Turkish Journal of Agriculture - Food Science and Technology, 10(4): 508-516, 2022
DOI: https://doi.org/10.24925/turjaf.v10i4.508-516.4414

Turkish Journal of Agriculture - Food Science and Technology

Available online, ISSN: 2148-127X | www.agrifoodscience.com | Turkish Science and Technology Publishing (TURSTEP)

Effects of Cricket Addition on the Chemical, Functional, and Sensory Properties of Complementary Formulation from Millet Flour

Egwujeh Simeon Iko-Ojo Dignity[1,a,*], Audu Basiru Danjuma[1,b], Amidu Momoh[1,c]

[1]Department of Food Nutrition and Home Sciences, Faculty of Agriculture, Kogi State University, Anyigba Nigeria
[*]Corresponding author

A R T I C L E I N F O

Research Article

Received : 26/04/2021
Accepted : 25/05/2021

Keywords:
Millet
Cricket
Complementary food
Chemical composition
Functional properties

A B S T R A C T

The effect of cricket addition on the proximate composition, mineral compositions, functional and sensory properties of complementary food formulated from millet was studied. The result of the chemical composition showed significantly increase in the protein and fat level of the formulated complementary food (9.28±0.16 - 20.20±0.07) % and (3.65±002 - 8.12±0.08) %, respectively. However, a significant decrease in the carbohydrate level (75.61±0.03 - 60.44±0.31) g/100g was observed. Evaluation of functional properties showed that cricket addition did not affect the bulk density but increased the water absorption (2.46±0.05), Emulsion (38.02±0.40%), foam (6.00±0.00), gelation (20.00±0.00%) capacities and pH (6.20±0.02). The mineral contents including Fe, Ca, Na, and K of the food ranged from 7.54±0.10 - 10.25±0.05 mL/100g, 30.35±0.15 - 34.98±0.10 mL/100g, 9.35±0.29 - 14.47±0.06 mL/100g and 30.92±0.03 - 56.40±010 mL/100g respectively increasing with increased addition of cricket flour The formulated samples were rated higher for taste, colour, flavour, texture and the overall acceptability than the control. In general sample 513 containing 75:25 cricket: millet flour showed more improvement than other formulated samples and most acceptable in terms of taste, flavour mouth feel and overall acceptability. Adding cricket flour to millet flour as complementary food would help in addressing protein energy malnutrition in children.

[a] idesnig@gmail.com https://orcid.org/0000-0002-4476-0277
[b] audubdanjuma12@gmail.com https://orcid.org/0000-0001-9595-7654
[c] amidumomoh2020@gmail.com https://orcid.org/0000-0002-0505-2876

Introduction

Complementary foods (plant products) are foods other than breast milk introduced to an infant to provide nutrients (Yusufu et al., 2013; Mohammed et al., 2020; Mohammed et al., 2021), between the time the diet consist exclusively of mother's breast milk and the time when it is mostly made of family food (WHO 2002) and may be in liquid, semisolid and solid form (Egwujeh et al., 2016a). It can be specially prepared for the infants or can be same food available for the family members modified in other to meet the eating skills and needs of the infants' (WHO 2003; Egwujeh et al., 2016a).

Complementary feeding starts when breast milk alone is no longer sufficient to meet the nutritional requirements of infants so that other foods and liquids are needed along with breast milk in adequate quantity and nutritional quality to meet normal healthy and development of life of the infant (WHO 2002; Sevindik et al., 2017; Akgül et al., 2021). In developing country like Nigeria complementary foods are mainly cereal based and these staple foods are given in the form of gruels that is either mixed with boiled water or boiled with water (Igyor et al., 2011).

