Vol. 12(12) pp. 353-359, December 2018
DOI: 10.5897/AJFS2018.1691
Article Number: BB3DF0659169
ISSN: 1996-0794

http://www.academicjournals.org/AJFS

ACADEMIC JOURNALS
expand your knowledge

African Journal of Food Science

Full Length Research Paper

Effect of pretreatments on the microbial and sensory quality of weaning food produced from blends of sorghum and soybean

Msheliza E. A.[1*], Ilesanmi J. O. Y. [2], Hussein J. B.[2] and Nkama I.[3]

[1]Department of Home Economics Education, Federal College of Education (Technical), Gombe, Gombe State, 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.

Received 19 January, 2018; Accepted 3 July, 2018

This study investigated the effect of pre-treatment on the microbial and sensory quality 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 separately 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 untreated sorghum : soybean. The microbial and sensory qualities of the samples were determined. The result of the microbial analysis of the formulated weaning food blends showed that all samples indicated a safety for consumption. The appearance of both treated and untreated were not significantly different ($p<0.05$) while the means scores of the blends in texture, taste, aroma and overall acceptability were significantly different ($p<0.05$). Fermentation and roasting used in this study showed that the processing methods had marked effect on the microbial and sensory quality of the weaning foods produced, thus, its recommendation for domestic processing of weaning foods.

Key words: Pretreatments, weaning food, sorghum, soybean, microbial and sensory qualities.

INTRODUCTION

Weaning is the gradual introduction of foods other than breast milk into a baby's diet from the age of six months. 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

*Corresponding author. E-mail: esthermusadurkwa@gmail.com. Tel: +2348163917067.

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 (Asma et al., 2006; Eshun et al., 2011).

Local foods and fortifying ingredients such as maize, millet, sorghum, soybean and cowpea have been utilized creatively with acceptability in mind (Mosha and Vicent, 2004; Mugula and Lyimo, 2000). In Nigeria, traditional weaning food consist of monocereal grains prepared from either millet, sorghum and maize is referred to as “Ogi” or “Akamu” which is of poor nutritional value (Abdulkadir and Danjuma, 2015; Rombouts and Nouts, 1995). Cereals are the most important staple food being the major sources of carbohydrates. Compositionally cereals consist of 12 to 14% water, 65 to 75% carbohydrates; 2 to 6%, lipids and 7 to 12% protein on dry weight basis. In their natural form, whole grain cereals are also significant contributor of vitamins, minerals like manganese, zinc, copper and magnesium and considerable iron but its bio-availability is low which results in incidence of iron deficiency anemia. However, processes like fermentation has improved the chemical bio-availability of iron (Oyarekua, 2011).

Abdulkadir and Danjuma (2015) reported that the major problem associated with infant during transitional phase of weaning is protein energy malnutrition (PEM) which results into condition such as marasmus or kwashiorkor. The formulation and development of nutritious weaning food from the combination of commonly used cereals with plant protein source like legumes can be used to prevent malnutrition during weaning, since cereals are deficient in lysine which are limited in legumes, whereas legumes are highly rich in lysine. The effects of the fortification are highly beneficial since nutritive value of products is also improved (Wang and Daun, 2006). The use of legumes seeds may be the beginning of a series of formulation which will lead to a substantial drop in dependency of animal source on nutritious foods. Unfortunately, legumes seeds contain anti-nutritional factors like enzymes inhibitors phytates, oxalate, saponin and polyphenolic compound, all of which limit their utilization (Abdulkadir and Danjuma, 2015). Although, remarkable improvement in the nutritive value and quality of legumes seeds have been achieved through de-hulling, heat treatment, germination, fermentation, soaking and partial hydrolysis of proteolytic enzymes (Akinrele and Bassir, 1967).

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 (Newkirk, 2010). 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 (Soetan, 2008). Fermented cereals are particularly important as weaning foods for infants and as dietary staples for adults. Ikemefuna et al. (1991) 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. (1991) 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 (Newkirk, 2010). 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 pretreatments (fermentation and roasting) on the microbial and sensory quality of weaning food produced from blends of sorghum and soybean.

MATERIALS AND METHODS

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 Home Economics Education Department, Federal College of Education (Technical), Gombe, Gombe State, Nigeria.

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 h 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 h to halt the fermentation process. It was milled to produce the fermented sorghum flour which was packaged in a clean polyethylene bag (Adebayo-Oyetoro et al., 2012).

