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Physico-Chemical and Sensory Properties of Complementary Foods from Blends of Malted and Non-Malted Sorghum, Soybean and *Moringa Oleifera* Seed Flours

Bello A.A.[1,*], Gernah D.I.[2], Ariahu C.C.[3], Ikya J.K[4]

Department of Food Science and Technology, Federal University of Agriculture, Makurdi
*Corresponding author: alicebello53@yahoo.com

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Abstract Complementary foods for infants in developing countries are mainly cereals, thus meeting all their nutrient needs is difficult due to micronutrient deficiency. The aim of this study is to evaluate the quality of complementary foods from blends of malted and non-malted sorghum, soybean and *Moringa oleifera* seed flours. Four samples each of malted and non-malted sorghum and soybean based foods were formulated by material balance to obtain 16g protein/100g food by adding to each formulated food sample; 0%, 5%, 10% and 15% *Moringa oleifera* seed flour respectively. The food formulations were analyzed for physico-chemical and sensory properties using standard methods. Results showed that malting and addition of *Moringa oleifera* significantly (P< 0.05) improved the properties of the complementary foods. Viscosity, bulk density and swelling index decreased while water absorption capacity and reconstitution index increased. There were reductions in moisture content, crude fat, crude fibre, carbohydrate and energy contents but increases in crude ash and crude protein contents. All the micronutrients increased in malted food formulations. The pH, peroxide value and total volatile bases were lower in malted food formulations. Appearance, aroma, taste and overall acceptability increased except the food formulation that had 15% *Moringa oleifera* seed flour addition. The most acceptable food formulation was the one that had 10% *Moringa oleifera* seed flour addition. In conclusion, this study showed the possibility of producing complementary foods from cheap raw materials using simple malting technology which can also meet the nutrient needs of infants and children and thus its production should be encouraged.

Keywords: *malted sorghum, non-malted sorghum, soybean, Moringa oleifera seed, complementary food, food formulation, infants, children*

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1. Introduction

Studies have shown that breast milk is the ideal food for infants during the first six months of life [1,2]. It contains all the nutrients and immunological factors an infant requires to maintain optimal health and growth. However, breast milk is not sufficient to provide all the nutrients and calories that allow infants to thrive or increase in birth weight after six months of life [3]. The global strategy for infant and young child feeding states that infants should be exclusively breastfed for the first six months of life to achieve optimal growth, development and health and thereafter, receive nutritionally adequate and safe complementary foods while breastfeeding continues for up to two years and beyond [4].

In developing countries including Nigeria, malnutrition remains a major health problem in infants because cereal gruels are the common complementary foods which are characterized by low energy and protein density due to its large volume of water relative to its solid matter content during preparation [2]. Adequate nutrition is being met through commercially available complementary foods prepared in developed countries of the world but the products are too expensive for the low income groups especially in developing countries like Nigeria [5]. Cereal gruels are sometimes complemented with legumes because of their limiting essential amino acids particularly lysine and tryptophan. However, complementation with legumes has been reported to produce high viscosity and bulk leading to low nutrient density and low energy value [6,7]. Legumes also contain anti-nutritional factors (ANFs) such as phytate, phenol and trypsin inhibitors [7].

Processing technologies such as malting and fermentation could however, be used to reduce bulk density and viscosity [7].

Meeting the high nutrient needs of infants and young children with diets based predominantly on cereals and legumes is difficult due to micronutrient deficiency [8]. Fortification with micronutrient rich foods from indigenous and traditional trees could help address complementary feeding nutrient gaps. Fortification of complementary foods using sorghum and soybean with *Moringa oleifera* seed flour is the focus of this study. Information on the use of *Moringa oleifera* seed flour in complementary foods is scanty.

2. Materials and Methods

2.1. Preparation of Non-malted and Malted Sorghum

The adopted method of [7] was employed. The sorghum grains were first cleaned and winnowed to remove chaff and other light contaminants. It was then poured into a bowl of water so that the bad seed could float and be skinned off. Soaking also known as steeping was done for 12 hours at room temperature (30±2°C) in order to soften the coats. The grains were drained and dried in the oven at 75°C to constant weight and then milled into flour. It was sieved using 600*um* mesh and packaged in low density air tight black polythene bags which in turn were put in plastic containers tightly covered at room temperature (30±2°C) before analysis.

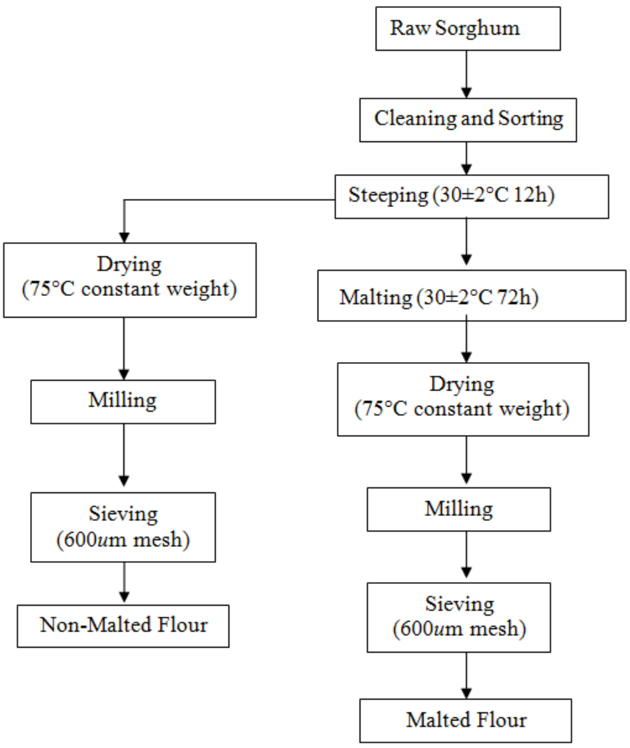

Figure 1. Flow chart for Production of the Different Sorghum Flours (Adopted from [7])

For the malted flour, after soaking for 12 hours like the non-malted sorghum, the grains were spread on cleaned, moistened jute bags for 72 hours for germination to take place. The grains were moistened with water at an interval of 12 hours within these 72 hours. They were later kilned or dried in the oven at 75°C to constant weight. The testa and rootlets were nipped from the cotyledon and removed by winnowing. The dried grains were milled, sieved through a sieve of 600µm particle size. The flour was packaged in low density dark coloured polythene bags stored in plastic containers with airtight lids at room temperature (30±2°C) until analysis as shown in Figure 1.

2.2. Preparation of Soybean Flour

The method of [9] was employed. The soybeans were sorted and washed with clean water. The seeds were then soaked overnight in cold water for 12 hours at 25-30°C and de-hulled. It was then boiled at 100°C for 30 minutes. The seeds were drained through a nylon sieve for 1 hour. The seeds were oven dried at 60°C for 24hours, milled and sieved using 600 µm mesh. The flour was stored in low density dark coloured polythene bags stored in plastic containers with airtight lids at room temperature (30±2°C) until analysis (see Figure 2).