Since young children have small gastric capacities, they are unable to consume enough of the diluted porridge to meet their energy requirements and consequently may become malnourished (Melese et al., 2016). Gruel is watery and bulky thus has low energy density hence sufficient quantities have to be consumed by infants to meet their energy and nutritional needs (Onoja et al., 2014). Complementary foods are often of low nutritional quantity and given in sufficient amounts, but displaces breast milk when given too frequently and too early (Villapando 20008; WHO 2002), resulting to poor feeding practices and short fall in food intake. Many African mothers, mainly those from low income class, feed their infants with complementary foods that are inadequate in energy value; poor swallow ability and deficient in micro nutrients such as iron, zink, calcium vitamins A, B and C (Egwujeh et al., 2016a). This might be a result of lack of funds to purchase the industrially processed ones and or low knowledge of how to produce nutritionally adequate complementary foods in a traditional way. For this reason they depend on the complementary foods from sing cereals or legumes which according Egwujeh et al., (2016a), might not meet the nutritional needs of the infants. This is the most important direct factor responsible for malnutrition and illness amongst children in Nigeria (Solomon 2005).

Millets are cereals of variable small seed grasses grown globally with different economic important across the continents of the world (Kiprotish et al., 2015). Unlike other cereals such as rice and wheat, millets are well adapted to Africa semi-arid and sub-tropical agronomic condition forming small grains cultivated in diverse environment, mostly in the dry, semi-arid to sub-humid drought prone agro ecosystem (Fasasi, 2009; Obilana et al., 2002).

Nutritionally, millet has high energy, less starch, high fiber (1.2g/100g, most of which is insoluble), 8-15 times greater α-amylase activity as compared to wheat, low glycemic index (55) and is gluten free (Vanisha et al., 2011). Pearl millet is comparable and even greater to major cereals with respect to energy value, proteins, fat and minerals. It is rich in B vitamins, chiefly niacin, B_{12}, B_6 and folic acid (Olaitan et al., 2014). It makes an important contribution to human diet due to high levels of minerals, lipids and high quality proteins and also very rich in dietary fiber and micro nutrients (Malik et al., 2002).

The whole grain can be consume as popped, roasted or sprouted or used in stews, soups and as cooked cereals (Anu Sehgal and Kwatra 2006; Malik et al., 2002). In many African countries, millet is often the main component of many meals and is essentially consumed as steam cooked products (couscous), thick porridges (Tó), semi thick porridge (ogi) and thin or watery liquid (gruel) which can be used as a complementary food for infants and young children (Fasasi 2009).

Crickets (Brachytrypes membranacous) are edible insects related to grasshoppers (Otte et al., 2007). Most humans in developed countries regard the consumption of insects with some revulsion, and where exceptions occur, insects are generally considered as food more for their novelty than their nutrients, and for example, it is embedded in chocolates or ice cream (Johnson 2010). In Japan and part of Italy however, insects are eaten as part of the traditional diet (Overstreet 2003; Nonaka 2010).

Nutritionally, insects generally contain high quantities of important micronutrients, such as iron and zinc, while some also contain useful amounts of certain vitamins (van Huis 2013; van Huis et al., 2013). Vitamin B_{12}, vital for human health, which occurs only in food of animal origin, is found in sufficient amounts in crickets about 5.4 μg/100 g in adults and 8.7 μg/100g in nymphs which meets the recommended dietary amount of 2.4 μg daily (van Huis, et al., 2013).

Crickets are a huge source of nutrition, providing a great source of protein, iron, calcium, B_{12}, and are commonly eaten as a nibble; prepared by deep frying the soaked and sparkling insects (Bray 2010). In West and Central Africa, insects are not used as emergency food to strive against starvation, but are included as a normal part of the diet throughout the year or in seasons of occurrence (Banjo et al., 2006).

Industrial Complementary foods are always beyond the reach of many rural mothers as well as families of low income; hence many depend on traditionally processed foods from single cereals such as maize, sorghum and millet which are always sweetened with sugar that in some cases lead to diarrhea in infants. Poor feeding practices and short fall in food intake might be a major factor responsible for malnutrition and illness amongst children of 6 -18 month of age in rural areas. The traditional infant foods from cereals are usually bulky and might be low in several nutrients (macro and micro) and may equally contain substantial amounts of anti-nutritional factors that may interfere with nutrient utilization.

Since cereal grains alone cannot satisfy the nutritional requirements of infants, there is a need to supplement the food with other sources. It is therefore necessary to improve upon the nutritional quality of millet for the purpose of weaning children and to, at the same time, reduce malnutrition among infants and growing children. The incorporation of cricket into the traditional complementary food from millet might alleviate the nutritional quality of the food. The objectives of this study were to formulate complementary food from millet and cricket flours and to determine the proximate composition, functional, mineral and sensory properties of the formulations.