Fermented soybean

One kilogram (1 kg) of soybean was soaked for 12 h in 3 L of clean water 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 h 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 h 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, they 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 were soaked for 12 h in 3 L of clean water 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 sun dried. The soybean was then traditionally roasted using an open thick aluminum pot. An attrition mill was used to mill the dehulled grain into fine flour and 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/roasted sorghum and soybean flour

One kilogram (1 kg) of sorghum grain was dehulled and dry cleaned. This was then fermented in a plastic bucket for 72 h. Thereafter, it was sun dried and roasted traditionally using an open thick aluminum pot. It was then milled into flour using attrition mill and stored in a plastic container until needed. These procedures were used for the preparation of fermented/roasted soybean.

Malting of sorghum

The sorghum was malted as described by Badau et al. (2006). The grains were steeped at room temperature (32 ± 2°C) for 12 h. The steeped liquor was changed after 6 h. One air rest period of 1 h was applied after 6 h 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 h. During germination, small and the grains were turned by moving a clean wooden rod inside the germinating grains. For the first 48 h of malting, the sample was quantity of water (15 ml) was sprayed on the germinating grains moistened twice a day at 08:00 and 16:00 hour by spraying a mist of water on it for about 5 s and then it was turned over. On the seventy-two hour of germination, the sample was spread in the morning (8 h) and turned over in the afternoon (16 h).

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 h. 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 ratios shown in Table 1.

Microbial analysis

Materials that were used were sterilized by autoclaving at pressure of 1 kg/cm^2 (121°C) for 15 min as described by Jideani and Jideani (2006). Glass wares were sterilized by dry-heat at temperature of 160°C for 60 min. The work-place was aseptically cleaned (with antiseptic and careful control) to ensure microbial reduction inhibiting the place. Media after preparation were sterilized at 1 kg/cm^2 (121°C) for 15 min and placed in water bath at 100°C to avoid gelling before use. Besides, Bunsen burner was used to “heat fix” smears, sterilize wire loop and other equipment. Inoculation methods such as streaking and poor plating were used to culture and subculture. Preliminary observations and tests were carried out followed by secondary observation.

Serial dilution

A prepared 1 g of sample was transferred into a bottle containing 9 ml of distilled water to form the stock solution as described by Jideani and Jideani (2006). From the stock solution, 1 ml was aseptically transferred into subsequent bottles containing sterile distilled water using sterile pipette, that is, from first to second, second to third and third to fourth until after required serial dilution was made.

Standard plate count method (SPCM)

From the prepared sample, 1 ml of the diluent from a test tube was transferred aseptically into cleaned and sterilized labeled plate (pour plate count) using sterile pipette. The lid of each was aseptically opened to introduce about 15 ml molten medium (Nutrient agar or MacConkey agar) into the plate (Petri dish) to ensure total bottom covering of the plate. It was swirled gently, cooled and solidified before incubating it at 35°C for 24 h as described by Jideani and Jideani (2006). The number of microorganism per gram of the original sample (colony forming unit per gram [Cfu/gram]) was obtained using:

$$\text{Colony forming unit per gram (Cfu/g)} = \frac{number\ \ of\ colonies}{volume\ \ transferred\ \ to\ plate} \times dilution\ blank\ factor \quad (1)$$

Table 1. Formulation of the weaning foods.

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

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).

Sensory evaluation of weaning food gruel

The gruel of the developed weaning food was served to 20 weaning mothers who were asked to rank the gruel on the basis of some quality attributes (taste, texture, appearance, aroma and overall acceptability) using 9 points Hedonic scale, where 1 = 'dislike extremely' and 9 = 'like extremely'. Weaning food gruels were served to panelist in transparent plastic cups and they were asked to rinse their mouth with fresh room temperature water provided, before next serving. The containers with the samples were coded and kept far apart to avoid crowding and for independent judgment. The panelists were selected based on the basic requirements of a panelist, such as availability for the entire period of evaluation, interest, willingness to serve, good health (not suffering from colds), not allergic or sensitive to the product emulated (Badau et al., 2005).

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 $p< 0.05$ (Hussein et al., 2016).