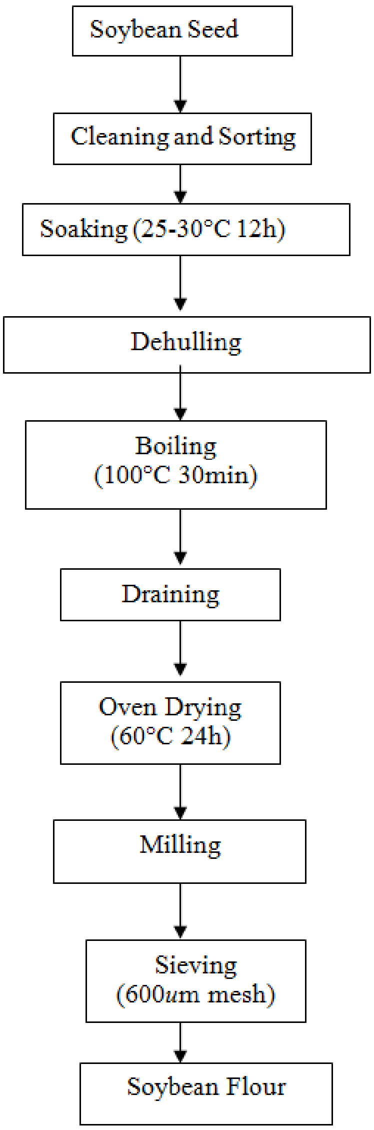

Figure 2. Flow chart for Production of Soybean Flour (Source: [9])

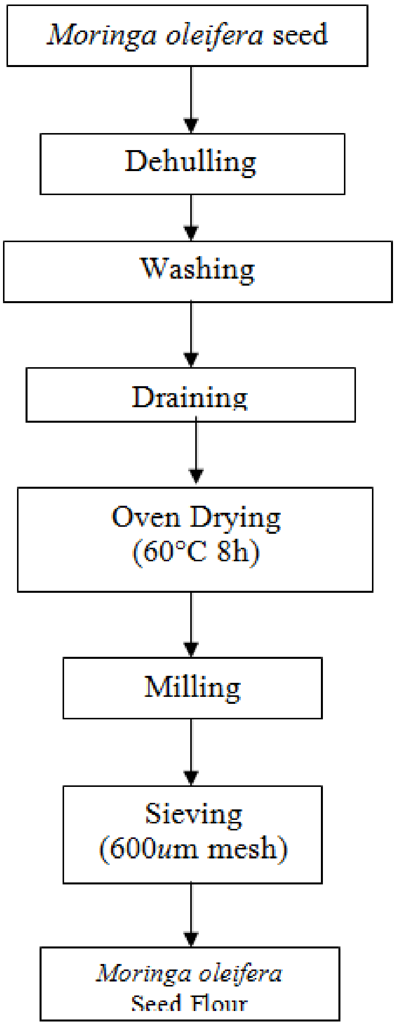

Figure 3. Flow chart for Production of *Moringa oleifera* Seed Flour (Source: [10])

2.3. Preparation of *Moringa oleifera* Seed Flour

The method of [10] was employed. The *Moringa oleifera* seeds were de-hulled, picked, washed and drained. They were spread thinly on a tray and oven dried at 60°C for 8hours to constant weight. The dried seeds were milled and sieved through 600 µm sieve. The flour was then packaged in low density dark coloured polythene bags stored in plastic containers with air tight lids at room temperature (30±2°C) until analysis as shown in Figure 3.

2.4. Food Products Formulation by Material Balance (16g Protein/100g)

Proximate composition of non-malted sorghum, malted sorghum, soybean and *Moringa oleifera* seed flours were analyzed (Table 1). The sources of the Minimum Dietary Requirement (MDR) were Protein Advisory Group [11] and [12]. The food products were then formulated by material balance [13] and proximate compositions to obtain 16g protein/100g food formulations. Eight food formulations were obtained using non-malted and malted sorghum and soybean based food formulations by varying the percentages of *Moringa oleifera* seed flour addition (0%, 5%, 10% and 15%) in either the malted or non-malted samples as shown in Table 2.

2.5. Preparation of Gruels

Gruels were prepared from each of the eight food formulations using the method described by Uvere *et al.* (2002). Approximately 10.00 grams of each of the food formulations was dissolved in 100ml of sterile distilled water to give smooth slurry. The slurries were cooked for 10 minutes at 90°C, cooled to 40 - 42°C and analysed.

Table 1. Proximate Compositions of Non-Malted Sorghum, Malted Sorghum, Soybean and *Moringa oleifera* Seed Flours

Proximate Composition (%)	Non-Malted Sorghum Flour	Malted Sorghum Flour	Soybean Flour	*Moringa oleifera* Seed Flour	Minimum Dietary Requirement (MDR)*
Protein	10.45	12.13	35.13	9.87	16 (g)
Fat	3.50	3.12	20.43	39.70	10 (g)
Fibre	3.14	2.34	4.23	18.04	5 (g)
Ash	3.10	2.01	5.21	4.10	10 (g)
Moisture	12.09	12.22	10.22	9.71	5-10 (g)
Carbohydrate	67.72	68.18	24.78	18.58	50 (g)
Energy (Kcal)	344.18	349.32	423.51	471.10	350-400

* PAG – [11]
SON – [12].

Table 2. Food Formulations by Material Balance (16g Protein/100g)

Ingredients	Food Formulations (%)							
	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4
Non-Malted Sorghum (%)	77.51	72.39	67.28	62.16	____	____	____	____
Malted Sorghum (%)	____	____	____	____	83.17	77.68	71.77	66.70
Soybean Flour (%)	22.49	22.61	22.72	22.84	16.83	17.32	18.23	18.30
Moringa oleifera Seed Flour (%)	____	5.00	10.00	15.00	____	5.00	10.00	15.00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

2.6. Physical Determinations

2.6.1. Determination of Bulk Density

The method for the determination of packed bulk density was as described by [15]. A 10ml graduated cylinder was weighed and gently filled with the food sample. The bottom of the cylinder was tapped gently on a laboratory bench several times until there was no further diminution of the sample level. Bulk density was calculated as follows:

$$Bulk\ Density\ (g/ml) = \frac{Weight\ of\ Sample(g)}{Volume\ of\ Sample(ml)}.$$

2.6.2. Determination of Viscosity

Viscosity of the food formulation was determined by the method described by [16]. 3g of each sample was suspended in 30ml of distilled water placed in a beaker, 600ml in volume and 7.5cm in diameter. The suspension was agitated with a mechanically operated stirrer. A 1% sodium hydroxide solution was added. Stirring at 200 revolutions per minute was continued for 3 minutes from the moment the sodium hydroxide was poured in. The mixture was left to stand in a bath at room temperature (30±2°C) for 27 minutes. After this, it was carefully poured into the Engler viscometer and the flow of the solution was started. The sodium hydroxide was allowed to act upon the flour for exactly 30 minutes before the measurement of viscosity was started.

2.6.3. Determination of Swelling Index

The method described by [17] was used to determine the swelling index. 1.0g of sample was put in a test tube and 10ml of distilled water was added. The mixture was heated in a water bath at a temperature of 90°C for 30 minutes with continuous shaking. In the end, the test tube was centrifuged at 1500rpm for 20 minutes in order to facilitate the removal of the supernatant which was carefully decanted and the volume of the supernatant taken. The swelling power was calculated as follows:

$$Swelling\ Index\ (ml/g) = \frac{Waterabsorbed(ml)}{Weightofdrysample(g)}.$$

2.6.4. Determination of Reconstitution Index

The reconstitution index of the samples was determined according to method described by [16].