Materials and Methods

Sources of Materials

The pearl millet (*Pennisetum glaucum)* was obtained from Anyigba main market while cricket was obtained from Emabu, in Anpka Local Government Area both of Kogi State Nigeria. Equipment used including, drying trays, buckets, harmer mill, weighing balance, sealer, fan driven hot air oven and 40 mesh size sieves were provided by the Department of Food, Nutrition and Home Sciences, Department of Soil and Environmental Management and Department of Biochemistry all in Kogi State University Anyigba, Nigeria.

Preparation of Cricket Flour

Crickets were cleaned manually by removing the wings, eviscerating and washing under tap to remove dirt. The cleaned cricket were laid on drying trays in single layer and dried in a locally constructed solar dryer for one week. The dried crickets were milled, packaged and kept in the refrigerator (Egwujeh et al., 2018) Figure 1.

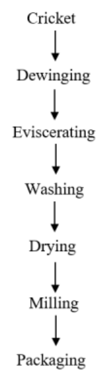

Figure 1. Flow chart for the production of cricket flour
Source: Egwujeh et al. (2018)

Preparation of Millet Flour

Millet grains were processed according to the methods described by Egwujeh et al., (2016a). The millet grains were cleaned of dirt, stone and other extraneous materials and then soaked in clean water for 8hours (overnight). The soaked grains were washed, sundried, milled with hammer (Grain Maker® Grain Mill Model No.116) and sieved. The flour was packaged in plastic container with lid and kept in the refrigerator Figure 2.

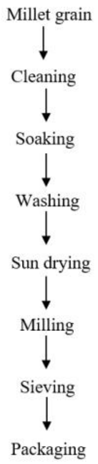

Figure 2ç Flow chart for the production of millet flour (Egwujeh et al., 2016a)

Formulation of Complementary Food

The complementary food was formulated by blending wheat and cricket flours as shown in Table 1

Table 1. Formulation of complementary food from millet and cricket flours

Sample codes	Millet flour (g)	Cricket flour (g)
ABC	100	0
AAA	95	5
BCA	90	10
CBC	85	15
BAC	80	20
ACB	75	25
BBB	70	30

ABC = (100% millet flour as control), AAA = (95% millet, 5% cricket flour) BCA = (90% millet, 10% cricket flour), CBC = (85% millet, 15% cricket flour) BAC = (80% millet, 20% cricket flour), ACB = (75% millet, 25% cricket flour) BBB = (70% millet, 30% cricket flour)

Preparation of Gruel

Gruel (pap) was made from the blended flours according to the traditional method. 45g of flour from each samples formulated was weighed; 50mL of cold distilled water was added to make paste and 250mL of boiled water was added to cook the slurry.

Analytical Methods

Chemical analysis

The moisture, crude protein, ash, crude fibre and fat contents of the complementary food samples were determined following the procedures described by AOAC (2010) while carbohydrate was calculated by difference according to Onwuka (2005). Energy was calculated using Atwater factors described by Yusufu et al., (2016).

Determination of moisture content

The moisture content of the gruel samples was determined by measuring 2g of the sample into a metal crucibles of known weights previously dried at 100°C. The sample was dried in a hot air oven at 105°C to a fairly constant weight.

The sample moisture content was calculated as:

$$\text{Moisture (\%)} = \frac{\text{Loss in weight}}{\text{Weight of sample}} \times 100$$

Determination of fat

In determining the fat content of the samples, two grams of sample were weighed into extraction thimble, and covered with cotton wool. The recovering flask was weighed. About 50mL of petroleum spirit (40-60°C) was poured into the flask connected to the thimble and sample. The extractor was connected to a heating mantle. Fat was extracted for 18 hours. The extract obtained was dried in a hot air oven and held in a desiccator for cooling after which it was weighed. The fat content was calculated as:

$$\text{Fat (\%)} = \frac{\text{Weight of fat (W2)}}{\text{Weight of sample(W1)}} \times 100$$

Determination of protein

The Kjedahl procedure of protein determination was followed digesting two grams of samples with concentrated H_2SO_4 in a fume hood. The digested samples was allowed to cool and then distilled into a boric acid containing bromocresol indicator after diluting appropriately with distil water and later with sodium-thiosulphate and sodium hydroxide solution. The solution was then titrated against 0.1mL of hydrochloric acid (HCl). A blank titration was similarly carried out and the percentage protein was estimated as percentage nitrogen multiply by 6.25(1mL of HCl = 0.014N). The proStein content was calculated thus:

$$\text{\% Nitrogen} = \frac{\text{Titre} \times 0.0014 \times \text{dilution factor}}{\text{Sample Weight}} \times 100$$

% Protein = % Nitrogen × factor (6.25).