RESULTS AND DISCUSSION

Effect of pretreatments on the safety of the formulated weaning foods from blends of sorghum and soybean

The result of microbial analysis as presented in Table 2 showed that pretreatments (fermentation, roasting and the combination of fermentation and roasting) have positive effect on the microbial load of the weaning foods samples as compared to the untreated samples. The total plate count (TPC) ranged from 1.30×10^3 to 2.83×10^3 (cfu/g) with sample F55:40:5 having the highest value while sample R55:40:5 had the lowest value. In the fermented samples, there was a significant decrease in the TPC in all the blends as the percentage inclusion of soybean increased. The percentage reduction in TPC of fermented sample was 4.59%. There was also a significant decrease in the TPC of all the roasted blends as the percentage inclusion of soybean increased. The same trends of decrease were observed for fermented and roasted samples. The percentage reduction in TPC of fermented sample was 3.70% and fermented/roasted was 4.75%. While the untreated samples shows a significant increase in the TPC of all the blends as the percentage inclusion of soybean increased. The higher TPC of fermented samples to fermented/roasted, roasted and untreated samples were observed to be due to the multiplication of microorganism during fermentation process. The TPC of all the roasted and fermented/ roasted samples were very low. This was observed to be due to high temperature of roasting as most microorganisms cannot survive higher temperature.

There was no detectable yeast and moulds growth in fermented, roasted and fermented/roasted samples. The untreated samples showed very low growth of 5.00×10^1 cfu/g, 4.80×10^1 cfu/g and 4.60×10^1 cfu/g for samples U60:40, U70:30 and U80:20, respectively. These results are much lower than the FAO/WHO limits of 10^4 to 10^6 cfu/g for bacteria and 10^2 to 10^4 cfu/g for moulds in weaning foods (Abdulkadir and Danjuma, 2015). The yeast and moulds growth in the untreated samples were observed to be present as contaminants and do not appear after the pretreatments. The expected decrease or elimination was also reported by Mbata et al. (2009) for fermentation of maize flour fortified with Bambara groundnut. This shows clearly the importance of these pretreatments used in the aspect of weaning food processing. The microbial analysis of the formulated weaning food blends reveals that all the formulation indicated a safety of the products for consumption and this was due to higher standard of personal hygiene and quality maintenance of manufacturing practice observed during the preparation. Nwokoro and Chukwu (2012) highlighted the importance of adequate hygiene during the preparation of food and also link between infection

Table 2. Microbial load of the weaning foods prepared from the blends of sorghum and soybean (cfu/g).

Sample blends		Total plate count	Yeast and moulds count
	F55:40:5	2.70×10^3	No growth
Fermented	F65:30:5	2.74×10^3	No growth
	F75:20:5	2.83×10^3	No growth
	R55:40:5	1.30×10^3	No growth
Roasted	R65:30:5	1.33×10^3	No growth
	R75:20:5	1.35×10^3	No growth
	FR55:40:5	2.00×10^3	No growth
Fermented and roasted	FR65:30:5	2.00×10^3	No growth
	FR75:20:5	2.10×10^3	No growth
	U60:40	2.30×10^3	5.00×10^1
Untreated	U70:30	2.20×10^3	4.80×10^1
	U80:20	2.10×10^3	4.60×10^1

F55:40:5, F65:30:5 and F75:20:5 = fermented samples; R55:40:5, R65:30:5 and R75:20:5 = roasted samples; FR55:40:5, FR65:30:5 and FR75:20:5 = fermented and roasted samples; U60:40, U70:30 and U80:20 = untreated samples.

Table 3. Sensory qualities of the weaning foods prepared from the blends of sorghum and soybean.

Sample blends		Appearance $^{(na)}$	Texture	Taste	Aroma	Overall acceptability
	F55:40:5	7.45 ± 0.42	7.40 ± 0.32^a	4.35 ± 0.57^b	4.05 ± 0.55^d	5.45 ± 0.46^b
Fermented	F65:30:5	7.15 ± 0.47	6.95 ± 0.41^a	4.65 ± 0.55^b	4.70 ± 0.45^{cd}	5.30 ± 0.58^b
	F75:20:5	7.75 ± 0.27	7.35 ± 0.29^a	4.85 ± 0.57^b	6.00 ± 0.50^{bc}	5.25 ± 0.63^b
	R55:40:5	7.80 ± 0.30	6.95 ± 0.37^a	8.15 ± 0.30^a	7.70 ± 0.40^a	7.85 ± 0.43^a
Roasted	R65:30:5	6.85 ± 0.52	6.75 ± 0.45^a	7.80 ± 0.28^a	7.35 ± 0.49^{ab}	7.80 ± 0.32^a
	R75:20:5	7.35 ± 0.48	7.20 ± 0.45^a	7.60 ± 0.39^a	7.35 ± 0.47^{ab}	7.65 ± 0.42^a
	FR55:40:5	6.60 ± 0.50	5.35 ± 0.43^b	7.50 ± 0.41^a	7.15 ± 0.27^{ab}	7.70 ± 0.31^a
Fermented and roasted	FR65:30:5	6.60 ± 0.40	5.05 ± 0.46^b	7.30 ± 0.50^a	7.05 ± 0.46^{ab}	7.65 ± 0.51^a
	FR75:20:5	6.75 ± 0.49	4.85 ± 0.55^b	7.25 ± 0.46^a	6.90 ± 0.58^{ab}	7.55 ± 0.54^a
	U60:40	6.95 ± 0.56	6.90 ± 0.45^a	7.20 ± 0.48^a	6.70 ± 0.60^{ab}	7.00 ± 0.60^a
Untreated	U70:30	7.15 ± 0.43	7.60 ± 0.35^a	7.20 ± 0.37^a	6.35 ± 0.46^{ab}	7.65 ± 0.51^a
	U80:20	6.75 ± 0.54	6.65 ± 0.55^a	7.25 ± 0.48^a	6.35 ± 0.44^{ab}	7.50 ± 0.43^a

