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# Effect of Fermentation and Roasting on the Physicochemical Properties of Weaning Food Produced from Blends of Sorghum and Soybean

**Msheliza EA[1]*, Hussein JB[2], Ilesanmi JOY[2] and Nkama I[3]**

*[1]Department of Chemistry Education, Federal College of Education (Technical), Gombe, Nigeria*
*[2]Department of Food Science and Technology, Modibbo Adama University of Technology, Yola, P. M. B. 2076 Yola, Adamawa State, Nigeria*
*[3]Department of Food Science and Technology, University of Nigeria, Nsukka, Enugu State, Nigeria*

## Abstract

This study investigated the effect of fermentation and roasting on the physicochemical properties of weaning foods produced from blends of sorghum and soybean. Sorghum and soybean were fermented, roasted and fermented/roasted, then milled into flours. Untreated sorghum and soybean flours were also produced and serve as the control. A portion of sorghum was malted and milled to obtain malted sorghum flour of which 5% was added to each sample except the control samples. Weaning foods were prepared in the following ratios: (75:20:5), (65:30:5) and (55:40:5) of sorghum:soybean:malt for the treated samples and the control samples contained (80:20), (70:30) and (60:40) of sorghum:soybean. The physicochemical properties of the weaning food blends were determined. Moisture ranged from 5.16 to 8.03%, crude protein 11.43 to 26.72%, crude fat 5.19 to 8.03%, ash 0.91 to 2.72%, crude fibre 0.30 to 1.16% and carbohydrate 57.14 to 71.40%. The buck density ranged from 0.68 to 0.76 g/ml, viscosity 561.33 to 1065 mPas, dispersibility 63.33 to 72.67%, wettability 11.55 to 46.54s, Water absorption capacity (WAC) 8.00 to 8.41 ml/g and gelation temperature 71.00 to 77.67°C. Fermented samples showed a least gelation capacity compared to roasted, fermented/roasted and untreated samples. Fermentation and roasting used in this study showed that the processing methods had marked effect on the physicochemical properties of the weaning foods produced. Thus, its recommendation for domestic processing of weaning foods.

**Keywords:** Fermentation; Roasting; Weaning food; *Sorghum*; Soybean; Physicochemical properties

## Introduction

Weaning refers to the gradual introduction of foods other than breast milk into a baby's diet. Weaning foods are foods widely used during the transition from consuming solely human milk or infant formulas to the introduction of a mixed diet. The foods are solely introduced to complement breast milk, progressively replace it and eventually adopt the child to adult diets. Usually, the breast milk which is the baby's first food is inadequate to maintain the rapid growth and development of the baby after six months of age of the child. Hence, there is the need to introduce appropriate weaning foods to the child which will supply the additional safe sources of energy and protein to complement breast milk and fully aid the growth and development of the child. Failure to feed the baby with appropriate food could lead to malnutrition, a problem that is common with most children in the developing countries of which Nigeria is one [1,2].

The commercially standardized foods are generally very good and can help meet the nutritional requirements of young children. Unfortunately, these foods are relatively expensive and are popularly used by the few high-income groups who can afford them. The formulation and development of nutritious weaning foods from local and readily available raw materials has received considerable attention by many food processors and researchers in many developing countries. However, to our knowledge there is limited qualitative data available regarding the effects of fermentation and roasting on sorghum/ soybean based weaning foods.

Sorghum (*Sorghum bicolor*) is a tropical grass grown primarily in semiarid parts of the world. According to the Food and Agricultural Organization [3] sorghum is quantitatively the world's fifth largest most important cereal grain, after wheat, maize, rice, and barley. In 2010, Nigeria was the world's largest producer of grain sorghum, followed by the United States and India. Over 90% of sorghum produced by United States and India is destined to animal feed, making Nigeria the world leading country for food grain sorghum production. In virtually all the North of the country, it is the primary food crop [4]. For some impoverished regions of the world, sorghum remains a principal source of energy, protein, vitamins and minerals. Being a cereal, it is limiting in the essential amino acid lysine, there is therefore the need to complement it with other abundantly available staple foods like legume (such as soybean) in other to obtain a more nutritive food. Infants and young children need high-energy dense, high-nutrient dense, palatable diets to support rapid growth. Sorghum's familiar taste and high carbohydrate content is a suitable base for weaning foods and young children. Sorghum-soy-fortified flour/food may be used [5].