5g of each sample was dissolved in 50ml of boiling water. The mixture was agitated for 90 seconds and was transferred into a 50ml graduated cylinder and the volume of the sediment was recorded after settling for 30 minutes. The calculation was done as follows:

$$Reconstitution\ Index\ (ml/g) = \frac{Volume\ of\ Sediment}{Weight\ of\ Sample}.$$

2.6.5. Determination of Water Absorption Capacity (WAC)

Water Absorption Capacity (WAC) was determined using the method as described by [16].

1g of each food formulation sample was weighed into a conical graduated centrifuge tube of known weight and mixed with 10ml of distilled water for one minute with a glass rod. The tube was then centrifuged at 5000rpm for 30 minutes. The volume of free water (the supernatant) was discarded and the tube together with its content was reweighed as water absorbed per gram of sample. The volume of water absorbed (total volume – free volume) was multiplied by the density of the sample to convert to grams. Absorption capacity is expressed in grams of water absorbed per gram of sample.

$$Water\ Absorption\ Capacity\ (g/g) = \frac{Density\ of\ water \times volumea\ bsorbed}{weight\ of\ sample}.$$

2.7. Proximate Analysis

Nutrient composition of the food samples was determined in triplicate using the standard procedures of Association of Official Analytical Chemists [18] as follows:

2.7.1. Determination of Moisture Content

Two (2) g of each sample was weighed inside a clean dried crucible (W1) and was dried at 60°C in a hot stimulating oven (Gallenkamp) for 24 hours to a constant weight. It was later cooled in desiccators for 30minutes and weighed (W2). The crucible was washed, dried in the oven and the weight was recorded (W0).

$$Moisture\ content\ (\%) = \frac{W_1 - W_2}{W_1 - W_0} \times \frac{100}{1}$$

Where:
W_1 = Weight of sample + empty crucible
W_0 = weight of empty crucible
W_2 = Weight of dried sample + empty crucible,

2.7.2. Determination of Crude Protein

The crude protein content (N x 6.25) was determined by Kjeldhal method. A quantity of 0.5 g of each sample was added to 10 ml of conc. sulphuric acid and 1 g of the catalyst mixture. It was then heated cautiously on digestion rack under fume hood until a greenish clear solution appeared, cooled and then made up to 50 ml with distilled water. The digested sample was transferred into distillation apparatus and distilled. 10 ml of the distillate was titrated with 0.1M HCL to first pink colour. Temperature of digester was above 420°C for about 30 min.

$$Nitrogen\ (\%) = \frac{Titrate \times 14.01 \times 0.01m \times 100 \times 50}{100 \times 0.5g \times 10}$$

$$\%\ crude\ protein\ =\ N\ x\ 6.25.$$

2.7.3. Determination of Crude Fat

Crude fat was determined by exhaustively extracting each sample in petroleum ether in a soxhlet extractor. The weighed sample (W_0) was poured into a thimble and covered with a clean white cotton wool. Petroleum ether (200 ml) was poured into a 250 ml extraction flask which was previously dried in the oven at 105^{0}C for 30 minutes and weighed (W_2). Extraction was done for 5 hours. It was cooled in desiccators and reweighed (W_1).

$$Crude\ fat(\%) = \frac{W_1 - W_2}{W_0} \times 100$$

Where: W_o= weight of sample (g)
W_1 = Weight of flask + oil (g)
W_2 = Weight of flask (g)

2.7.4. Determination of Ash Content

2 g sample was transferred into a previously heated, cooled and weighed crucible (W_0) and then weighed (w_1). It was placed into a Gallenkamp muffle furnace at 550°C for 3 hours. It was allowed to cool in desiccators and weighed (W_2).

$$\%\ Ash = \frac{W_2 - W_0}{W_1 - W_0} \times \frac{100}{1}.$$

2.7.5. Determination of Crude Fibre

2g of the sample was defatted with petroleum ether, boiled under reflux for 30 minutes with 200 ml of a solution containing 1.25 g of H_2SO_4 per 100 ml of solution. It was then filtered with Whatmann No 1 filter paper, washed with boiled water until the washing was no longer acid. The residue was transferred to a beaker and boiled for 30 minutes with 200ml of a solution containing 1.25g of carbonate free sodium hydroxide per 100ml. It was then filtered and transferred into a crucible. The residue was dried in the oven at 600^0C in a muffle furnace and the dried weight recorded.

$$Crude\ Fibre\ (\%) = \frac{W_1 - W_2}{W_0} \times 100.$$

Where: W_0 = Weight of sample (g)
W_1 = Weight of dried sample (g)
W_2 = Weight of ash sample (g).

2.7.6. Determination of Carbohydrate Content

Carbohydrate content was determined by difference [9]. This was done by subtracting the summed up percentage composition of moisture, ash, fat, protein and fibre contents from 100 g.

$$Carbohydrate\ (\%) = 100\% - \begin{pmatrix} \%moisture + \%\ ash + \%\ fat \\ +\%\ protein + \%\ fibre \end{pmatrix}.$$

2.7.7. Determination of Energy

Energy was determined by using the Atwater's conversion factor where the values of crude protein, fats and carbohydrate were multiplied by 4.0, 9.0 and 4.0 respectively and their products summed up. The result was expressed as kilocalories/100g [19].

2.8. Micronutrients Analysis

2.8.1. Determination of Vitamins

Vitamin A, Thiamine (B_1) Riboflavin (B_2) and Niacin (B_3) were the vitamins analyzed for in the food formulation by the method described by AOAC [18]. This was performed at the optimum separation condition by High Performance Liquid Chromatography (HPLC) with isocratic binary mobile phase consisting of methanol: water (65:35 v/v) with flow rate of 1ml.min^{-1}. The pH was measured using pH meter (metrohm 827 Switzerland) combined with a glass electrode. A 320R Hettich centrifuge (Germany) and a digital 10P ultrasonic bath (Sonorex, Germany) were used. A calibration curve was prepared for each vitamin and the correlation coefficient based on the concentration curve was found.

2.8.2. Determination of Minerals

Calcium (Ca), Phosphorus (P), Iron (Fe), Zinc (Zn), Potassium (K), Sodium (Na) and Magnesium (Mg) were the minerals analyzed for in the food formulations and they were carried out by Atomic Absorption Spectrophotometer as described by [18]. The ash was isolated by heating in the oven at a temperature of 550°C for 6 hours. The resultant ash was then used for determination of the individual minerals. 1.0g of the sample was digested with 20ml of acid mixture (650ml conc. HNO_3, 80ml perchloric, acid, 20ml H_2SO_4) and aliquots of the diluted clear digest were used for atomic absorption spectrophotometry, using filters that matched the different minerals.

2.8.3. pH Determination

Hydrogen ion concentration (pH) was determined by the method described by [18]. 5 grams of each sample was weighed into a beaker and 50 ml of distilled water was added and it was allowed to stand for 30 minutes in a water bath at 40°C. It was filtered and the pH determined by pH meter.

