oldest. It works great with every kind of food item, making it convenient for users in times of need or low supply. You can use this method to preserve your pap as long as you keep it away from moisture, air, and humid areas to avoid forming mold" (Akubor, 2009).

There are different drying processes available, but the drying method to be discussed here is sun drying.

Here is one method for drying your papaya without the need for any specialized drying tools. Despite its ease of use, this approach is not the safest. This is due to the fact that if it isn't properly sun-dried in a secure location, it may draw birds, bugs, rodents, and even dust or dirt. As a result, it requires careful attention or cheesecloth is used to cover it when exposed to the sun. For quicker sun drying, make sure the water in your pap is completely drained. Thinly spread it out onto a tray. It can dry in two days if the weather is sunny enough, but it will take longer to dry if there is a lot of humidity due to cloud cover or rain.

2.0 MATERIALS AND METHODS

2.1 MATERIALS

Materials for this research work includes sorghum (*Sorghum bicolor*), soybean (*Glycine max*), potable water, milling machine, cooking pot, tray, muslin cloth, sieve, gas cooker, bowl, oven dryer, spoon, packaging material (plastic)was purchased from Wukari main market Taraba State, Nigeria.

2.1.2 Preparation of Sorghum-Based Ogi flour

Figure 1 is the flow chart commonly employed in traditional sorghum ogi preparation in many parts of Nigeria. This method is adopted in this research work. The Sorghum was cleaned by winnowing to remove chaffs and other contaminants. It was poured into a bowl of water such that the bad seed can float and be skim off; it was washed with the same water. Soaking was done for 24 hours to soften the grains because longer duration will produce too much-fermented products and spoilage may start as well. The soaked grain was rinsed and wet milled to smooth paste, wet Sieving followed immediately especially when the milling plates were worn out and do not produce smooth slurry. Much water was added to the slurry formed and allowed to settle. For an accelerated result, the slurry was put in a bag made from cotton material and hung to allow the water to drain out. At this stage, it was dried and milled into fine flour and packaged. Sorghum-Ogi is ready for consumption and storage.

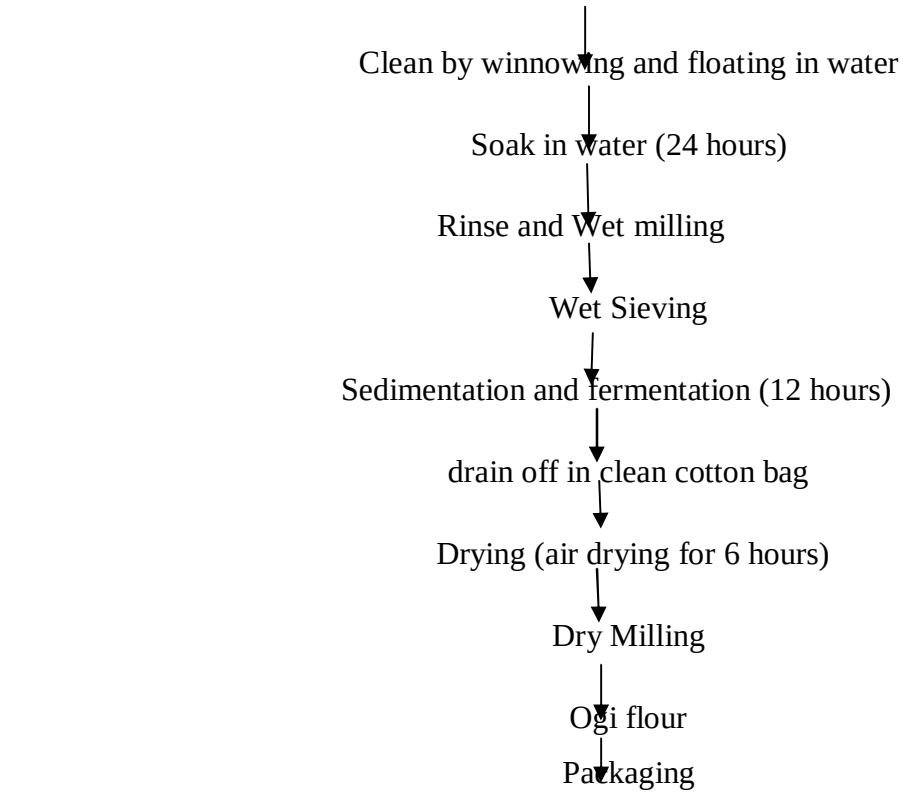


Figure 1. Flow diagram for the production of ogi flour from Sorghum

2.1.3 Preparation of Soybean Flour

Guy Eshun (2012) described the production of soybean flour as having received the soybean seeds, soaked in water for 12 hours. The soaked soybean was washed and poured into a basket for the water to drain off, it was boiled (blanched) for 20 minutes to inactivate enzyme activity and to simplify decortication (testa removal). The water was drained off and allowed to cool. After cooling, it was dried and roasted at 120°C for 30 minutes. The roasted soybean was crushed, winnowed and milled into flour. The flour was finally sieved to obtain a fine product.

2.1.4 Composite Flour Blend Formulation

The prepared flours were then mixed in a ratio of Samples; sample 100:0 (100% sorghum flour), Sample 90:10 (90% sorghum and 10% soy-flour), sample 80:20 (80% sorghum and 20% soy-flour), sample 70:30 (70% sorghum and30% soy-flour) and Sample 60:40 (90% sorghum and 10% soy-flour), sample 50:50 (50% sorghum and 50% soy-flour). Where to be reconstituted with the addition of 300 mL of water.