The soybean (*Glycine max*) is the seed of the leguminous soybean plant. It is a staple food of great nutritional value, its importance ranges from milk and oil production, livestock feeds, human consumption to industrial uses [6]. Interest in soybean foods has increased with consumer awareness of its health and nutritive benefits, especially with soybean related ingredients being utilized as one of the major sources of high-protein fortification [7,8]. Soybean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage. Adding sugar and oil can increase energy content, but not many can afford these ingredients. In addition, these

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***Corresponding author:** Msheliza EA, Department of Chemistry Education, Federal College of Education (Technical), Gombe, Nigeria, Tel: +2348163917067; E-mail: mshelizaesther@yahoo.com

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foods are low in protein that is essential to growth and development. These ingredients make foods bulky to fill a child's stomach without necessarily providing adequate nutrition. Enriching weaning foods with soybean is a convenient, inexpensive, and highly effective way to upgrade the quality of traditional weaning foods and to provide the nutrition a growing child needs. Soybean works together with cereals to achieve an overall increase in the value of the protein.

As in most other developing countries, the high cost of fortified nutritious complementary food is always, if not beyond the reach of most Nigerian families. Such families often depend on inadequately processed traditional foods consisting mainly of un-supplemented cereal porridges made from maize, sorghum and millet. This poor quality of weaning foods and improper weaning practices predispose infants to malnutrition, infections and mortality. In tropical developing countries where the supply of animal protein is inadequate to meet the rapid population growth, intense research efforts are currently directed toward identification and evaluation of food grains which normally have considerable high protein content. Such studies are of great importance to reduce hunger and malnutrition among the vulnerable group which basically consist of children and pregnant women. The technologies for the production of weaning foods such as malting, roasting, fermenting, grinding is available in Africa [9-11]. All these are geared towards the development of low-cost, high-protein food supplements for weaning infants from local and readily available raw materials which have remained a constant challenge for developing countries [2]. This study forms part of exploration work on the improvement of the nutritional quality of the traditional complementary foods in Nigeria using cheap and locally available foods.

Soybeans and sorghum are typically processed prior to human consumptions. It is important that the anti-nutritional components are denatured prior to their consumptions. Numerous methods of eliminating anti-nutritional factors have been developed and tested [12]. Most of the toxic and anti-nutrient effects could be removed by several processing methods such as soaking, germination, boiling, autoclaving, fermentation, genetic manipulation and other processing methods [13]. Fermented cereals are particularly important as weaning foods for infants and as dietary staples for adults. Ikemefuna et al. [14] reported that a combination of cooking and fermentation improved the nutrient quality and drastically reduced the anti-nutritional factors to safe levels much greater than any of the processing methods tested. Ikemefuna et al. [14] also reported that soaking and fermentation decreased the tannins content because these processes produce enzymes that break down complexes to release free tannins thus; the free tannins were leached out. Roasting which is the application of heat in measured amounts, denatures the trypsin inhibitors, hemagglutinins (lecithins) and possibly allergenic proteins without damaging the quality and digestibility of the protein in the meal [12]. Roasting also create a convenient method of increasing fat content in the diet without the need to physically handle a liquid oil product.

The aim of this study is to examine the effects of fermentation and roasting on the chemical and functional properties of weaning foods produced from blends of sorghum and soybean.

## Materials and Methods

### Materials

Sorghum and soybean grains were purchased from Gombe Main Market, Gombe State, Nigeria. All samples were kept in a moisture free environment until when needed. The chemicals and reagents used were of analytical grade and they were obtained from the laboratories of Food Science and Technology, Modibbo Adama University of Technology, Yola, Adamawa State and Chemistry Education, Federal College of Education (Technical), Gombe, Gombe State, Nigeria.

### Methods

**Preparation of samples:** The sorghum and soybean grains were manually cleaned (separately) to remove sand, foreign seeds, broken and infested seeds, dirt and other contaminants.

**Fermented sorghum:** One kilogram (1 kg) of sorghum was dehulled after tempering using the commercial grains huller at Gombe Main Market. After dehulling, the grains were winnowed and washed to remove the hulls and germs. The grains were steeped at room temperature (32 ± 2°C) for 72 hours and the steep water decanted. The fermented grains were then dried in hot air oven (Model: TO008GA-34, AKAI-TOKOYO, JAPAN) set at 60°C for 10 hours to halt the fermentation process. It was milled to produce the fermented sorghum flour which was packaged in a clean polyethylene bag [15].

**Fermented soybean:** One kilogram (1 kg) of soybean was soaked for 2 hours in clean water of three times its weight by volume until the seed coat became soaked and wet to facilitate dehulling. Mortar and pestle were used for dehulling. The dehulled soybean was washed to remove the seed coat. The soybean was allowed to ferment naturally in a clean covered plastic bucket for 72 hours and the steep water decanted. The fermented grain was then dried in hot air oven (Model: TO008GA-34, AKAI-TOKOYO, JAPAN) at 60°C for 10 hours to halt the fermentation process. It was then milled to produce the fermented soybean flour which was packaged in clean polyethylene bag until needed.