Determination of ash content

The ash crucible was thoroughly washed dried in an oven and weighed. Two grams of the sample were weighed into the crucible and incinerated. The sample was then transferred into a muffle furnace and heated at 550^0C for 6 hours. The ash was cooled in a desiccator and weighed using a Mettler top loading balance.

The ash content was calculated as:

$$\text{\% Ash} = \frac{\text{Weight of ash}}{\text{Weight of sample}} \times 100$$

Determination of carbohydrate

The total carbohydrate (TC) content was determined by difference; as

TC(%)=100–(%Ash+%Fat+%moisture+% protein)

Energy value

Energy was calculated using Atwater factors (9 × fat + 4 × protein + 4 × carbohydrates)

Functional properties

Foaming capacity, bulk density, water absorption capacity and least gelation capacity were determined according to methods described by Onwuka (2005).

Foaming capacity

In 10mL of distilled water, 2g of the sample was blended for 5minutes at 1600rpm. The mixture was transferred in to 250mL cylinder and allowed to stand for 30 seconds. Thereafter, the volume was taking and the forming capacity was calculated thus:

$$\text{Foaming capacity (\%)}=\frac{V_a\text{-}V_b}{V_b}\times 100$$

Where

V_a= volume after whipping,

V_b= volume before whipping

Least gelation capacity

This was determined by making 1g suspension of each sample in 5mL of distilled water was prepared in the test tube. The test tubes with the samples were heated for 1hour in a boiling water bath after which they were cooled under cold running tap. Further cooling for 2hours at 4°C was carried out. The test tubes were then invert and the least gelation concentrations were taken as the sample that first fell off the test tube.

Emulsion capacity

The emulsification capacity (EC%) of the formulated complementary food was determined by blending 2g of the sample in 25mL of distilled water for 30seconds at 1600rpm. Thereafter, 25mL vegetable oil was added and blended for another 30seconds. The blended sample was then centrifuged at 1600 rpm for 5minutes.

$$\text{EC\%}=\frac{\text{Height of emulsified layer}}{\text{Height of the whole solution in centrifuged tube}}\times 100$$

Water absorption capacity

To determine the water absorption capacity of the samples, 1g of each sample was measured into centrifuge tubes**.** 10mL of distilled water was added and mixed thoroughly. The mixture was allowed to stand for 30minutes at room temperature after which they were centrifuged for 30minutes at 5000rpm. Thus water absorbed was calculated:

$$\text{\% Absorption}=\frac{\text{Initial volume} - \text{Final volume}}{\text{Initial volume}}\times 100$$

Bulk density

Bulk density of the samples was determined by tapping 30g of the sample in a cylinder 100 times on the laboratory bench. The volume after tapping was noted. The bulk density was calculated thus:

$$\text{Bulk density}=\frac{\text{Weight of the sample}}{\text{Volume of sample after tapping}}$$

Hydrogen ion concentration (pH)

The pH of the complementary food was determined using method described by AOAC (2010). A 10% w/v suspension of the samples in distilled water was prepared and mix thoroughly in a warring micro blender. The pH was taken with the pH meter.

Sensory evaluation of the gruel

The cooked complementary food was evaluated on the attributes of colour, aroma, texture, taste, and general acceptability using a 9 point Hedonic scale (9-like extremely, 1-dislike extremely). The panellist consisted of twenty (20) nursing mothers drawn from staff and students of Kogi State University, Anyigba. The panellists were served the coded gruel samples in a randomised order for evaluation. The scores obtained were subjected to statistical analysis using multiple comparisons Test (Ihekorony and Ngoddy 1985; Iwe 2002), using one way Analysis of variance (ANOVA) to evaluate the means and difference established using Duncan's new multiple range test to separate the mean ($P \leq 0.05$) using SPSS (statistical package for social scientists), version 16.0, Windows 2006.