Sample 100:0 = Sorghum-Based Ogi Flour as control

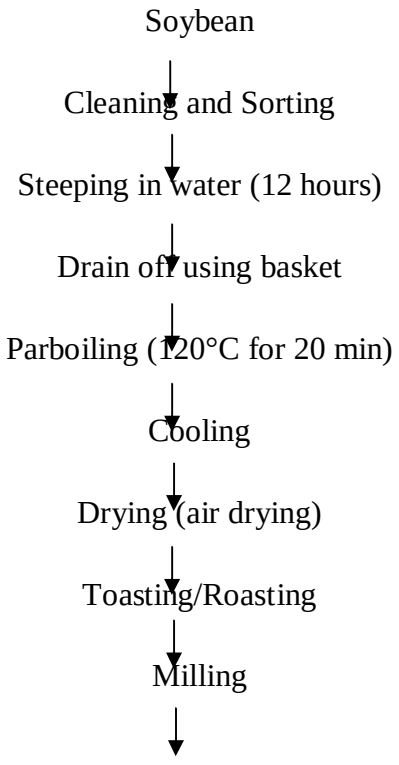
Sample 90:10 = 90% Sorghum-Based Ogi Flour and 10% Soybean Flour

Sample 80:20 = 80% Sorghum-Based Ogi Flour and 20% Soybean Flour

Sample 70:30 = 70% Sorghum-Based Ogi Flour and 30% Soybean Flour

Sample 60:40= 60% Sorghum-Based Ogi Flour and 40% Soybean Flour

Sample 50:50 = 50% Sorghum-Based Ogi Flour and 50% Soybean Flour



Sieving

↓

Soy flour

Figure 2. Flow diagram for the production of soybean flour

Table 1. COMPOSITE FLOUR BLENDS FORMULATION RATIO

Sample code (%)	Sorghum-flour (%)		Soy-flour (%)
100:0	100	:	0
90:10	90	:	10
80:20	80	:	20
70:30	70	:	30
60:40	60	:	40
50:50	50	:	50

KEY: Sample 100:0 (100% Sorghum-Based Ogi Flour as control)

Sample 90:10 (90% Sorghum-Based Ogi Flour and 10% Soybean Flour)

Sample 80:20 (80% Sorghum-Based Ogi Flour and 20% Soybean Flour)

Sample 70:30 (70% Sorghum-Based Ogi Flour and 30% Soybean Flour)

Sample 60:40 (60% Sorghum-Based Ogi Flour and 40% Soybean Flour)

Sample 50:50 (50% Sorghum-Based Ogi Flour and 50% Soybean Flour)

2.2 ANALYTICAL METHODS

2.2.1 Proximate Composition of Fortified Sorghum Ogi

2.2.1.1 Determination of Moisture Content

The method of AOAC (2010) was used. 2g of the samples was weighed into an evaporating dish and placed inside an oven for 3 hours at a temperature of 100℃. After which they were removed from the oven and dried at hourly interval, cooled and weighed until constant weight was achieved. The percentage moisture content was calculated as:

$$moisture\ content\ (\%) = \frac{weight\ difference}{initial\ weight\ of\ sample} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

2.2.1.2 Determination of Crude Protein Content

The Marco kheldhal method as described by the AOAC (2010) was used. 10g of the samples was weighed into a conical flask (250ml), 0.8g of the catalyst (potassium sulphate) was poured into the conical flask and 5ml of sulphuric acid and three glass beads (anti-bumps) were dropped inside the conical flask and swirled. The mixture was heated on the Kjeldhal apparatus for 2-3 hours at 100°C, until it turned bluish white. The digest was allowed to cool in the air and diluted with 10ml distill water. This was distilled using Markham distillation apparatus where 100ml conical flask containing 5ml of buric acid and 2-3 drops of mixed indicator was attached. The 5ml of the digest was introduced into the body of the apparatus and followed by 10ml of 40-45% sodium hydroxide solution. The distillate collected as ammonium sulphate, which was titrated against 0.1 M hydrochloric acid. A blank titration was carried out using distilled water instead of the distilled. Percentage nitrogen was calculated using the formula

$$\%\ Nitrogen = \frac{Titre\ value - blank \times 0.0014g \times 100 \times 25}{weight\ of\ sample} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

% Crude protein = % N × 6.25 (conversion factor)

On the assumptions that N contribute 16% to protein.

2.2.1.3 Determination of Crude Fibre content

Crude protein was determined using the method described by the AOAC (2012). 2g of the samples was measured and poured into 500ml beaker and a 200ml of boiling sulphuric acid (H2SO4) solution and anti-foaming agent (asbestos) was added to the flask that is connected to the digestion flask with a condenser and heat for 30 minutes. Thereafter, the suspension would be filtered using filter paper and rinsed with hot water to obtain the filtrates. The residues obtained were transferred into a crucible and placed in an oven at 110°C to a constant weight. It was cooled in a desiccator and weighed. The crucible and its contents would finally be ignited in a muffle furnace at 550°C for 30 minutes; the residue will be cooled in a desiccator and weighed. Percentage fibre was calculated using the formula:

$$\%\ crude\ fibre = \frac{\text{loss in weight (g) of sample after incineration}}{\text{Weight of original food}} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

2.2.1.4 Determination of Crude Fat content

Fat was extracted using Soxhlet extractor by the AOAC (2010) with hexane and quantified gravimetrically. 1g of sample was weighed into an extraction thimble and put on hold with grease-free cotton. Before extraction commence, the round bottom cans wasdrie, cooled and weighed. The thimble was placed in the extraction chamber and 80ml hexane was added to extract the fat. The extraction was carried out at 135°C for 1hour, 49 minutes after which the fat collected at the bottom of the cans was cooled in a desiccator. It was calculated using:

$$\%crude\ fat = \frac{weight\ of\ fat}{weight\ of\ sample} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

2.2.1.5 Determination of Ash Content

The method of AOAC (2010) was used. The crucibles were washed thoroughly, dried in hot air oven at 100℃, cooled in a desiccator and weighed. 2g of the samples was weighed into the crucibles and put in the furnace. Heating started gradually until the temperature of 600℃ was

reached. The temperature was maintained for 6 hours. After burning to ashes, the furnace was switched off and the temperature was allowed to drop before the crucibles were removed. The crucibles were put inside a desiccator and cooled. After cooling, they were weighed. The percentage ash was thus calculated as:

$$Ash(\%) = \frac{(x+y)}{(z-y)} \times 100 \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where Y = weight (g) of crucible, Z = weight (g) of the crucible + sample before burning to ashes,

X = weight (g) of crucible + sample after burning to ashes.