**Roasted sorghum:** Whole grains of sorghum weighing 1 kg were dehulled using the commercial grains huller at Gombe Main Market. After dehulling the grains were winnowed, washed, drained and then partially sun dried. The sorghum was then traditionally roasted using an open thick aluminum pot. Commercial grinding machine was used to mill the grains into flour. A local sieve of about 1 mm in diameter was used to sieve the flour in order to obtain a fine particle size. The flour was packaged in a plastic container and sealed until needed.

**Roasted soybean:** Whole grains of soybean weighing 1 kg was soaked for 2 hours in clean water of three times its weight by volume until the seed coat became soaked and wet to facilitate dehulling. Mortar and pestle were used for dehulling. The dehulled soybean was washed to remove the seed coat, drained and then partially sun dried. The soybean was then traditionally roasted using an open thick aluminum pot. A commercial grinding machine was used to mill the dehulled grain into fine flour and let to pass through a sieve of about 1 mm mesh screen. The roasted soybean flour was packaged in a plastic container until when required.

**Fermented and roasted sorghum flour:** The procedures for fermentation and roasting of sorghum grain as described above was carried out on 1 kg of sorghum grain before it was milled into flour and stored in a plastic container until needed.

**Fermented and roasted soybean flour:** The procedures for fermentation and roasting of soybean as described above was carried out on 1 kg of soybean grain before it was milled into flour and stored in a plastic container until when needed.

**Malting of sorghum:** The sorghum was malted as described by Badau et al. [9]. The grains were steeped at room temperature (32

± 2°C) for 12 hours. The steeped liquor was changed after 6 hours. One air rest period of 1 hour was applied after 6 hours of steeping. After steeping, the grains were immersed in 0.1% (v/v) solution of commercial bleach (hypo) that is, 5 ml of 3.5% sodium hypochlorite. After sterilization, the grains were wrapped in a wet piece of cotton cloth and placed on a wet jute bag. Another wet jute bag was used to cover the grain wrapped in the wet cloth. The sorghum grains were allowed to germinate at room temperature (32 ± 2°C) for 72 hours. During germination, small quantity of water (15 ml) was sprayed on the germinating grains and the grains were turned by moving a clean wooden rod inside the germinating grains. For the first 48 hours of malting, the sample was moistened twice a day at 08:00 and 16:00 hour by spraying a mist of water on it for about 5 seconds and then it was turned over. On the seventy-second hour of germination, the sample was sprayed in the morning (8 hours) and turned over in the afternoon (16 hours).

At the end of the germination, the germinated grains were dried to moisture content of 5.45 ± 0.48% in an oven set at 50°C for 24 hours. The dried germinated grains were polished by removing shoots and rootlets. Rootlets and shoots were separated from the kernels by rubbing between the palms in a local sieve of about 1 mm mesh size. This allows the rootlets and shoots to escape but retain the kernels. The polished malt was then milled into fine flour in a commercial milling machine and sieved using a local sieve of about 1 mm mesh screen. The malted sorghum flour was packaged in an air tight plastic container until when it was needed.

**Formulation of weaning foods:** The weaning foods were formulated in the following ratios as shown in Table 1.

## Chemical analyses

**Proximate composition:** The weaning food Samples were analyzed for the following parameters, moisture, crude protein, crude fat, ash content, crude fibre and carbohydrate. The moisture content was determined according to the method of AOAC [16]. The Samples were dried at 105°C for 3 hours using the preset oven (Fisher Scientific Isotemp Oven, model 655F, Chicago, USA). The method described by AOAC [16] was employed for ash content determination. The crucible containing the pre-weighed samples were placed in a heated furnace (Fisher Isotemp Muffle Furnace, model 186A, USA) at 600°C for 6 hours after which they were cooled to room temperature in desiccators and weighed. The protein content (% nitrogen x 6.25) and fat content were (1 g was extracted for ether extract determination using diethyl ether (64°C as solvent) determined according to the method of AOAC [16]. The defatted samples were then used for the determination of crude fibre. The carbohydrate content was determined by difference between 100 and total sum of the percentage of moisture, protein, fat, fibre and ash [17]. All analyses were carried out in triplicate.

| Samples | Sorghum (%) | Malted sorghum (%) | Soybean (%) |
|---|---|---|---|
| F1, R1 & FR1 | 55 | 5 | 40 |
| F2, R2 & FR2 | 65 | 5 | 30 |
| F3, R2 & FR3 | 75 | 5 | 20 |
| U1 | 60 | - | 40 |
| U2 | 70 | - | 30 |
| U3 | 80 | - | 20 |

**Key:** F1, F2 and F3 = Fermented samples (55:40:5, 65:30:5 and 75:20:5 respectively)
R1, R2 and R3 = Roasted samples (55:40:5, 65:30:5 and 75:20:5 respectively)
FR1, FR2 and FR3 = Fermented and roasted samples (55:40:5, 65:30:5 and 75:20:5 respectively)
U1, U2 and U3 = Untreated samples (60:40, 70:30 and 80:20 respectively)