2.8.4. Determination of Peroxide Value (PV)

This was determined by the method of [18]. 1.0g of each sample was weighed into a clean and dry boiling tube. Potassium iodine (1.0g) and 2ml of glacial acetic acid + chloroform (2:1:v.v) were added, followed by heating in boiling water for 30 seconds. The mixture was quickly transferred into a flask containing 20ml of 5% (w:v) potassium iodide solution. The tube was rinsed twice into a flask containing 25ml distilled water and the extract added to the flask. The resultant solution was titrated against 0.002M sodium thiosulphate solution using 5% starch as indicator. A blank consisting of distilled water in place of extract was used. Peroxide value (PV) was calculated by multiplying the volume (ml) of 0.002m sodium thiosulphate by 2-0 and expressing the result as milli-equivalent of peroxide/kg sample (meq/kg).

2.8.5. Determination of Total Volatile Bases

The total volatile bases, expressed as nitrogen content was estimated according to the method of [18]. Each of the samples (5.0g) was mixed thoroughly with 50ml of distilled water and quantitatively transferred into a distilling flask with 50ml of distilled water. Magnesium oxide (1.0g) and a few anti-bumping glass beads were added. Thereafter, 20ml of boric acid and a few drops of methyl red indicator were added to the recovering flask. The apparatus was connected to ensure that the receiver tube was below the surface of the boric acid solution. The distillation flask was heated so that the liquid boiled for

10minutes and distilled for exactly 25 minutes at the same rate of heating. The condenser was washed with distilled water and the distillate titrated against 0.1M H_2SO_4.

$$TVB\ (mgN/kg) = \frac{(mlacid - mlblank) \times M \times 14 \times 100}{gsample}$$

Where M = normality of acid used
14 = constant
100 = conversion factor to %.

2.9. Sensory Evaluation

Sensory evaluation of gruels produced from the eight food formulations was performed by descriptive analysis and affective testing [9]. Twenty ladies mainly mothers were used for the assessment. A 9 – point hedonic scale (1-dislike extremely, 9-like extremely) was used to rate the sensory attributes of appearance, taste, aroma, and overall acceptability of the products. Each attribute was evaluated separately on a daily basis in the morning. On each day, each panelist judged eight samples which were presented randomly with fresh tap water used for mouth rinsing in between evaluations. The gruel was stored in food flasks from where they were served to the panelists using coded transparent plastic cups and colourless transparent spoons.

2.10. Statistical Analysis

All results were subjected to Analysis of Variance (ANOVA) using a pre-packaged Computer Statistical Software (SPSS version 20). LSD was used to separate the means at 5% probability level [9].

3. Results

3.1. Physical Properties

Table 3 shows the results of the physical properties of both the non-malted and malted sorghum and soybean based food formulations.

3.1.1. Bulk Density

The results of bulk density ranged from 1.11-1.54g/ml in non-malted sorghum and soybean based food formulations and from 1.13-1.27 in malted sorghum and soybean based food formulations. The values of bulk density in malted food formulations were significantly (P< 0.05) lower than the values in the non-malted food formulations. The more the addition of *Moringa oleifera* seed flour, the less was the value of bulk density.

3.1.2. Viscosity

Viscosity ranged from 193-474cP in non-malted food formulations and 122-156cP in malted food formulations. The more the addition of *Moringa oleifera* seed flour, the less was the viscosity in both groups. The malted food formulations significantly (P< 0.05) had lower values of viscosity than the non-malted food formulations.

3.1.3. Swelling Index

The results of swelling index ranged from 6.39-6.84ml/g in non-malted sorghum and soybean based food formulations and 6.22-6.80ml/g in malted sorghum and soybean based food formulations. The malted food formulations had significantly (P< 0.05) less swelling index than the non-malted food formulations. The more the addition of *Moringa oleifera* seed flour, the more was the swelling index in both non-malted and malted sorghum and soybean based food formulations.

3.1.4. Reconstitution Index

The values of reconstitution index ranged from 2.80-4.00ml/g in non-malted sorghum and soybean based food formulations and 4.20 – 5.20ml/g in malted sorghum and soybean based food formulations. The results also showed that the malted food formulations had significant (P< 0.05) increase of reconstitution index than the non-malted food formulations. Reconstitution index also increased with increased addition of *Moringa oleifera* seed flour in both the non-malted and malted sorghum and soybean based food formulations.

Table 3. Effect of *Moringa oleifera* Addition on Physical Properties of Non-Malted and Malted Sorghum and Soybean Based Food Formulations

		Food Formulations				
Parameters	**Non-Malted Sorghum (%)**	**77.51**	**72.39**	**67.28**	**62.16**	**LSD**
	Soybean (%)	**22.49**	**22.61**	**22.72**	**22.84**	
	***Moringa oleifera* Seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	
Bulk Density (g/ml)		474.00^{a}±2.00	245.00^{b}±1.00	239.00^{c}±1.00	193.50^{d}±0.10	2.31
Viscosity (cP)		1.54^{a}±0.01	1.27^{b}±0.01	1.21^{c}±0.01	1.11^{d}±0.01	0.01
Swelling Index (ml/g)		6.39^{d}±0.01	6.67^{c}±0.01	6.75^{b}±0.03	6.84^{a}±0.01	0.01
Reconstitution Index (ml/g)		2.80^{d}±0.10	3.40^{c}±0.10	3.60^{b}±0.10	4.00^{a}±0.10	0.19
Water Absorption Capacity (g/g)		1.16^{d}±0.02	1.34^{c}±0.01	1.52^{b}±0.02	1.54^{a}±0.02	0.02
	Malted Sorghum (%)	**83.17**	**77.68**	**71.77**	**66.70**	
	Soybean (%)	**16.83**	**17.32**	**18.23**	**18.30**	**LSD**
	***Moringa oleifera* Seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	
Bulk Density (g/ml)		156.00^{a}±1.00	154.00^{a}±1.00	132.00^{b}±1.00	122.^{c}00±2.00	2.50
Viscosity (cP)		1.27^{a}±0.01	1.24^{b}±0.01	1.22^{c}±0.01	1.13^{d}±0.01	0.01
Swelling Index (ml/g)		6.22^{b}±0.04	6.56^{a}±0.01	6.69^{a}±0.01	6.80^{a}±0.02	0.60
Reconstitution Index (ml/g)		4.20^{d}±0.20	4.50^{c}±0.10	5.00^{b}±0.02	5.20^{a}±0.20	0.29
Water Absorption Capacity (g/g)		1.64^{d}±0.01	1.76^{c}±0.01	1.84^{b}±0.01	1.88^{a}±0.01	0.02

Values are means ± standard deviations of triplicate determinations
Means with the same superscripts within the same row are not significantly different (p> 0.05).

3.1.5. Water Absorption Capacity (WAC)

The results of Water Absorption Capacity ranged from 1.16-1.54ml/g in non-malted sorghum and soybean based food formulations and 1.64-1.88ml/g in malted sorghum and soybean based food formulations. The water absorption capacities in malted food formulations were significantly (P< 0.05) higher than those in non-malted food formulations. Addition of *Moringa oleifera* seed flour also increased the water absorption capacities of the two groups of food formulations.