2.2.1.6 Determination of Carbohydrate Content

Carbohydrate content was determined according to the method of Dagem*et al*. (2010) as the differences in the sum total of all parameters from 100.
Percentage Carbohydrate = 100– (%Moisture+%Protein+%Crude fiber+%Ash**).**

2.2.2 Determination of Mineral Contents of Fortified Sorghum Ogi

2.2.2.1 Determination of Magnesium (M)

According to the method of AOAC (2010), 2ml of ogi sample was transferred into three test tubes with 3ml of Water. 2ml of 10% sodium tungstate and 2ml of 0.67N sulfuric acid was added and centrifuge for 5minutes. Then 5ml of the supernatant was added to 1ml water, 1ml of 0.05% titian yellow, and 1ml of 0.1% gum ghatti. 2ml of 10% sodium hydroxide was added and the absorbance taken at 520NM against the blank.

2.2.2.2 Determination of Iron (Fe) Content

According to AOAC (2010), phenanthroline method was used to determine the iron content of fortified ogi. Phenanthroline solution will be prepared by dissolving 100mg 1, 10-phenanthroline molybdate in 100ml distilled water heating at 80°C with constant stirring. Hydroxylamine solution was prepared by dissolving 10g in 100ml distilled water, as ammonium acetate buffer solution was prepared also by dissolving 250g in distilled water. 5ml of the digested ogi sample was put into a test tube then, 3ml phenanthroline solution and 2ml of HCL was added. 1ml

Hydroxylamine solution was added to the mixture and boiled in a steam bath at 600°C for 2 minutes. Then, 9ml of ammonium acetate buffer solution was added and 35ml diluted to 5ml water. The absorbance was taken at 510NM. Calibration curves were prepared by pipetting 2, 4, 6, 8, and 10ml standard iron solution into 100ml volumetric flasks to prepare a solution of known concentration. The curve obtained indicate the reading value of the iron content.

2.2.2.3 Determination of Calcium (Ca)

Titrimetry method as described by Lawani*et al*., (2014). 5.0g of sample was placed inside an 8ml of concentrated sulphuric acid and 10 ml of concentrated nitric acid into a heat-resistant beaker. 2 cm^3 aliquot of concentrated nitric acid was constantly added at any time the solution began to darken. The solution was cooled with about 10 mL of distilled water and evaporated to fuming again, then the solution was made up to mark in 100 mL volumetric flask. 25 ml aliquot of sample digest was pipetted into a beaker and 1M NaOH solution was added to it. Two drops of solo chrome dark blue was then added and immediately titrated against a 0.01M EDTA solution to the blue end-point.

2.2.3. Functional Properties of Sorghum-Based Ogi Fortified With SoybeanFlour

The following functional properties such as water absorption capacity, swelling and solubility power and bulk density and viscosity were determined.

2.2.3.1 Water absorption capacity

This was determined by the method described by Onwuka (2005). 1g of the samples was dispensed into a weighed centrifuge tube. 10ml of distilled water was added to the sample and mixed very well. The mixture was allowed to stand for one hour (1h) before it was centrifuged at 8000-rpm × g for 15 minutes. The volume of free water (the supernatant) was read directly from the graduated centrifuge tube.

Water absorption capacity (g/ml) =

$$\frac{(\text{Weight of centrifuge tube+sediment})-(\text{weight of centrifuge tube+sample})}{\text{weight of sample}} \quad \ldots\ldots\ldots\ldots (6)$$

2.2.3.2 Swelling capacity

The swelling power and solubility of the fortified ogi (soy-ogi) samples were determined using the method of Onwuka (2005).A 1g of soy-ogi blend was weighed into centrifuge tube and 50ml-distilled water was added. These tubes were immersed in water bath at temperature range from 50 for 30 minutes, thoroughly and constantly stirred with glass rod during the heating period. The tubes were removed, cooled to room temperature and centrifuged at 5000 rpm for 15 minutes. The supernatant was fully transferred into a conical flask and 5ml was pipetted into a weighed petri dish, evaporated over a steam bath and dried in the air oven at 105°C for 4 hours. The weight of the pastes were determined and used to calculate the swelling power as gram of sediment paste per gram starch.

$$\text{Swelling capacity (g/g)} = \frac{\text{Totral volume of swollen sample}}{\text{weight of sample}} \quad \text{.......................... (7)}$$

2.2.3.3 Viscosity determination

According to Onwuka, (2005), 5g portion of each of the samples was dissolved in 100 ml of water in a beaker and heated to boiling in a water bath. The beakers were then removed and cooled to room temperature (25°C). Each sample in the beakers was placed under the Brookfield DV-E viscometer. All viscosity measurements were carried out immediately after preparing the soy-ogi porridge, using spindle number 3 at the speed of 20, 30, 50 and 60rpm dial respectively. Readings were taken and recorded as centipoises (cp)..