**Table 1:** Formulation of the weaning foods.

**Functional properties:** The gruel of the weaning formulations was prepared as described by Badau et al., [9]. The slurries of the weaning food formulations were prepared by dissolving 20 g in 100 ml distilled water to give 20% (w/v) concentration. The slurries were heated in a boiling water bath (Model SUS, Cambridge Ltd, UK) to reach a cooking temperature of 95°C within 7-10 minutes and they were kept at cooking temperature for 15 minutes. The viscosities of the gruel for the formulations were then measured with viscometer (Model SV, Fine wave Vibro) at appropriate temperature and shear rates as described by Nkama and Badau [18]. Bulk density of the weaning foods formulations was determined by weighing the sample (50 g) into 100 ml graduated cylinder, tapping 10 times against the palm of the hand and the final volume was expressed as g/ml [19].

The dispersibility was measured by placing 10 g of the flour sample in a 100 ml stoppered measuring cylinder and then increasing the volume by adding water gradually to make 100 ml as described by Asma et al. [2]. The mixture was vigorously shaken and allowed to stand for 3 hours. The volume of the settled particle was subtracted from the total volume and the difference expressed as percentage dispersibility. The method of Onwuka [20] was used to determine the Wettability and Gelation capacity. Water absorption capacity of the weaning foods formulations were determined by placing 1 g of flour into 10 ml of water and allowed to stand at room temperature for 1 hour and centrifuged at 3500 rpm for 15 minutes. The volume of the water was measured. Water absorption capacity was calculated as ml of water absorbed per gram of flour [19]. Gelatinization temperature was determine as described by Pearson [21].

Ten (10) percent of each suspension of the flour sample was prepared and put in to a clean test tube. The aqueous suspension was heated in a thermostatically controlled water bath with continuous stirring. The gelatinization temperature was visually noticed and then recorded after 30 seconds as the gelatinization temperature.

## Statistical analysis

All experiments were performed in triplicate, and the results were expressed as means ± standard error (SE). Analysis of variance (ANOVA) was carried out to determine any significant differences in measurements using the SPSS statistical software (SPSS 20.0 for Windows; SPSS Inc., Chicago, IL, USA) and considering the confidence level of 95%. The significance of the difference between the means was determined using the Duncan's Multiple Range Test, and the differences were considered to be significant at $p<0.05$ [22].

# Results and Discussions

## Effect of fermentation and roasting on the proximate composition of weaning foods blend from sorghum and soybean

Table 2 shows the results obtained for proximate composition (moisture, protein, fat, ash, fibre and carbohydrate) of weaning foods prepared from the blends of Sorghum and Soybean. The percentage moisture contents ranged from 5.16 to 8.03% with sample R55:40:5 roasted, having the lowest value while sample U80:20 untreated, had the highest. There was significant difference ($p<0.05$) among the moisture content of the fermented samples and the roasted samples, fermented/roasted samples and the untreated samples. The moisture content of the untreated samples was significantly higher than fermented, roasted