3.2. Chemical Properties

3.2.1. Proximate Composition

Table 4 shows the effect of *Moringa oleifera* seed flour addition on proximate compositions of the food formulations.

3.2.1.1. Moisture Content

Moisture Content ranged from 7.78 – 8.65% in non-malted sorghum and soybean based food formulations and it ranged from 7.55-7.96 in malted sorghum and soybean based food formulations. There was significant (P < 0.05) reduction of moisture content in malted food formulations more than that of non- malted food formulations. The more the addition of *Moringa oleifera* seed flour, the less was also the moisture content.

3.2.1.2. The Ash Content

The Ash Content in non-malted sorghum and soybean based food formulations ranged from 1.82-2.05% and from 3.25-4.45% in malted sorghum and soybean based food formulations. The malted food formulations significantly (P < 0.05) had more ash content than the non-malted food formulations. The more the addition of *Moringa oleifera* seed flour, the more was the ash content.

3.2.1.3. Crude Fat Content

Crude Fat Content ranged from 6.26-9.00% in the non-malted sorghum and soybean based food formulations and from 6.00-7.86% in the malted sorghum and soybean based food formulations. The values of crude fat in malted sorghum food formulations were significantly (P< 0.05) lower than those in non-malted sorghum food formulations. The more the addition of *Moringa oleifera* seed flour, the more was the fat content.

3.2.1.4. The Crude Protein Content

The Crude Protein Content of the non-malted sorghum and soybean based food formulations ranged from 16.20-16.28% and those of the malted sorghum and soybean based food formulations ranged from 16.54 -16.64%. The malted sorghum and soybean based food formulations had significantly (P<0.05) higher protein content than those of non-malted sorghum and soybean based food formulations.

3.2.1.5. The Crude Fibre Content

The Crude Fibre Content ranged from 1.38-2.49% in non-malted sorghum and soybean based food formulations and 1.32-1.89 in malted sorghum and soybean based food formulations. The malted sorghum and soybean based food formulations had significantly (P< 0.05) less fibre than the non-malted food formulations. The more *Moringa oleifera* seed flour was added the more was the crude fibre content.

3.2.1.6. Carbohydrate Content

Carbohydrate Content ranged from 62.48-65.61% in non-malted sorghum and soybean based food formulations and 61.71 – 64.83% in malted sorghum and soybean based food formulations. The malted food samples had significantly (P< 0.05) less carbohydrate. The more *Moringa oleifera* seed flour was added, the less was the carbohydrate content.

Table 4. Effect of *Moringa oleifera* Seed Addition on Proximate Compositions of Non-Malted and Malted Sorghum and Soybean Based Food Formulations

Nutrients (%)		**Food Formulations**				
	Non-Malted Sorghum (%)	**77.51**	**72.39**	**67.28**	**62.16**	**LSD**
	Soybean (%)	**22.49**	**22.61**	**22.72**	**22.84**	
	***Moringa oleifera* seed (%)**	**0.0 0**	**5.00**	**10.00**	**15.00**	
Moisture content		$8.65^{a} \pm 0.01$	$8.53^{b} \pm 0.01$	$8.28^{c} \pm 0.01$	$7.78^{d} \pm 0.01$	0.01
Crude protein		$16.28^{a} \pm 0.01$	$16.26^{b} \pm 0.01$	$16.24^{b} \pm 0.01$	$16.20^{c} \pm 0.01$	0.02
Crude fat		$6.26^{d} \pm 0.01$	$8.00^{c} \pm 0.02$	$8.42^{b} \pm 0.01$	$9.00^{a} \pm 0.02$	0.01
Ash content		$1.82^{c} \pm 0.01$	$1.90^{b} \pm 0.03$	$2.00^{ab} \pm 0.10$	$2.05^{a} \pm 0.02$	0.10
Crude fibre		$1.38^{d} \pm 0.01$	$1.67^{c} \pm 0.01$	$2.18^{b} \pm 0.01$	$2.49^{a} \pm 0.01$	0.01
Carbohydrate		$65.61^{a} \pm 0.02$	$63.64^{b} \pm 0.01$	$62.88^{c} \pm 0.03$	$62.48^{d} \pm 0.01$	0.04
Energy (Kcal/100g)		383.90	391.60	392.26	395.74	
	Malted sorghum (%)	**83.17**	**77.68**	**71.77**	**66.70**	
	Soybean (%)	**16.83**	**17.32**	**18.23**	**18.30**	**LSD**
	***Moringa oleifera* seed (%)**	**0.00**	**5.0 0**	**10.00**	**15.00**	
Moisture		$7.96^{a} \pm 0.01$	$7.75^{b} \pm 0.01$	$7.66^{c} \pm 0.01$	$7.55^{d} \pm 0.01$	0.01
Crude protein		$16.64^{a} \pm 0.02$	$16.60^{b} \pm 0.01$	$16.58^{b} \pm 0.02$	$16.54^{c} \pm 0.01$	0.03
Crude fat		$6.00^{d} \pm 0.02$	$6.84^{c} \pm 0.04$	$7.42^{b} \pm 0.01$	$7.86^{a} \pm 0.01$	0.06
Ash content		$3.25^{d} \pm 0.02$	$4.26^{c} \pm 0.01$	$4.33^{b} \pm 0.01$	$4.45^{a} \pm 0.01$	0.01
Crude fibre		$1.32^{d} \pm 0.01$	$1.47^{c} \pm 0.01$	$1.68^{b} \pm 0.01$	$1.89^{a} \pm 0.01$	0.01
Carbohydrate		$64.83^{a} \pm 0.03$	$63.18^{b} \pm 0.06$	$62.51^{c} \pm 0.01$	$61.71^{d} \pm 0.02$	0.06
Energy (Kcal/100g)		379.90	380.68	381.52	383.74	

Values are means ± standard deviations of triplicate determinations
Means with the same superscripts within the same row are not significantly different (p<0.05).

3.2.1.7. The Energy Content

The Energy Content in non-malted sorghum and soybean based food formulations ranged from 383.90-395.74Kcal and 379.90-383.74Kcal in malted sorghum and soybean based samples. The more *Moringa oleifera* seed flour was added, the more was the energy content.

3.3. Micronutrient Content

3.3.1. Vitamin Content

Table 5 shows the results of the vitamin content in the food formulations. The malted sorghum and soybean based food formulations increased significantly (P<0.05) in vitamins than the non-malted sorghum and soybean based food formulations. It was found that the more the addition of *Moringa oleifera* seed flour, the more was the vitamin content in both groups. Vitamin A, thiamine (B_1), riboflavin (B_2) and Niacin (B_3) were the vitamins analyzed.

3.3.2. Mineral Content

Table 6 shows the mineral content of the food formulations. Phosphorus (P), Calcium (Ca), Iron (Fe), Zinc (Zn), Magnesium (Mg), Sodium (Na) and Potassium (K) were the minerals determined in the analysis. All minerals increased significantly (P<0.05) with the addition of *Moringa oleifera* seed flour except calcium. The values of the minerals in malted sorghum and soybean based food formulations were significantly (P<0.05) higher than those of the non-malted sorghum and soybean based formulations.