2.2.3.4 Bulk Density

Bulk density of the flour samples was determined as described by Onwuka (2005). 50g of flour was poured into a 100ml measuring cylinder and tapped to a constant volume. The result was calculated using the formula below:

$$\text{Bulk density (g/ml)} = \frac{\text{weight of sample}}{\text{volume of sample after tapping}} \quad \text{....................................(8)}$$

2.2.4 Microbiological Analysis

2.2.4.1 Serial Dilution

Ten (10) fold serial dilutions of the soy-ogi blend samples was carried out using the procedure described by Jideani (2003). Ten (10) sterile test tubes containing 9 ml of sterile normal saline (8.5 g NaCl mixed with 1 L of water, autoclaved at 121°C for 15 min at 15 psi) were arranged on a plastic rack. One gram (1 g) of each soy-ogi blend sample was weighed using electronic balance (Metler MT-2000). The weighed sample was carefully introduced into the first test tube using a sterile spatula, vigorously mixed and labelled as dilution 10-1. A sterile pipette was used to transfer 0.1 ml solution from dilution 10-1 to the next test tube (dilution 10-2). Subsequent stepwise transfers were carried out using a sterile pipette for each transfer until dilution 10-7 will be reached. The content of each test tube was shook vigorously before transferring an aliquot (0.1 ml) of the mixture into the next test tube.

2.2.4.2 Total bacterial plate count (CFU/g)

The total microbiological plate counts were determined using pour plate techniques. Potato-dextrose agar, nutrient agar and MacConkey agar were prepared and used for this study according to methods described by (Badau*et al.*, 2005). It was determined by culturing the samples on nutrient agar (NA) plates using pour plate method. The 10-3 and 10-4 dilution of the samples were selected, and aliquot (0.1 ml) of the dilutions were separately inoculated in well-labeled sterile Petri dishes in duplicates. Autoclaving of MacConkey agar (L-S Biotech, India), NA (Biomark Laboratories, India) and potato dextrose agar (LS Biotech, India) was carried out at 121°C for 15 min at 15 psi using the autoclave (Lincoln Mark Medical England, Model YX-280A). The autoclaved culture media prepared using manufacturers' instruction was allowed to cool to about 45°C, then poured on the sterile Petri dishes containing the inoculum, gently stirred and allowed to solidify. The inoculated plates were incubated at 37°C for 24 h using the incubator (Axiom Medical LTD UK). After incubation, the colonies observed on the culture plates were manually counted and results obtained was then recorded. The bacterial population of the duplicate samples was calculated using the formula below.

$$\frac{\text{Cfu.}}{\text{mL.}} = \text{No. of colonies.} \times \frac{1.}{\text{serial dilution}} \times \frac{1.}{\text{dilution plate}} \quad \text{..... (9)}$$

2.2.4.3 Total fungal count

An aliquot (0.1 ml) of dilutions 10-3 and 10-4 of the soy-ogi blend samples were transferred aseptically into Petri dishes containing freshly prepared potato dextroseagar (PDA) in duplicates and properly labeled. The culture plates were incubated at room temperature (28 ± 2°C) for 24h. On completion of the incubation period, the fungal colonies on the culture plates was counted manually and the results obtained was expressed in colony forming units per millilitre (CFU/ml) using the formula below**.**

$$\frac{\text{Cfu.}}{\text{mL.}} = \text{No. of colonies.} \times \frac{1.}{\text{serial dilution}} \times \frac{1.}{\text{dilution plate}} \quad \text{..... (10)}$$

2.2.5 Sensory Properties

Sensory evaluation of the fortified soy-ogi samples was performed with the aid of 20 panelists who were selected at random using the effective method of sensory evaluation. The qualities analyzed were on color, taste, flavour, consistency, and general acceptability on a 9-point hedonic scale as described by (Lawless, 2010). The ranking would be 9 = like extremely, 8 = like

very much, 7 = like moderately, 6 = like slightly, 5 = Neither Like nor Dislike, 4 = Dislike slightly, 3 = Dislike moderately, 2 = Dislike very much and 1 = Dislike extremely. The samples were labelled as follows: sample A = 100% (control), sample B = 90:10, sample C= 80:20, sample D = 70:30, sample E = 50:50.

35Cl of boiled water (98°C) was gradually added to the reconstituted flour blends and stirred continuously to avoid lump formation. The mixture was allowed to simmer for three minutes and stirred continuously until properly cooked (gelatinized). Sample code A (100% SOGF) sorghum ogi porridge will be served as the control.

2.2.6 Statistical Analysis

Data was subjected to analysis of variance of a completely randomized design (CRD) using the statistical package for social science (SPSS) version 26.0. Results were presented as mean ± standard deviations. One-way analysis of variance (ANOVA) was used. Comparison of the means and differences between the means were separated by Duncan multiple range test at (p ± 0.05) confidence.

3.0 RESULTS AND DISCUSSIONS

TABLE 2. PROXIMATE COMPOSITION OF FORTIFIED SORGHUM OGI

Sample (%)	Crude fiber (%)	Crude protein (%)	Moisture content (%)	Ash (%)	Fat (%)	Carbohydrate (%)
100:0	1.13^{e}±0.04	24.87^{f}±0.09	6.93^{a}±0.04	1.43^{e}±0.04	7.50^{f}±0.14	58.14^{a}±0.04
90:10	1.16^{d}±0.04	26.46^{e}±0.03	6.65^{b}±0.21	1.53^{bc}±0.04	8.57^{e}±0.04	55.63^{b}±0.02
80:20	1.28^{bc}±0.04	36.78^{d}±0.04	6.35^{c}±0.07	1.94^{d}±0.02	11.43^{d}±0.04	42.22^{c}±0.01

70:30	1.33^{c}±0.04	39.20^{c}±0.04	6.10^{bc}±0.14	2.43^{c}±0.04	15.17^{c}±0.05	35.77^{d}±0.03
60:40	1.40^{b}±0.01	48.84^{b}±0.07	5.65^{cd}±0.21	2.48^{a}±0.21	16.87^{b}±0.04	24.76^{e}±0.19
50:50	1.92^{a}±0.04	49.05^{a}±0.14	5.65^{d}±0.21	3.15^{b}±0.01	17.30^{a}±0.14	22.93^{f}±0.04

Values are mean ± standard deviation of the triplicate determinations. Means within each column not followed by the same superscript are significantly different ($P \leq 0.05$) from each other using Duncan multiple range test.