Results and Discussions

Proximate Composition

The proximate compositions of the complementary food are presented in Table3. Compositional analysis showed that differences ($P \leq 0.05$) generally existed between the control (sample ABC) and the ones containing cricket flour. Carbohydrates decreased with increasing amounts of cricket. Similar trend was observed in the moisture and crude fiber contents of the formulated food.

Sample BBB (70:30millet: cricket flour) had the lowest value of moisture which ranged from 9.02±0.16 - 11.13±0.21 %. This is an indication that the product would have better storage stability than the control (100% millet) which had the highest moisture. Egwujeh and Ariahu (2014) had earlier reported that moisture content of a food predict its stability on the shelves as it encourages microbial activities, enzymatic and non- enzymatic reactions leading to food spoilage. Moisture content in food sample is an index of stability and determines the appearance, keeping quality and yield of the product (Ejoh et al., 2006). The significant decrease in moisture as the quantity of cricket flour was increased was good for stability of the product on the shelf.

The total ash content of the samples ranges from (0.95±0.08-1.51±0.04) % indicating that the ash content of the formulation was increasing with increase in cricket addition. The ash content of the control sample (0.95±0.08%) was significantly lower than the formulated samples.

Ash content represents the total mineral content in foods (Nnamani et al., 2009). The high ash content might be an indication of presence of minerals in the infant food formulation. Sample CBC containing 85:15millet: cricket was not significantly ($P \leq 0.05$) different from BAC which contained 80:20millet: cricket in ash content. The ash contents of complementary formula in this study compared with reports of Ijarotimi and Keshinro (2012) for infant formula prepared from Germinated popcorn, Bambara groundnut and African locust bean.

Table 3. Proximate composition of the formulated complementary food

Sample codes	Moisture (%)	Ash (%)	Crude fiber (g)	Fat (g)	Protein (g)	Carbohydrate (g)	Energy (Kcal)
ABC	11.13^{g}±0.1	0.95^{a}±0.08	0.95^{e}±0.02	3.55^{a}±0.01	9.28^{a}±0.16	75.61^{f}±0.03	309^{a}±0.15
AAA	10.45^{e}±0.15	1.32^{b}±0.03	0.20^{a}±0.02	3.65^{a}±0.02	11.07^{b}±0.09	73.36^{e}±0.21	341^{b}±0.04
BCA	10.13^{f}±0.08	1.25^{b}±0.05	0.22^{a}±0.01	3.72^{a}±0.03	13.95^{c}±0.05	69.83^{d}±0.13	369^{c}±0.09
CBC	9.85^{d}±0.04	1.36^{b}±0.02	0.35^{b}±0.01	7.56^{b}±0.03	17.04^{d}±0.35	63.90^{c}±0.03	392^{d}±0.02
BAC	9.18^{b}±0.08	1.42^{c}±0.08	0.39^{c}±0.01	7.64^{c}±0.10	18.20^{e}±0.04	63.66^{c}±0.14	396^{e}±0.03
ACB	9.11^{a}±0.10	1.51^{d}±0.02	0.40^{c}±0.01	8.12^{e}±0.08	19.16^{f}±0.06	62.26^{b}±0.29	399^{f}±0.10
BBB	9.02^{c}±0.16	1.51^{d}±0.4	0.43^{d}±0.1	7.85^{d}±0.05	20.20^{g}±0.07	60.44^{a}±0.31	393^{dg}±0.08

Values are means ± SD of 3 replications. Means in a column followed by different are significantly (p ≤ 0.05) different. ABC = (100% millet flour as control), AAA = (95% millet, 5% cricket flour) BCA = (90% millet, 10% cricket flour), CBC = (85% millet, 15% cricket flour) BAC = (80% millet, 20% cricket flour), ACB = (75% millet, 25% cricket flour) BBB = (70% millet, 30% cricket flour),

The crude fiber contents of the samples ranged from 0.22±0.01 - 0.95±0.02 and showed that the control sample (100% millet) was significantly (P≤0.05) higher in the fiber content than the samples containing cricket flour that decreased with increasing cricket substitution. This could be good for infants as research shows that dietary fiber increases bulk and satiety but reduces nutrient digestibility and energy density, hence be limited in diets of children especially malnourished ones, (USAID 2011).