Table 5. Effect of *Moringa oleifera* Seed Addition on Vitamin Content of Non-malted and Malted Sorghum and Soybean Based Food Formulations

		Food formulations				
Vitamin Content	**Non-malted sorghum (%)**	**77.51**	**72.39**	**67.28**	**62.16**	
	Soybean (%)	**22.49**	**22.61**	**22.72**	**22.84**	
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
Vitamin A (µg/100g)		0.28^{d} ±0.01	0.30^{c} ±0.01	0.54^{b} ±0.01	0.76^{a} ±0.01	0.02
Thiamine (mg/100g)		0.17^{c} ±0.01	0.18^{bc} ±0.01	0.19^{b} ±0.01	0.21^{a} ±0.01	0.02
Riboflavin (mg/100g)		0.17^{c} ±0.59	0.18^{bc} ±0.02	0.19^{b} ±0.02	0.21^{a} ±0.02	0.56
Niacin (mg/100g)		1228^{d} ±1.00	1476^{c} ±1.00	1488^{b} ±1.00	1536^{a} ±1.00	1.89
	Malted sorghum (%)	**83.17**	**77.68**	**71.77**	**66.70**	
	Soybean (%)	**16.83**	**17.32**	**18.23**	**18.30**	**LSD**
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	
Vitamin A (µg/100g)		1.06^{d} ±0.01	1.47^{c} ±0.01	1.65^{b} ±0.01	1.80^{a} ±0.01	0.02
Thiamine (mg/100g)		0.20^{c} ±0.01	0.21^{c} ±0.01	0.27^{b} ±0.01	0.33^{a} ±0.01	0.01
Riboflavin (mg/100g)		0.20^{c} ±0.02	0.21^{c} ±0.02	0.27^{b} ±0.02	0.33^{a} ±0.02	0.04
Niacin (mg/100g)		1474^{d} ±2.00	1724^{c} ±1.00	1968^{b} ±2.00	2216^{a} ±1.00	2.98

Values are means ± standard deviations of triplicate determinations
Means with the same superscripts within the same row are not significantly different (p<0.05).

Table 6. Effect of *Moringa oleifera* Seed Addition on Mineral Content of Non-Malted and Malted Sorghum and Soybean Based Food Formulations

		Food formulations				
Mineral Content (mg/100g)	**Non-malted sorghum (%)**	**77.51**	**72.39**	**67.28**	**62.16**	
	Soybean (%)	**22.49**	**22.61**	**22.72**	**22.84**	
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
Phosphorus		120.70^{d} ±0.02	126.80^{c} ±0.02	143.70^{b} ±0.02	144.04^{a} ±0.01	0.02
Calcium		17.33^{a} ±0.02	16.45^{b} ±0.02	16.27^{c} ±0.01	16.17^{d} ±0.01	0.03
Iron		1.08^{d} ±0.01	1.28^{c} ±0.02	1.32^{b} ±0.02	1.48^{a} ±0.02	0.03
Zinc		1.68^{d} ±0.02	1.73^{c} ±0.02	1.80^{b} ±0.01	1.83^{a} ±0.03	0.04
Magnesium		5.15^{d} ±0.02	5.28^{c} ±0.02	5.33^{b} ±0.03	5.53^{a} ±0.01	0.04
Sodium		0.11^{d} ±0.01	0.14^{c} ±0.01	0.16^{b} ±0.02	0.17^{a} ±0.01	0.02
Potassium		0.17^{d} ±0.01	0.22^{c} ±0.01	0.27^{b} ±0.01	0.30^{a} ±0.01	0.01
	Malted sorghum (%)	**83.17**	**77.68**	**71.77**	**66.70**	
	Soybean (%)	**16.83**	**17.32**	**18.23**	**18.30**	
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
Phosphorus		159.30^{d} ±0.01	176.50^{c} ±0.01	180.65^{b} ±0.02	182.00^{a} ±1.00	0.94
Calcium		21.84^{a} ±0.02	19.1^{b}1±0.03	19.02^{c} ±0.01	17.38^{d} ±0.01	0.04
Iron		2.74^{d} ±0.01	3.07^{c} ±0.02	4.59^{b} ±0.03	6.14^{a} ±0.01	0.04
Zinc		2.02^{d} ±0.01	2.49^{c} ±0.01	3.20^{b} ±0.02	3.76^{a} ±0.03	0.04
Magnesium		5.94^{c} ±0.03	6.53^{d} ±0.01	6.71^{b} ±0.02	6.95^{a} ±0.17	0.16
Sodium		0.13^{d} ±0.01	0.15^{c} ±0.01	0.17^{b} ±0.01	0.18±^{a} 0.01	0.02
Potassium		0.21^{d} ±0.01	0.23^{c} ±0.01	0.28^{b} ±0.01	0.32^{a} ±0.01	0.01

Values are means ± standard deviations of triplicate determinations
Means with the same superscript letters within the same row are not significantly different (p>0.05).

3.3.3. pH

The pH values of the non-malted sorghum and soybean based samples ranged from 6.5-6.9.Those of the malted sorghum and soybean based food formulations ranged from 6.2-6.5.Malting significantly (P<0.05) reduced the pH values and the more *Moringa oleifera* seed flour was added, the less was the pH value.

3.3.4. Peroxide Value

The results of the Peroxide Value (PV) ranged from 1.931 – 8.819 and 1.895 – 6.674 in non-malted and malted food formulations respectively. The addition of *Moringa oleifera* seed flour significantly (P<0.05) reduced Peroxide Values in the food formulations. Malting also significantly (P<0.05) reduced Peroxide Values.

3.3.5. Total Volatile Bases

The results of the Total Volatile Bases (TVB) in non-malted food formulations ranged from 10.226-12.134 and 10.213 – 11.283 in malted food formulations. The malted food formulations had significantly (P<0.05) less Total Volatile Bases than the non-malted food formulations. The addition of *Moringa oleifera* seed flour also reduced the values.

Table 7 presents the pH, Peroxide Value and the Total Volatile Bases for the food formulations.

3.3.6. Sensory Attributes

Table 8 and Table 9 show the sensory attributes of gruels of non-malted and malted sorghum and soybean based food formulations respectively. The values for appearance ranged from 7.30-8.35 in non-malted food formulations and 7.70-8.35 in malted food formulations on a 9-point rating scale. The attribute of aroma ranged from 7.20-8.30 in non-malted food samples and 7.55-8.20 in malted food samples. Taste ranged from 6.85-8.00 in non-malted food formulations and 7.50-8.15 in malted food formulations. The scores for overall acceptability ranged from 7.45-8.10 in non-malted food formulations and 7.35-8.60 in malted food formulations. The scores for all the sensory attributes were significantly (P<0.05) higher in malted sorghum and soybean based food formulations than in non-malted food samples except the food sample that had the highest addition of *Moringa oleifera* seed flour (15%). The malted food formulation with 10% *Moringa oleifera* seed flour addition had the highest scores in all the sensory attributes.