Key: Sample 100:0 (100% sorghum as control)

Sample 90:10 (90% sorghum 10% soy)

Sample 80:20 (80% sorghum 20% soy)

Sample 70:30 (70% sorghum 30% soy)

Sample 60:40 (60% sorghum 40% soy), Sample 50:50 (50% sorghum 50% soy).

3.1 PROXIMATE COMPOSITION OF FORTIFIED SORGHUM OGI FLOUR

Fortification of sorghum ogi (SOR) with soy flour (SOY) was carried out to improve their nutritive value. The results of the proximate values are shown in Table 2. There were significant ($p<0.05$) difference in the nutritive values as influenced by increased substitution of SOY in these formulations.

The crude fiber content of the fortified ogi product significantly increased from sample 100:0 (1.13%), sample 90:10 (1.16%), sample 80:20 (1.28%), sample 70:30 (1.33%), sample 60:40 (1.40%) to sample 50:50 (1.92%) Table 2. The highest crude fiber (1.92%) was found in sample 50:50. Similar increasing trend in crude fiber content is also reported by (Farzana, 2015) for the supplementation of soy flour on the production of biscuits. This could be due to increase in soy flour in the blended flour (Ndife*et al.*, 2011).

The crude protein content was found to increase from sample 100:0 (24.87%), sample 90:10 (26.46%), sample 80:20 (36.78%), sample 70:30 (39.20%), sample 60:40 (48.84%) to sample 50:50 (49.05%) Table 2. The highest crude protein (49.05%) was found in sample 50:50. This increasing trend of protein content is in accordance with (Banureka, 2009). "This because soybean is a high-protein legume and an excellent complement to lysine-limited cereal protein" (Garg *et al*., 2014). Due to high protein content, soy flour could be used as an economical protein supplement in food products such as biscuit, bread, pasta, and other cereal products.

The moisture content of the six ogi samples varied significantly as sample 100:0 (6.93%), sample 90:10 (6.65%), sample 80:20 (6.35%), sample 70:30 (6.10), sample 60:40 (5.65%), to sample 50:50 (5.35%) table 2. The highest moisture content (6.93%) was found in control 100:0. "The results showed that the moisture content gradually decreased from 6.93% to 5.65% with the increasing proportion of soy flour, supported by the findings of other studies" (Oluwamukomi*et al*., 2005). This may be explained as soy flour contained a greater amount of total dry solid with high emulsifying properties compared to other flours. According to El Wakeel (2007), "moisture content less than 10% is considered as more proper for keeping quality of floury products especially soy-ogi flour".

The crude ash ranged from sample 100:0 (1.43%), sample 90:10 (1.53%), sample 80:20 (1.94%), sample 70:30 (2.43%), sample 60:40 (2.48%), sample 50:50 (3.15%) Table 2. Highest ash content (3.15%) was found in sample 50:50. This increasing trend of ash content with the increasing of soy flour is in accordance with the study of (Ayo *et al*., 2014); due to the presence of soy flour, as soy flour, is a good source of minerals, according to (Sengev*et al*., 2013).

The crude fat of the fortified ogi increased from sample 100:0 (7.50%), sample 90:10 (8.57%), sample 80:20 (11.43%), sample 70:30 (15.17%), sample 60:40 (16.87%) to sample 50:50 (17.30%) Table 2 with the increase in soy flour. The highest fat content (17.30%) was found in sample 50:50. "This increasing trend in fat content is in agreement with the study of (Ayo *et al*., 2014), on soy flour fortification for the preparation of cookies and could be explained as soy flour is globally considered as the number one edible oil source, containing 20%–24% of fat, most of which are unsaturated in nature, 61% polyunsaturated fat, and 24% monounsaturated fat" (Reddy, 2004).

Carbohydrate content was gradually decreased with the increase in fortification of soy flour sample 100:0 (58.14%), sample 90:10 (55.63%), sample 80:20 (42.22%), sample 70:30 (35.77%), sample 60:40 (24.76%) to sample 50:50 (22.93%) Table 2. Highest carbohydrate content (58.14%) was observed in control (sample 100:0). Similar decreasing trend in carbohydrate content is also reported by (Ayo *et al.*, 2014), and may be due to the low carbohydrate content when soy-flour is added.

TABLE 3. Functional Property of Fortified SorghumOgi

Sample (%)	Bulk density (g/ml)	water absorption (ml/g)	swelling capacity (ml/g)
100	0.98^{a}±0.04	1.51^{e}±0.01	5.65^{a}±0.21
90:10	0.94^{ab}±0.01	1.58^{d}±0.04	4.65^{b}±0.21
80:20	0.91^{ab}±0.01	1.66^{c}±0.01	4.05^{c}±0.07
70:30	0.87^{bc}±0.04	1.71^{c}±0.01	3.64^{d}±0.01
60:40	0.82^{c}±0.02	1.77^{b}±0.02	3.60^{d}±0.00
50:50	0.73^{d}±0.04	1.84^{a}±0.02	2.52^{e}±0.04

Values are mean ± standard deviation of functional property of the flour samples. Means within each column not followed by the same superscript are significantly different ($P \leq 0.05$) from each other using Duncan multiple range test.