Means in the same column bearing different superscripts are significantly different ($p<0.05$); F55:40:5, F65:30:5 and F75:20:5 = fermented samples; R55:40:5, R65:30:5 and R75:20:5 = roasted samples; FR55:40:5, FR65:30:5 and FR75:20:5 = fermented/roasted samples; U60:40, U70:30 and U80:20 = Untreated samples.

and nutrition.

Also, the indication of very low microbial contents of the products can be attributed to the low moisture content of the products, which is an indication of low water activity preventing microbial growth. Similar results were reported by Amankwah et al. (2009) for formulation of weaning food from fermented maize, rice, soybeans and fish meal.

Effect of pretreatments on sensory evaluation of the formulated weaning foods from blends of sorghum and soybean

Table 3 shows the results obtained for sensory qualities of the weaning foods prepared from the blends of sorghum and soybean. All the weaning mothers were conversant with the factors governing the qualities of the weaning foods. The sensory attributes of the weaning blends show that there were significant differences ($p<0.05$) among the means scores of the blends in texture, taste, aroma and overall acceptability, while there were no significant difference ($p>0.05$) among the means scores in appearance. In terms of appearance, the scores ranged from 6.60 to 7.80 with the sample FR55:40:5, fermented/roasted having the lowest score, while sample R55:40:5 roasted had the highest score, thereby the most preferred by the panelists. The appearance of both treated and untreated were significantly preferred ($p<0.05$) despite no addition of 5% malt to untreated samples. Similar result was reported by Badau et al. (2005) for weaning food gruel produced from pearl millet and legumes.

The scores for texture ranged from 4.85 to 7.60 with the sample FR75:20:5, fermented/roasted having the lowest score while the most preferred by the panelists was sample U70:30, untreated. This is due the viscous nature of the untreated blend upon cooling as observed by the panelist. In terms of taste, the scores ranged from 4.35 to 8.15 with sample F55:40:5 fermented having the lowest score while sample R55:40:5, roasted, had the highest score, thereby the most preferred by the panelists. With regards to the aroma, the scores ranged from 4.05 to 7.70 with the sample F55:40:5, fermented, being the least preferred by the panelists and sample R55:40:5, roasted, was the most preferred by the panelists. The taste and aroma of the roasted samples preferred by the panelists is due to the flavoring agent and the least preferred taste and aroma of fermented blends were observed to be due to higher acidity resulting from the prolonged fermentation time. The weaning food blends from roasted samples had significantly ($p<0.05$) higher mean score in appearance, taste, aroma and overall acceptability followed by fermented and roasted samples. These relatively higher mean scores of the roasted samples followed by fermented and roasted samples could be probably due to the roasted flavour and aroma imparted on soybean during roasting coupled with astringency and aromatic compounds conferred on the sorghum by the fermentation process. Similar results were reported by Adedeji et al. (2015) that fermentation imparts desirable flavors, esters, ketones, aldehydes and aromatic compounds as well as characteristic astringency on products. But in this study, relatively lower mean sensory scores were obtained for fermented samples in terms of taste. These lower mean scores were due to beanny flavour imparted by the soybean supplementation. Both treated and untreated samples when reconstituted were smooth and homogeneous, without noticeable lumps. This was the reason why untreated samples were accepted coupled with the fact that the weaning mothers are used to these untreated ones. The overall acceptability scores ranged from 5.25 to 7.85 with the sample F75:20:5 fermented having the lowest score while sample R55:40:5, roasted, had the highest score thereby the most preferred by the panelists.