| Sample blends | | Moisture | Crude Protein | Crude Fat | Crude Ash | Crude Fibre | Carbohydrate |
|---|---|---|---|---|---|---|---|
| **Fermented** | F55:40:5 | $6.43 \pm 0.02^{f}$ | $26.72 \pm 0.12^{a}$ | $8.03 \pm 0.03^{a}$ | $0.91 \pm 0.06^{g}$ | $0.77 \pm 0.02^{d}$ | $57.14 \pm 0.06^{h}$ |
| | F65:30:5 | $6.69 \pm 0.10^{e}$ | $23.55 \pm 0.08^{bcd}$ | $7.45 \pm 0.14^{b}$ | $1.18 \pm 0.03^{f}$ | $0.95 \pm 0.05^{b}$ | $60.17 \pm 0.11^{fg}$ |
| | F75:20:5 | $6.86 \pm 0.03^{d}$ | $20.98 \pm 0.02^{def}$ | $7.28 \pm 0.14^{b}$ | $2.25 \pm 0.06^{cd}$ | $1.16 \pm 0.01^{a}$ | $61.47 \pm 0.25^{ef}$ |
| **Roasted** | R55:40:5 | $5.16 \pm 0.03^{k}$ | $23.73 \pm 0.07^{bc}$ | $7.55 \pm 0.09^{b}$ | $2.11 \pm 0.04^{d}$ | $0.42 \pm 0.02^{g}$ | $61.03 \pm 0.13^{efg}$ |
| | R65:30:5 | $5.43 \pm 0.03^{j}$ | $21.65 \pm 0.22^{cd}$ | $7.40 \pm 0.15^{b}$ | $2.34 \pm 0.04^{c}$ | $0.58 \pm 0.03^{f}$ | $62.60 \pm 0.38^{def}$ |
| | R75:20:5 | $5.59 \pm 0.04^{i}$ | $16.09 \pm 0.11^{g}$ | $5.61 \pm 0.33^{de}$ | $2.72 \pm 0.06^{a}$ | $0.75 \pm 0.02^{de}$ | $69.25 \pm 0.33^{b}$ |
| **Fermented and Roasted** | FR55:40:5 | $6.13 \pm 0.02^{h}$ | $25.74 \pm 0.12^{ab}$ | $7.37 \pm 0.12^{b}$ | $1.54 \pm 0.08^{e}$ | $0.54 \pm 0.02^{f}$ | $58.67 \pm 0.13^{gh}$ |
| | FR65:30:5 | $6.23 \pm 0.01^{gh}$ | $21.44 \pm 1.01^{cde}$ | $6.34 \pm 0.13^{c}$ | $2.10 \pm 0.03^{d}$ | $0.67 \pm 0.08^{e}$ | $63.22 \pm 0.20^{de}$ |
| | FR75:20:5 | $6.31 \pm 0.03^{fg}$ | $18.58 \pm 0.13^{f}$ | $5.29 \pm 0.10^{de}$ | $2.51 \pm 0.06^{b}$ | $0.86 \pm 0.02^{c}$ | $66.45 \pm 0.06^{c}$ |
| **Untreated** | U60:40 | $7.29 \pm 0.13^{c}$ | $23.51 \pm 0.08^{bcd}$ | $5.77 \pm 0.27^{cd}$ | $1.08 \pm 0.02^{f}$ | $0.30 \pm 0.04^{h}$ | $62.05 \pm 0.27^{ef}$ |
| | U70:30 | $7.68 \pm 0.16^{b}$ | $20.04 \pm 0.18^{ef}$ | $5.66 \pm 0.13^{de}$ | $1.23 \pm 0.05^{f}$ | $0.35 \pm 0.03^{gh}$ | $65.04 \pm 0.04^{dc}$ |
| | U80:20 | $8.03 \pm 0.19^{a}$ | $11.43 \pm 2.80^{h}$ | $5.19 \pm 0.05^{e}$ | $1.39 \pm 0.07^{e}$ | $0.56 \pm 0.07^{f}$ | $71.40 \pm 0.69^{a}$ |

Means in the same column bearing different superscripts are significantly different ($p<0.05$).

**Table 2:** Proximate composition of weaning foods from blends of sorghum and soybean (%).

and fermented/roasted samples though all were within FAO/WHO recommended safe limit (<10%) as higher moisture may affect the storage quality of the foods. It is believed that materials such as flour and starch containing more than 12.5% moisture have less storage stability than those with lower moisture content. For this reason, a water content of not more than 12.5% is generally specified for flours and other related products [23]. Makinde and Ladipo [24] reported similar values for physicochemical and microbial quality of sorghum-based complementary food enriched with soybean *(Glycine max)* and sesame *(Sesamum indicum)*. Temple et al. [25] and Makinde and Ladipo [24] reported that high moisture content in foods has been shown to encourage microbial growth. This is an important consideration in local feeding methods in Nigeria because most mothers often prepare large quantities of dry infant foods and keep in containers, to avoid frequent processing in order to have spare time and energy for other domestic activities.

The percentage crude protein ranged from 11.43 to 26.72% with the untreated sample U80:20, having the lowest value while fermented sample F55:40:5 had the highest value. There were significant difference ($p<0.05$) among the protein content of the fermented sample F55:40:5 and roasted sample, R55:40:5, fermented/roasted sample FR55:40:5 and the untreated sample, U60:40. The values of crude protein obtained in this study were relatively higher than 16.70% which was the minimum recommendations of FAO/WHO for weaning foods. Fermented samples had higher values than roasted, fermented and roasted and untreated samples. This was due to the fact that fermentation enhances the nutritive value of food by increasing thiamine, nicotinic acid, riboflavin and perhaps protein content as a result of microbial activities [26]. It was also observed that as the soybean addition increased, the crude protein increased as well.

The percentage crude fat ranged from 5.19 to 8.03% with sample U80:20 untreated, having the lowest value while fermented sample F55:40:5 had the highest value. There were no significant differences ($p>0.05$) in the fat content among the treated samples F55:40:5, R55:40:5 and FR55:40:5 however, there were significant differences ($p<0.05$) between each one of them and the untreated sample U60:40. The values of crude fat obtained in this study were relatively higher than 6.00% which was the minimum recommendations of FAO/WHO for weaning foods. The crude fat content of the fermented samples was relatively higher than roasted, fermented/roasted and untreated samples. Also, the crude fat content increased as the addition of soybean increased. This could be attributed to the high content of oil in soybean. Similar results were reported by Anigo et al. [27] for nutrient composition of complementary food gruels formulated from malted cereals, soybeans and groundnut. Anigo et al. [27] reported that the inclusion of oil-dense soya beans in the complementary diets will not only increase the energy density but also be a transport vehicle for fat soluble vitamins. Adedeji et al. [23] reported that flours of high fat content supply high energy, however, food containing high fat is susceptible to both hydrolytic and oxidative/enzymatic rancidity which is responsible for off flavour and this affect both the general acceptability and storage stability of the products. The fat contents of the products were lower enough to allow for good storage if packaged properly.