Key: Sample 100:0 (100% sorghum as control)

Sample 90:10 (90% sorghum : 10% soy)

Sample 80:20 (80% sorghum : 20% soy)

Sample 70:30 (70% sorghum: 30% soy)

Sample 60:40 (60% sorghum : 40% soy)

Sample 50:50 (50% sorghum : 50% soy).

3.2 THE RESULTS OF THE FUNCTIONAL PROPERTIES OF FORTIFIED SORGHUM OGI

“The results of functional properties of the fortified ogi flour are presented in Table 3. Functional property is an important parameter for the suitability of diet behavior of nutrients in food during processing, storage, preparation, its application, and end use because it affects not only the general food quality but also its acceptability to the people” (Adeleke, 2010).

The bulk density of the fortified ogi with the control includes sample 100:0 (0.98g/ml), sample 90:10 (0.94g/ml), sample 80:20 (0.91g/ml), sample 70:30(0.87g/ml), sample 60:40 (0.82g/ml), sample 50:50 (0.73g/ml). The highest bulk density (0.98g/ml) was found in the control (sample 100:0 followed by sample 90:10) Table 3. This decreasing trend of bulk density in the study is in agreement with the study of (Akubor,ss 2003). This may be due to the increasing proportion of soy flour in the ogi as soy flour has lower bulk density than sorghum flour (Akubor, 2003). According to Oppong *et al.* (2015), “the bulk density is important for dietary bulk and packaging requirements”. “Nutritionally, a loose bulk density not only promotes easy digestibility of food but also enhances nutrient and calorie density per feed that offers an extra advantage in formulating complementary foods” (Osundahunsi, 2002).

Water absorption capacity is the ability of product to incorporate water. The range of water absorption capacity of the fortified ogi was sample 100:0 (1.51g), sample 90:10 (1.58g), sample 80:20 (1.66g), sample 70:30 (1.71g), sample 60:40 (1.77g), and sample 50:50 (1.84g) Table 3. Sample 50:50 had the highest water absorption capacity (1.84g). This result is in accordance with the finding of (Akubor, 2003). The increase in water absorption capacity in the present research work is due to the higher protein content of soy flour because proteins are capable of binding large quantities of water due to their ability to form hydrogen bonds between molecules and polar group on the polypeptide chain.

The swelling capacity is the measure of the ability of starch to imbibe water and swell. In the present study, the swelling capacity of the fortified ogi samples also followed the same pattern of sample 100:0 (5.65g), sample 90:10 (4.65g), sample 80:20 (4.05g), sample 70:30 (3.64g), sample 60:40 (3.60g), and sample 50:50 (2.52g). The highest swelling capacity (5.65ml/g) is in the

control (sample 100:0 followed by Sample 90:10).Table 3. This decreasing trend of swelling capacity with the increase of soy flour substitution is supported by a study of (Juliant*et al.* 2017). This may be as a result of lipids which act as amylose swelling inhibitor, starch and protein interaction, and attraction of their opposite charges to form inclusion complexes during gelatinization which restricts swelling (Shimelis, 2006).

3.3 VISCOSITIES AT DIFFERENT ROTATION PER MINUTE

The viscosity of the fortified ogi samples at different rpm were observed in Table 4. The viscosity at different rotation per minute (rpm), decreases at 20rpm, 30rpm, 50rpm, and 60rpm from the control (sample 100:0 to sample 50:50) respectively Table 3. Viscosity is an important characteristic of liquid foods in many areas of food processing. It gives an idea of the ability of a material to gel after cooking. Viscosity of each sample shows the same decreasing pattern with increasing rpm as supported by the study of (Abdel *et al.*, 2014). Among the samples, the highest viscosity was observed for control (sample100:0 followed by sample 90:10). This decreasing trend may be due to decrease in starch content with the increasing proportion of soy flour and interaction of components such as fat content from soy flour with sorghum starch. (Juliant*et al*., 2017).

TABLE 4 VISCOSITIES AT DIFFERENT ROTATION PER MINUTE (CP)

Sample (%)	20 rpm	30 rpm	50 rpm	60 rpm
100:0	1862.50^{a}±3.54	1067.50^{a}±3.54	725.00^{a}±3.36	582.50^{a}±3.54
90:10	1076.50^{b}±2.12	752.50^{b}±3.54	525.00^{b}±3.36	445.00^{b}±7.07
80:40	752.50^{c}±3.54	575.00^{c}±3.36	442.50^{c}±10.61	346.50^{c}±4.95
70:30	552.50^{d}±3.54	452.50^{d}±3.54	325.00^{d}±3.36	275.00^{d}±7.07
60:40	447.50^{e}±3.54	347.50^{e}±3.54	252.50^{e}±3.54	105.00^{e}±7.07

50:50	247.50^{t}±3.54	152.50^{t}±3.54	127.50^{t}±3.54	82.50^{t}±3.54

Values are mean ± standard deviation of viscosity. Means within each column not followed by the same superscript are significantly different (P ≤ 0.05) from each other using Duncan multiple range test.

Key: Sample 100:0 (100% sorghum as control)

Sample 90:10 (90% sorghum : 10% soy)

Sample 80:20 (80% sorghum : 20% soy)

Sample 70:30 (70% sorghum: 30% soy)

Sample 60:40 (60% sorghum : 40% soy)

Sample 50:50 (50% sorghum : 50% soy).