Table 7. Effect of *Moringa oleifera* Seed Flour Addition on the pH, Peroxide Value and Total Volatile Bases of Non-Malted and Malted Sorghum and Soybean Based Food Formulations

pH, PV and TVB	Food formulations					
	Non-malted sorghum (%)	**77.51**	**72.39**	**67.28**	**62.16**	
	Soybean (%)	**22.49**	**22.61**	**22.72**	**22.84**	
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
pH		6.96^{a} ±0.01	6.86^{b} ±0.01	6.78^{c} ±0.01	6.56^{d} ±0.01	0.01
PV(Meq/Kg)		8.82^{a} ±0.01	6.69^{b} ±0.01	3.58^{c} ±0.01	1.93^{d} ±0.01	0.01
TVB (mgN/100g)		12.13^{a} ±0.01	10.87^{b} ±0.01	10.47^{c} ±0.01	10.23^{d} ±0.01	0.01
	Malted sorghum (%)	**83.17**	**77.68**	**71.77**	**66.70**	
	Soybean (%)	**16.83**	**17.32**	**18.23**	**18.30**	
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
pH		6.70^{a} ±0.06	6.45^{b} ±0.10	6.40^{b} ±0.15	6.35^{b} ±0.10	0.20
PV (Meq/Kg)		6.67^{a} ±0.01	6.09^{b} ±0.01	3.38^{c} ±0.01	1.90^{d} ±0.01	0.01
TVB (mgN/100g)		11.28^{a} ±0.01	10.37^{b} ±0.01	10.23^{c} ±0.01	10.21^{d} ±0.01	0.01

Values are means ± standard deviations of triplicate determinations
Means with the same superscripts within the same row are not significantly different (p<0.05)
KEY:
pH = Hydrogen ion
PV=Peroxide Value.
TVB= Total Volatile Bases.

Table 8. Effect of *Moringa oleifera* Seed Flour Addition on Sensory Attributes of Gruels of Non-Malted sorghum and Soybean Based Food Formulations

Sensory Attribute	**Food formulations**					
	Non-malted sorghum (%)	**77.51**	**72.39**	**67.28**	**62.16**	
	Soybean (%)	**22.49**	**22.61**	**22.72**	**22.84**	
	***Moringa oleifera* seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
Appearance		7.30^{b} ±0.92	7.70^{b} ±0.98	$8.20a^{b}$ ±1.06	8.35^{a} ±0.67	0.58
Aroma		7.20^{c} ±1.40	7.55^{bc} ±1.15	8.00^{ab} ±1.45	8.30^{a} ±0.98	0.79
Taste		6.85^{b} ±1.42	7.55^{ab} ±1.40	7.65^{a} ±1.04	8.00^{a} ±1.08	0.79
Overall acceptability		7.45^{b} ±1.36	8.05^{ab} ±1.10	8.05^{ab} ±0.69	8.10^{a} ±0.85	0.65

Values are means ± standard deviations of triplicate determinations

- On a scale with 9 = like extremely, 8 = like very much, 7=like moderately, 6= like slightly, 5=Neither like, 4 = dislike slightly, 3=dislike moderately, 2=dislike very much and 1= dislike extremely.
- Values with common superscript letters are not significantly different (P>0.05) within each row for a given attribute.

Table 9. Effect of *Moringa oleifera* Seed Flour Addition on Sensory Attributes of Gruels of Malted Sorghum and Soybean Based Food Formulations

Sensory Attribute	Food Formulations					
	Malted Sorghum (%)	**83.17**	**77.68**	**71.77**	**66.70**	
	Soybean (%)	**16.83**	**17.32**	**18.23**	**18.30**	
	***Moringa oleifera* Seed (%)**	**0.00**	**5.00**	**10.00**	**15.00**	**LSD**
Appearance		8.20^{a} ±1.06	8.00^{ab} ±0.86	8.35^{a} ±0.93	7.70^{b} ±0.98	0.60
Aroma		8.05^{a} ±1.15	7.80^{ab} ±0.83	8.20^{a} ±0.77	7.55^{b} ±1.23	0.64
Taste		8.15^{a} ±1.09	7.95^{a} ±0.76	8.10^{a} ±0.91	7.50^{a} ±1.54	0.70
Overall acceptability		8.25^{a} ±0.64	8.10^{a} ±0.64	8.60^{a} ±0.68	7.35^{b} ±1.35	0.55

Values are means ± standard deviations of triplicate determinations

- On a scale with 9 = like extremely, 8 = like very much, 7=like moderately, 6= like slightly, 5=Neither like, 4 = dislike slightly, 3=dislike moderately, 2=dislike very much and 1= dislike extremely.
- Values with common superscript letters are not significantly different (P>0.05) within each row for a given attribute.

4. Discussion

4.1. Physical Properties

4.1.1. Bulk Density

There was significant (P< 0.05) reduction in bulk density of malted food formulations and with addition of *Moringa oleifera* seed flour. This agreed with the finding of [15]. This could be because malting tends to soften the seeds, thus making the seeds to be milled into smaller particle size than the non-malted grain and hence the reduction in bulk density. The significance of this is that the less bulky flour has higher nutrient density, since more flour can be packaged in the same given volume [21].

4.1.2. Viscosity

Viscosity was significantly (P< 0.05) lower in malted food formulations than in non-malted food formulations. The addition of *Moringa oleifera* also reduced the viscosity. The more the addition of *Moringa oleifera*, the less was the viscosity. This reduction could be due to breakdown of macromolecules such as polysaccharides and polypeptides to smaller units such as sugars and amino acids respectively by the enzymes mobilized during germination [22]. Reduction in viscosity helps in the utilization of the food nutrients as malting permits the addition of higher quantities of food solids to the gruels in comparison with the non-malted food product [7].

4.1.3. Swelling Index

There was significant (P< 0.05) reduction in swelling index of the food formulations with malting but there was increase with the addition of *Moringa oleifera*. However, the general values were still lower than the non-malted food formulations. Increase with addition of *Moringa oleifera* might be as a result of *Moringa oleifera* containing more fibre than sorghum and soybean. The malted flour whose starch was already dextrinised could not swell as much as the non-malted food formulations (Uvere et al., 2002). The higher swelling index of the non-malted samples and also with addition of *Moringa* oleifera seed flour was as a result of starch and fibre [23].

4.1.4. Reconstitution Index

Reconstitution index significantly (P< 0.05) increased in malted food formulations and also increased with the addition of *Moringa oleifera* seed flour. This was because the malted food formulations which had higher water absorption capacity were easier to reconstitute in water when needed. Malted food materials often have modified functional properties. Modifications in protein structure of cereals during germination process have been reported to be largely responsible for functional changes such as water absorption, foaming and so on while viscosity, swelling index are starch related [22].

4.1.5. Water Absorption Capacity (WAC)

The result showed significant (P< 0.05) increase in water absorption capacity in malted food formulations and the addition of *Moringa oleifera* seed flour also increased the water absorption capacity within the food samples. This increased water absorption capacity could be as a result of increase in amount of soluble sugars present in the malted flour as a result of germination. This means that the malted formulations which had better water absorption capacity were easier to reconstitute in water when needed [7].