Ash contents ranged from 0.91 to 2.72% with sample F55:40:5 fermented having the lowest value while sample R75:20:5 had the highest value. The percentage crude fibre ranged from 0.30 to 1.16% with sample U60:40 untreated, having the lowest value while sample F75:20:5 fermented, had the highest value. Similar results were reported by Egounlety [28] for the production of legumes-fortified weaning food. Alemu [29] reported that ash contents of weaning foods significantly decreased after fermentation. Although, there was significant difference ($p<0.05$) between the formulated mixes in ash and crude fibre contents, the values obtained were within the recommended value of less than 5% for crude fibre and less than 10% for ash contents [30]. Fermented samples had high crude fibre contents which are an important dietary component in preventing overweight, constipation, cardiovascular disease, diabetes and colon cancer [31].

The percentage carbohydrate ranged from 57.14 to 71.40%. Sample F55:40:5 fermented, have the lowest value while sample U80:20 untreated had the highest value. There were significant differences ($p<0.05$) among samples F55:40:5, R55:40:5 and FR55:40:5. However, there were no significant differences ($p>0.05$) between sample FR55:40:5 and U60:40. Similar results were reported by Makinde and Ladipo [24] for physicochemical and microbial quality of sorghum-based complementary food enriched with soybean *(Glycine max)*.

| Sample blends | | Bulk density (g/ml) | Viscosity (mPas) | Dispersibilty (%) | Wettability (s) | WAC (ml/g) | Gelation Temperature (°C) |
|---|---|---|---|---|---|---|---|
| **Fermented** | F55:40:5 | $0.68 \pm 0.01^{e}$ | $562.00 \pm 1.15^{d}$ | $64.67 \pm 0.33^{fg}$ | $24.90 \pm 1.85^{b}$ | $8.22 \pm 0.02^{bcde}$ | $74.67 \pm 1.33^{cd}$ |
| | F65:30:5 | $0.70 \pm 0.01^{de}$ | $561.33 \pm 0.88^{d}$ | $68.67 \pm 0.67^{cd}$ | $26.96 \pm 0.49^{b}$ | $8.08 \pm 0.04^{de}$ | $75.33 \pm 0.67^{bcd}$ |
| | F75:20:5 | $0.73 \pm 0.01^{cd}$ | $561.33 \pm 0.88^{d}$ | $71.00 \pm 0.58^{a}$ | $25.42 \pm 0.66^{b}$ | $8.25 \pm 0.13^{bcd}$ | $74.33 \pm 0.33^{cd}$ |
| **Roasted** | R55:40:5 | $0.70 \pm 0.02^{de}$ | $574.67 \pm 7.06^{c}$ | $66.67 \pm 0.67^{e}$ | $18.02 \pm 1.08^{cd}$ | $8.12 \pm 0.06^{de}$ | $75.67 \pm 0.33^{abcd}$ |
| | R65:30:5 | $0.74 \pm 0.02^{bc}$ | $573.33 \pm 7.12^{c}$ | $69.00 \pm 0.58^{bc}$ | $17.27 \pm 0.62^{cd}$ | $8.25 \pm 0.03^{bcd}$ | $73.67 \pm 0.33^{d}$ |
| | R75:20:5 | $0.79 \pm 0.01^{a}$ | $575.00 \pm 7.21^{c}$ | $72.33 \pm 0.88^{a}$ | $10.51 \pm 1.39^{e}$ | $8.18 \pm 0.09^{cde}$ | $71.00 \pm 1.00^{e}$ |
| **Fermented and roasted** | FR55:40:5 | $0.68 \pm 0.01^{e}$ | $411.67 \pm 0.88^{f}$ | $63.33 \pm 0.67^{g}$ | $13.45 \pm 1.45^{de}$ | $8.02 \pm 0.04^{e}$ | $75.67 \pm 0.33^{abcd}$ |
| | FR65:30:5 | $0.72 \pm 0.01^{cd}$ | $425.67 \pm 1.20^{e}$ | $66.00 \pm 0.58^{ef}$ | $11.55 \pm 0.43^{e}$ | $8.03 \pm 0.03^{de}$ | $76.33 \pm 1.20^{abc}$ |
| | FR75:20:5 | $0.72 \pm 0.01^{cd}$ | $425.00 \pm 2.52^{e}$ | $67.00 \pm 0.58^{de}$ | $15.75 \pm 1.51^{de}$ | $8.00 \pm 0.06^{e}$ | $76.33 \pm 0.33^{abc}$ |
| **Untreated** | U60:40 | $0.76 \pm 0.01^{b}$ | $1042.67 \pm 1.45^{b}$ | $70.83 \pm 0.44^{ab}$ | $45.18 \pm 1.46^{a}$ | $8.40 \pm 0.03^{abc}$ | $77.67 \pm 0.33^{a}$ |
| | U70:30 | $0.74 \pm 0.01^{bc}$ | $1065.67 \pm 1.20^{a}$ | $71.67 \pm 0.88^{a}$ | $46.54 \pm 4.42^{a}$ | $8.53 \pm 0.12^{a}$ | $77.33 \pm 0.67^{ab}$ |
| | U80:20 | $0.76 \pm 0.01^{ab}$ | $1023.33 \pm 0.88^{b}$ | $72.67 \pm 0.67^{a}$ | $21.68 \pm 2.05^{bc}$ | $8.41 \pm 0.06^{ab}$ | $74.33 \pm 0.33^{cd}$ |