TABLE 5 MINERAL COMPOSITION OF FORTIFIED SORGHUM OGI

Sample (%)	Calcium (mg/100g)	Iron (mg/100g)	Magnesium (mg/100g)
100	2.99^{d}±0.01	1.98^{e}±0.04	0.39^{e}±0.02
90:10	3.30^{c}±0.14	2.15^{d}±0.07	0.47^{d}±0.02
80:20	3.62^{b}±0.02	2.32^{c}±0.02	0.51^{c}±0.01
70:30	3.78^{ab}±0.18	2.37^{bc}±0.02	0.53^{bc}±0.01
60:40	3.83^{ab}±0.04	2.43^{b}±0.04	0.55^{ab}±0.01
50:50	3.99^{a}±0.01	2.53^{a}±0.04	0.57^{a}±0.01

Values are mean ± standard deviation of mineral composition. Means within each column not followed by the same superscript are significantly different (P ≤ 0.05) from each other using Duncan multiple range test.

Key: Sorghum (SOR) (100% as control)

Key: Sample 100:0 (100% sorghum as control)

Sample 90:10 (90% sorghum : 10% soy)

Sample 80:20 (80% sorghum : 20% soy)

Sample 70:30 (70% sorghum: 30% soy)

Sample 60:40 (60% sorghum : 40% soy)

Sample 50:50 (50% sorghum : 50% soy).

3.4 MINERAL COMPOSITION OF FORTIFIED SORGHUM OGI FLOUR (mg/100g)

The mineral composition of the samples increased above the values of the control with increasing formulation with soy-flour. The results indicated that iron (Fe) increased by 2.53mg/100g, calcium (Ca) 3.99mg/100g and magnesium (M) 0.57mg/100g Table 4.

The calcium (Can) values ranged from sample 100:0 (2.99mg/100g), sample 90:10 (3.30mg/100g), sample 80:20 (3.62mg/100g), sample 70:30 (3.78mg/100g), sample 60:40 (3.83mg/100g) to sample 50:50 (3.99mg/100g) Table 4. Sample 50:50 had the highest value (3.99mg/kg) which was significantly ($P \leq 0.05$) different from the other samples respectively.

The iron (Fe) composition ranged from sample 100:0 (1.98mg/100g), sample 90:10 (2.15mg/100g), sample 80:20 (2.32mg/100g), sample 70:30 (2.37mg/100g), sample 60:40 (2.43mg/100g) to sample 50:50 (2.53mg/100g) Table 4. Sample 50:50 had the highest value (2.53mg/100g) which was significantly ($P \leq 0.05$) different from the other samples respectively.

The magnesium (Mg) content ranged from sample 100:0 (0.39mg/100g), sample 90:10 (0.47mg/100g), sample 80:20 (0.51mg/100g), sample 70:30 (0.53mg/100g), sample 60:40 (0.55mg/100g) to sample 50:50 (0.57mg/100g), with sample 50:50 recording the highest value (0.57mg/100g) Table 4.

The increase in minerals concentration in this research study, are attributed to soy fortifications with sorghum ogi. These mineral salts, Ca and Mg are important regulators of the acid-base

balance of the body system, calcium (Ca) is important for skeletal development, while iron (Fe) work in synergy with β-carotene for improved immune function for the infants.

Sample (%)	Total bacterial count (cfu/g)	Total fungi count (cfu/g)	Mould count (cfu/g)

TABLE 6. MICROBIOLOGICAL PLATE COUNT OF FORTIFIED SORGHUM OGI

100:0	1.2×10^5	1.0×10^5	1.0×10^5
90:10	3.7×10^5	nil	1.2×10^5
80:20	2.0×10^5	1.0×10^5	2.0×10^5
70:30	3.0×10^5	1.5×10^5	1.5×10^5
60:40	2.0×10^5	nil	Nil
50:50	2.0×10^5	nil	2.0×10^5

Key: Sample 100:0 (100% sorghum as control)

Sample 90:10 (90% sorghum : 10% soy)

Sample 80:20 (80% sorghum : 20% soy)

Sample 70:30 (70% sorghum: 30% soy)

Sample 60:40 (60% sorghum : 40% soy)

Sample 50:50 (50% sorghum : 50% soy).

3.5 MICROBIOLOGICAL PLATE COUNT OF FORTIFIED SORGHUM OGI

Table 5 shows the microbial count of Ogi blends. The total plate counts ranged from 1.2×10^5CFU/g to 3.7×10^5CFU/g, mould count ranges from 1.0×10^5 to 2.0×10^5 CFU/g. For coliform plate count, some indicated no growth while others have growth. Formulation containing only sorghum ogi was observed to have the least total plate count of 1.2×10^5 CFU/g. However, “total plate counts of all formulations were observed to show no much variation. Similarly, mould count, except formulations containing 60% sorghum and 40% soybeans showed no growth. Total bacteria plate count is very important. It measures the quantity of

aerobic and facultatively aerobic, mesophilic bacteria per unit volume of food sample" (Jideani*et al*., 2006). "It is often used for estimating food shelf life and also suitability of food for human consumption" (Jideani*et al*., 2006). In cereal and soybeans blends not more than 50,000 bacteria per gram excluding Salmonella (Iwe, 2003). However, "the values obtained are less than the one recommended. This is possible because of the fact that fermented food such as Ogi is colonized and fermented by many beneficial bacteria such as lactic acid bacteria. So there is expectation of high or low bacterial load since bacteria are agents of its production. Such product was reported to pose no health hazard since microorganisms of importance are either deliberately or indirectly used for their production" (Bolaji *et al*., 2015). Other studies on complementary foods reported comparable bacterial loads (Badau*et al*., 2005). O"n the other hand, fungiare regarded as any member of the microorgasmswhich grows at temperature of 37°C and which normally possesses the enzymes β-galactosidase and often used as index of sanitation in assessing both microbiological safety and quality of food" (Nwogwugwu*et al.*, 2012). "Their presence in any food revel possible presence of any other pathogenic organism and so is an indication of microbial health hazard to the consumer. The processes adopted for this study has proven safety of this product since few are detected. Therefore, the dried form of powdered Ogi is superior since diverse microorganisms were reported to associates with wet ones" (Anigo*et al*., 2009). "Moulds plate count also measures the total number of moulds per unit volume of food sample and is recommended to be no more than 20 load per unit food volume. However, the moisture contents of these blends are in condition that it will not promote growth of moulds and subsequent introduction of mycotoxins" (Elemo*et al*., 2011). Other studies also reviled diverse and higher microbial counts associated with wet Ogi (Akinyele *et al.*, 2014).