Conclusion

Weaning foods from blends of fermented (sorghum and soybean) and roasted (sorghum and soybean) grains were produced. The microbial analysis of the formulated weaning food blends revealed that all the formulations are safe for consumption. From the results of the sensory evaluation, it was concluded that fermentation and roasting processes improved the degree of acceptability of the various weaning foods blends. Therefore, every raw material to be used for the production of weaning foods should be pretreated for safety and enhancement of organoleptic quality.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

Abdulkadir M, Danjuma JB (2015). Microbial profile and nutritional quality during the fermentation of cereal based weaning food fortified with Soya Bean and Tiger Nut using Starter Culture. World Scientific News 24:103-115.

Adebayo-Oyetoro AO, Olatidoye OP, Ogundipe OO, Akande EA, Isaiah CG (2012). Production and Quality Evaluation of Complementary Food Formulated from Fermented Sorghum, Walnut and Ginger. Journal of Applied Biosciences 54:3901-3910.

Adedeji EO, Jegede ED, Abdulsalam KO, Umeobia UE, Ajayi AO, Iboyi JE (2015). Effect of processing treatments on the proximate, functional and sensory properties of Soy-Sorghum-Roselle complementary food. British Journal of Applied Science and Technology 6(6):635-643.

Akinrele IA, Bassir O (1967). The nutrient value of "Ogi" a Nigerian infant food. Journal of Tropical Medical Hygiene 70:279-280.

Amankwah EA, Barimah AKM, Nuamah JH, Oldman W, Nmaji CO (2009). Formulation of Weaning Food from Fermented Maize Rice, Soybeans and Fish Meal. Pakistan Journal of Nutrition 8(11):1747-1752.

Asma MA, Elfalil EB, Eltinay AH (2006). Development of Weaning Food From Sorghum Supplemented with Leagues and Oil Seeds. Food and Nutrition Bulletin 24(1):1-10.

Badau MH, Jideani IA, Nkama I (2005). Production, acceptability and microbiological evaluation of weaning food formulations. Journal of Tropical Pediatrics 52(3):166-172.

Badau MH, Jideani IA, Nkama I (2006). Rheological behaviour of weaning food formulations as affected by addition of malt. International Journal of Food Science and Technology 41:1222-1228.

Eshun G, Baffour NK, Ackah PY (2011). Nutrient content and sensory acceptability of a wearing diet formulated from mixtures of soya bean, groundnut and rice. African Journal of Food Science 5(17):870-877.

Hussein JB, Sanusi MS, Filli KB (2016). Evaluation of drying methods on the content of some bio-actives (lycopene,-carotene and ascorbic acid) of tomato slices. African Journal of Food Science 10(12):359-367.

Ikemefuna C, Obizoba J, Atii JV (1991). Effects of soaking, sprouting, fermentation and cooking on nutrient composition and some antinutritional factors of sorghum (guinesia) seeds. Plant Foods for Human Nutritional 41:203-212.

Jideani IA, Jideani VA (2006). Laboratory manual of food bacteriology. Amana printing and Advertising Ltd, Kaduna, Nigeria. pp. 90-112.

Mbata TI, Ikenebomeh MJ, Alaneme JC (2009). Studies on the microbiological, nutrient composition and antinutritional contents of fermented maize flour fortified with bambara groundnut (*Vigna subterranean* L). African Journal of Food Science 3(6):165-171.

Mosha TC, Vicent MM (2004). Nutritional value and acceptability of homemade maize/sorghum-based weaning mixtures supplemented with rojo bean flour, ground sardines and peanut paste. International Journal of Food Science Nutrition 55(4):301-315.

Mugula JK, Lyimo M (2000). Evaluation of the nutritional quality and acceptability of sorghum-based tempe as potential weaning foods in Tanzania. International Journal of Food Science Nutrition 51(4):269-277.

Newkirk R (2010). Soybean: Feed industry guide. Canadian International Grains Institute, Canada.

Nwokoro O, Chukwu B (2012). Studies on Akamu, A Traditional Fermented Maize. Industrial Microbiology, University of Nigeria Nsukka. Revised Child Nutrition 39(4):248-252.

Oyarekua MA (2011). Evaluation of the Nutritional and Microbiological Status of Co-fermented Cereals/Cowpea 'Ogi'. Agriculture and Biology Journal of North America 2(1):61-73.

Rombouts FM, Nouts MJR (1995). Microbial Fermentation in the Production of Plant Food. Journal Applied Bacteriology 79:1085-1175.

Soetan KO (2008). Pharmacological and other beneficial effects of antinutritional factors in plants-A review. African Journal of Biotechnology 7(25):4713-4721.

Wang N, Daun KJ (2006). Effect of Variety and Crude Protein Content on Nutrients and Anti-Nutrients in Lentils (*Lens culinaris*). Journal of Food Chemistry 95:493-502.