Means in the same column bearing different superscripts are significantly different ($p<0.05$)

**Table 3:** Functional properties of the weaning foods prepared from the blends of sorghum and soybean.

## Effect of fermentation and roasting on the functional properties of weaning foods blend from sorghum and soybean

The functional properties of dried flour played an important role in assessing their quality and palatability as well as the consumer acceptability [22]. Bulk density is an important property that has a direct impact on the packaging requirement of powders. It also provides indication of physical properties like cohesion and porosity and may affect flow ability and storage stability [22,32]. Table 3 shows the results obtained for functional properties of the weaning foods prepared from the blends of Sorghum and Soybean. The bulk density ranged from 0.68 to 0.79 g/ml with samples F55:40:5, fermented and FR55:40:5, fermented/roasted having the lowest value while sample R75:20:5, roasted had the highest value. These results agree with the findings of Oluwamukomi et al. [33] when soybean was incorporated (30:70) at different stages and states in the flow line for Ogi production. Also, in all the treatments, the bulk density decreased as the soy bean supplementation increased. Similar result was reported by Edema et al. [34] who reported a decrease in the bulk density of maize with increasing soy supplementation. Fermented samples had the lowest bulk density value followed by fermented and roasted samples, roasted samples and untreated samples. Singh et al. [32] reported that the Bulk density values decreased gradually with increase in fermentation periods. The decrease in bulk density of fermented flour would be an advantage in the preparation of infant foods. Fermentation has been reported as a useful and traditional method for the preparation of low bulk weaning foods [35]. Also, the lower the bulk density value, the higher the amount of flour particles that can stay together and thus increasing energy content that could be derivable from such diets [36].

Viscosity of food is one of the important determinants of food acceptability to both mothers and young children. Viscosity is the measure of the resistance to fluid flow. Food is visco-elastic in nature. Weaning or complementary food of high viscosity is usually unacceptable to growing infants as it makes feeding difficult and causes suffocation. Viscosity ranged from 411.67 to 1065.61 mPa.s with sample FR55:40:5, fermented/roasted having the lowest value while sample U70:30 untreated had the highest value. Following the results, there were significant differences ($p<0.05$) in the viscosity of all the treatments. The viscosities of the treated samples were highly significant in relation to the untreated samples. This was due to the addition of 5% sorghum malt. Badau et al. [37] reported that malt (5%) reduced the viscosity of weaning food. Also, in a mixture consisting of cereals and legumes, the malted cereal constituents substantially to the reduction in viscosity of a hot paste [38,39].

Fermented/roasted samples had the least viscosity compared with fermented only and roasted only. The lower value of viscosity in the fermented and roasted sample is an indication of the change in properties of cooked starch of the processed sorghum and in the case of soybean, denaturation of protein occurs which makes the cooked slurry to assume least viscosity even at higher concentrations. Addis et al. [40] reported that when the complementary food containing 5% malt was cooked, the viscosity was reduced with appreciable quantity even at 20% concentration because of partial hydrolysis of starch and reduction in its water holding capacity. Malted complementary flour is rich in α-amylase. During cooking, alpha-amylase in the malt hydrolyzes the 1, 4 α-D-glucosidic linkages of polysaccharides. Starch is therefore degraded to lower molecular weight dextrins by the enzyme, and thus, viscosity of the heated paste decreases [40,41].

The dispersibility of a mix in water indicates its reconstitution ability. The higher the dispersibility, the better the reconstitution property [42,43]. Percentage dispersibility ranged from 63.33 to 72.67% with sample FR55:40:5, fermented/roasted having the lowest value while sample U70:30, untreated had the highest value. The Percentage dispersibility of the untreated samples were significant ($p<0.05$) in relation to the treated samples. The wettability and water absorption capacity of the fermented/roasted samples were significant ($p<0.05$) to roasted only, fermented only and untreated samples. This lower value was due to partial hydrolysis of starch and denaturation of protein during fermentation and roasting processes.