Table 7 SENSORY PROPERTIES OF FORTIFIED SORGHUM OGI PORRIDGE

Sample (%)	Taste	Aroma	Colour	Consistency	General

					Acceptability
100:0	7.00^{a}±1.49	6.70^{e}±2.13	7.50^{a}±1.00	7.90^{a}±1.70	7.00^{a}±1.05
90:10	6.65^{b}±2.03	6.56^{d}±2.53	7.15^{b}±1.18	6.43^{b}±2.59	7.35^{b}±1.16
80:20	7.40^{c}±1.63	7.30^{c}±1.45	6.25^{c}±2.33	6.25^{c}±2.62	7.30^{b}±1.15
70:30	6.35^{d}±2.73	6.45^{b}±2.54	7.56^{cd}±2.68	6.50^{d}±2.61	7.60^{c}±2.09
60:40	6.90^{e}±2.25	6.68^{b}±2.46	7.30^{d}±1.72	6.30^{e}±2.73	6.70^{d}±2.45
50:50	6.60^{f}±2.25	6.35^{a}±2.25	6.00^{e}±2.25	6.00^{f}±2.25	6.30^{e}±2.25

Values are mean ± standard deviation of 20 panellists. Means within each column not followed by the same superscript are significantly different (P ≤0.05) from each other using Duncan multiple range test.

Key: Sample 100:0 (100% sorghum as control)

Sample 90:10 (90% sorghum: 10% soy)

Sample 80:20 (80% sorghum: 20% soy)

Sample 70:30 (70% sorghum: 30% soy)

Sample 60:40 (60% sorghum: 40% soy)

Sample 50:50 (50% sorghum: 50% soy).

3.6 SENSORY PROPERTIES OF FORTIFIED SORGHUM OGI

The sensory properties of the fortified ogi are shown in Table 6. According to Dehghan-Shoar*et al.* (2010), sensory properties of foods are a combination of the organoleptic properties like colour, aroma, taste and consistency. The taste is the primary factor which determines the acceptability of any food product which has the highest impact as far as market success of product is concerned.

The score for taste ranged from sample 100:00 (7.00), sample 90:10 (6.65), sample 80:20 (7.40), sample 70:30 (6.35), sample 60:40 (6.90) to sample 50:50 (6.60) Table 6. (7.40) was found highest in sample 80:20. Soybean may have slight decrease in glucose content at higher concentration. So, taste was found decreasing in other samples sample 100:0, sample 60:40 and sample 50:50.

"In case of aroma of the six samples including the control (sample 100:0), the mean score was ranged from sample 100:0 (6.70), sample 90:10 (6.56), sample 80:20 (7.30), sample 70:30 (6.45), sample 60:40 (6.68) to sample 50:50 (6.35) Table 6. The highest score (7.30) was obtained for sample 80:20, and after then. This may be due to be anyodor of soybean. At higher concentration, it imparted its characteristics odor and resulted in low score for aroma" (Akubor, 2003).

The colour of the fortified sorghum-ogi ranged from sample 100:00 (7.50), sample 90:10 (7.15, sample 80:20 (6.25), sample 70:30 (7.56), sample 60:40 (7.30) to sample 50:50 (6.00) Table 6.The highest score (7.56) was obtained for sample 70:30. This may be due to the decreasing reddish-brown color of sorghum as with increasing soy-flour percentages.

In case of consistency, the mean score was decreasing at increasing soy flour percentages sample 100:0 (7.90), sample 90:10 (6.43), sample 80:20 (6.25), sample 70:30 (6.50), sample 60:40 (6.30) to sample 50:50 (6.00) Table 6. Highest score (7.90) was for control (sample 100:0). This may be due to decreasing percentages of starch in sorghum by the increasing percentages of soybean which imparted consistency nature of ogi porridge.

The general acceptability includes sample 100:0 (7.00), sample 90:10 (7.35), sample 80:20 (7.30), sample 70:30 (7.60), sample 60:40 (6.70) to sample 50:50 (6.30) table 6.The general acceptability includes many implications, which is an important parameter in organoleptic estimation. Sample 70:30 had the highest mean value (7.60), while sample 50:50 had the least

mean value (6.30) for the general acceptability. At the 30% level of soy flour incorporation, the fortified ogi had highest score for the general acceptability

4.0. CONCLUSION

This research work showed the quality evaluation of the fortified sorghum ogi based on the functional, chemical, mineral compositions and microbial quality of the product. The low bulk density of the blends indicates its suitability in the preparation of high nutrient density complementary food. Fortifications of soy-flour with sorghum ogi on the swelling and viscous behaviour of the products were determined.Sample 50:50 is the best because of its highest mineral contents, while sample 80:20 is considered best based on the chemical composition which could help in the prevention of malnutrition which had been largely implicated in the development of infants. The blends could be useful where health promoting gruels from sorghum are desirable such as in the production of weaning food for infants.

Authors' contribution

Both authors carried out the research in a collaborative manner. Author OOO designed the study, wrote the protocol, performed the statistical analysis and proofread the draft of the manuscript. Author AMO carried out the literature reviews managed the analyses of the study and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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Details of the AI usage are given below:

1.

2.

3.

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