4.2. Chemical Properties

4.2.1. Proximate Composition

It was detected that the malted samples had significantly (P< 0.05) less percentage moisture content than the non-malted samples and the more addition of *Moringa oleifera* seed flour to the food sample, the less was the moisture content. This could be as a result of the processing technique which was malting. This agreed with the findings of [24]. *Moringa oleifera* seed flour also contains less moisture content than sorghum and soybean (Table 4). The lower moisture content observed in this study is an indication that the activity of the microorganism would be reduced and thereby increased the shelf life of the flour samples. This observation is in agreement with the report of [25]. The moisture content of the complementary food formulations is within FAO/WHO recommended safe limit (<10%) as higher moisture may affect the storage quality of the food. The ash content increased significantly with malting and addition of *Moringa oleifera* seed flour. This could be as a result of increased minerals in malted food samples as of similar observation by [7].

The crude fat significantly (P< 0.05) reduced with malting but increased significantly (P<0.05) with addition of *Moringa oleifera* seed flour. This could be as a result of de-hulling and soaking before germination which must have removed the aleurone layer of the seed that contains fat. Moreover, some of the fats would have been used up during germination. However the more *Moringa oleifera* seed flour was added, the more was the value of fat since *Moringa oleifera* seed contains more fat than sorghum and soybean. The decrease in fat content among the malted food formulations could be attributed to the increased activities of lipolytic enzymes during germination which hydrolysed fat component into fatty acids and glycerol. This might be of advantage during storage of flour samples. Similar observation was made by [26]. These authors reported that low levels of fat increased the shelf life of a product, since oxidative rancidity would be prevented.

Crude protein significantly (P< 0.05) increased with malting and also with the addition of *Moringa oleifera* seed flour. This result was similar to the findings of [6] and [24]. The increased protein value of malted food formulations could be attributed to the biochemical activities of the germinating seeds. Scientific studies have also reported that carbohydrates are mobilized to synthesize amino acids for the growing seedling during germination [27,28,29].

Crude fibre significantly (P< 0.05) increased with more addition of *Moringa oleifera* seed flour but significantly (P< 0.05) decreased with malting among samples. Soaking, de-hulling and germination led to the decrease in fibre content of the malted food formulations [7]. There was increase with more additions of *Moringa oleifera* seed flour because the seed contains more fibre than sorghum and soybean. Dietary fibre is necessary for health. Fibre is necessary for elimination of waste products which helps to prevent cancer, diabetes, hypertension, and so on. It is however not needed in much amount for complementary food as infants may not be able to digest too much fibre. Not more than 5% fibre is recommended by [12]. Results gotten were not up to 5% in all the food formulations.

Carbohydrate reduced significantly (P< 0.05) with malting and with addition of *Moringa oleifera* seed flour among food formulations. The decrease might be attributed to increase in alpha-amylase activity which breaks down complex carbohydrate into simpler and more absorbable sugars which are utilized by the growing seedlings during germination. This observation agreed with the findings of [29] and [24]. *Moringa oleifera* seed flour also contains less carbohydrate than sorghum and soybean.

The energy content significantly (P< 0.05) reduced in malted food formulations but increased a bit with addition of *Moringa oleifera* seed flour because *Moringa oleifera* had higher energy value than sorghum and soybean (Table 4). This decrease in food energy among the malted food formulations might be attributed to the decrease in fat content of the malted food formulations. This observation also agreed with the findings of [29] and [24]. The energy levels were however still within the recommended levels (350-400Kcal) for complementary foods by [12] and [11].

4.3. Micronutrients

4.3.1. Vitamins

The result shows that the addition of *Moringa oleifera* significantly (P<0.05) increased the values of vitamin A, vitamin B, vitamin B_2 and Niacin. The malted food formulations significantly had (P<0.05) higher values of the vitamins than the non-malted food formulations. This observation agreed with the findings of [7] which detected higher values of vitamins in malted flour. Vitamins are very important for fighting against diseases in the body. *Moringa oleifera* is well known for its medicinal purposes [30].

4.3.2. Minerals

The addition of *Moringa oleifera* significantly (P<0.05) increased phosphorus (P), iron (Fe), zinc (Zn), magnesium (Mg), sodium (Na) and potassium (K) in the food formulations except calcium that was still within the accepted value. Malted food formulations also significantly (P<0.05) had higher minerals than the non-malted food formulations except calcium. This result however agreed with [24] who found out higher increases of iron, sodium, potassium, magnesium and copper in malted *Moringa oleifera* seed flour. [31] also reported increase in phosphorus and iron with germination. All these minerals are needed for the osmotic regulation of the body processes.

4.3.4. pH, Peroxide value and Volatile Bases

Table 7 shows the effect of *Moringa oleifera* addition on the pH, Peroxide Value and Total Volatile Bases of non-malted and malted sorghum and soybean based food formulations.

The values of pH, peroxide value and total volatile bases significantly (P<0.05) reduced in malted food formulations as compared to non-malted food formulations. It also shows that the more addition of *Moringa oleifera*, the less was the values of these parameters. All the values were within the recommended values for example acceptable peroxide value is between 10 – 30 Meq, but produces rancidity or rancid odour from 30 – 40 Meq. The good news is that *Moringa oleifera* is an antioxidant, inhibiting and scavenging free radicals, thus providing protection to humans against infections and degenerative diseases. *Moringa oleifera* is used in Indian traditional medicine for a wide range of various ailments [32].

4.4. Sensory Attributes

Table 8 and Table 9 show the effect of *Moringa oleifera* seed addition on the sensory attributes of gruels of non-malted sorghum and soybean based food formulations. The sensory attributes of appearance, aroma, taste and overall acceptability were significantly (P<0.05) higher in malted food formulations than in non-malted food formulations except for the food formulations that had the highest addition of *Moringa oleifera* seed (15%). The malted food formulation with ten percent (10%) addition of *Moringa oleifera* was rated highest in all the attributes.

It also had the highest overall acceptability. It therefore meant that the malted food formulation with addition of ten percent (10%) *Moringa oleifera* was most acceptable to the panelists.

5. Conclusion

This study showed that production of complementary food from cheap raw materials (sorghum, soybean and *Moringa oleifera* seed flours) using simple malting technology to meet the nutritional needs of infants and children (0 -2years) is possible and should be encouraged.

Malting and addition of *Moringa oleifera* seed flour significantly (P< 0.05) improved the proximate compositions of the food formulations over those of the non-malted food formulations. Essential amino acids and micronutrients (vitamins and minerals) of the food formulations also increased significantly (P<0.05) through malting and addition of *Moringa oleifera* seed flour.

Malting and addition of *Moringa oleifera* significantly (P<0.05) reduced the pH, Peroxide Value (PV) and Total Volatile Base (TVB). These are indices of flour spoilage due to peroxide oxidation.

Malting and addition of *Moringa oleifera* seed flour significantly (P< 0.05) reduced viscosity, bulk density and swelling index of the food formulations thereby leading to improved nutrient density and water absorption capacity and reconstitution index were significantly (P< 0.05) increased which helped in easy preparation of the slurries.

Malting and addition of *Moringa oleifera* seed flour significantly (P< 0.05) improved the sensory attributes of the food formulations except the malted food formulation with highest addition of *Moringa oleifera* seed flour (15%). The food formulation with 10% *Moringa oleifera* seed flour addition was rated highest by the Panelists. A number of organoleptic features such as flavour, taste, aroma, texture and appearance may affect infant's intake of foods.

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