Water absorption capacity (WAC) and wettability of the fermented/roasted samples were lower than the values for the fermented only, roasted only and untreated samples. The water absorption capacity relates to the amount of water available for gelatinization. Fermentation and 5% malted sample added, also lowers water absorption capacity of the treated samples than the untreated

| Sample blends | | 2 % | 4 % | 6 % | 8 % | 10 % | 12 % | 14 % |
|---|---|---|---|---|---|---|---|---|
| Fermented | F55:40:5 | - | - | - | ± | + | ++ | +++ |
| | F65:30:5 | - | - | - | ± | + | ++ | +++ |
| | F75:20:5 | - | - | ± | + | ++ | +++ | +++ |
| Roasted | R55:40:5 | - | - | - | - | - | ± | + |
| | R65:30:5 | - | - | - | - | - | ± | + |
| | R75:20:5 | - | - | - | - | ± | + | ++ |
| Fermented and roasted | FR55:40:5 | - | - | - | - | - | ± | + |
| | FR65:30:5 | - | - | - | - | - | ± | + |
| | FR75:20:5 | - | - | - | - | ± | + | ++ |
| Untreated | U60:40 | - | - | - | - | ± | + | ++ |
| | U70:30 | - | - | - | - | ± | + | ++ |
| | U80:20 | - | - | - | - | ± | + | ++ |

**Key:**
- = No gel formed
± = Very weak gel formed
+ = Weak gel formed
++ = Strong gel formed
+++ = Very strong gel formed

**Table 4:** Least gelation capacity concentration of the weaning foods prepared from the blends of sorghum and soybean.

ones. This lower water capacity would be desirable for producing thinner gruels or porridges for children. Gruels of low water capacity will allow for increase total solid [44]. Gelation temperature ranged from 71.00 to 77.67°C with sample R75:20:5, roasted having the lowest value while sample U60:40, untreated had the highest value. The gelation temperature of the untreated samples was significant ($p<0.05$) in relation to the treated samples.

### Effect of fermentation and roasting on the least gelation capacity of weaning foods blend from sorghum and soybean

Table 4 shows the results obtained for least gelation capacity concentration of the weaning foods prepared from the blends of Sorghum and Soybean. Fermented samples F55:40:5 and F65:30:5 formed a very weak gel at 8%, weak gel at 10%, strong gel at 12% and very strong gel at 14%. No gel was formed at 2, 4 and 6% concentrations. While fermented sample F75:20:5 formed a very weak gel at 6%, weak gel at 8%, strong gel at 10% and very strong gel at 12 and 14% concentrations. No gel was formed at 2 and 4% concentrations. Roasted samples R55:40:5 and R65:30:5 formed a very weak gel at 12% and weak gel at 14%. No gel was formed at 2, 4, 6, 8 and 10% concentrations. Roasted sample R75:20:5 formed a very weak gel at 10%, weak gel at 12% and strong gel at 14% concentrations. No gel was formed at 2, 4, 6 and 8% concentrations.

Fermented/roasted samples FR55:40:5 and FR65:30:5 formed a very weak gel at 12% and weak gel at 14%. No gel was formed at 2, 4, 6, 8 and 10% concentrations. Fermented and roasted sample FR75:20:5 formed a very weak gel at 10%, weak gel at 12% and strong gel at 14 % concentrations. No gel was formed at 2, 4, 6 and 8 %. All the untreated samples U60:40, U70:30 and U80:20 formed a very weak gel at 10%, weak gel at 12% and strong gel at 14% concentrations. Fermented samples show a least gelation capacity compared with roasted only, fermented/roasted and untreated samples. No significant difference ($p<0.05$) was observed between roasted samples and fermented/roasted samples. It was also observed that treatments blends with high supplementation of soybean formed very weak gel at high concentrations level. Similar results were reported by Maha et al. [43] for pearl millet supplemented with soybean. From the results obtained, it indicates that lower flour concentration would be required to form gel for fermented samples than roasted only, fermented/roasted and untreated samples due to their higher starch contents.

## Conclusion

Weaning foods from blends of fermented (sorghum and soybean) and roasted (sorghum and soybean) grains were produced. From the chemical composition of the weaning foods produced, it shows that fermentation and roasting processes improved the nutritional composition of the blends. Fermentation and roasting processes improved the functional properties of the weaning foods blends produced. Also, the presence of malted sorghum flour in the formulation had essentially influenced these properties. Therefore, the domestic processing methods like fermentation and roasting is recommended to improve the nutritional status of infants in the developing nations.

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