The crude protein content in this study was in the range of 9.28±0.16 - 20.20±0.07, increasing significantly with increased cricket flour addition. Sample ABC containing 100% millet flour was significantly (P≤0.05) lower than all the formulated samples.

Adebayo et al., (2011), had reported an increase in the protein content with corresponding increase in the proportion of Bambara flour supplementations in complementary food produced from ofada rice flour. The protein contents of the samples in this study were higher than those reported for maize based complementary porridge in World Bank Infant and Young Child Feeding projects for children ages 12 to 23 months (World Bank 2013).

The values for crude fat of the samples were from 3.65±002 - 8.12±0.08. Differences were not observed 100% millet flour and those that contained 95:5 % Millet: cricket flours and 90:10 Millet: cricket flours. Sample ACB containing 75: 25% millet: cricket flours had 8.12 fats which was significantly higher (P≤0.05) than the other samples. Rancid soon after production due to lipid oxidation would have been expected here but for low moisture, this might not be evident. The high crude fat in the samples might contribute to energy value of the food. Similar increase in fat content of cereal based food had earlier been reported for maize blended with beni-seed, soybean on quality protein maize and cowpea on cocoyam, (Ayinde et al., 2012).

The carbohydrate contents of complementary formula in this study decreased with increasing cricket flour addition. It was greater in the control than in other samples. Despite the reduction, the samples contained more carbohydrate than that reported for maize and quality protein maize based products (Olayiwola et al., 2012). Decreased carbohydrate observed here was a result of high amounts of protein and fat in field cricket which replaced the carbohydrate proportion.

The energy contents of the complementary food samples ranged from 309±0.15 - 399±0.10 kcal /100g. This satisfies the minimum energy requirement of an infant. The result also indicated that the energy content increased with increase quantities of cricket flour addition. The energy content of the samples could have resulted from cricket been a high source of fat especially oleic and linoleic acids, and suggested, field cricket should be given some attention as a potential oil source for food as saturated fatty acids played important role for human health, (Wang et al., 2004). The energy values of the formulated complementary food were within the recommended daily allowance of energy 370 to 420kcal per 100gm for complementary foods in developing countries reported by Walker (1990).

Mineral Compositions

Table 4 below shows the mineral composition of the formulated complementary food samples.

The iron content (mg/g) samples CBC, BAC and BBB were not significantly different (P≤ 0.05) but were different from samples AAA and BCA which are equally different from ACB that was unexpectedly higher in the mineral than all other samples containing cricket. Although there was a general reduction in the iron as more cricket flour was added, these contained more iron than the control (100% millet). The reduction might be due to low content of the mineral in cricket (Adeyeye and Awokunmi 2010). The WHO (2013) recommended 5.8mg/g iron in complementary foods, a recommendation which the finding here satisfies.

The value of Ca ranges from (30.35±0.15 - 34.98±0.10) mg/g indicating that the calcium content decreased with increased quantities of the cricket flour. However, the values agreed with the recommendation of CODEX CAC/GL 08 (1991) that calcium content in cereal based complementary food shall not be less than 20 mg/100 kJ (80 mg/100 kcal). The presence of iron and calcium in the formulated complementary food in the required amount might be helpful in bone and teeth development in the growing children (Akinjayeju 2010). There was a slight increase in sodium as millet was been supplemented with cricket flour. Although the all the samples containing cricket had higher sodium than the control without cricket, the contents were within permissible level in controlling high sodium intake at the early stage or growth which might condition them to lifelong salt appetite (WHO 2003).

The potassium content is shown in table 4 and ranged from 30.92±0.03 - 56.40±010 (ml/g). The potassium contents of the food are enough to balance up the sodium content of the food. A low intake of dietary potassium, especially in the presence of high sodium intake, has been implicated in the pathogenesis of elevated blood pressure (BP) (Institute of Medicine 2004; Moris et al., 2006). Since potassium is required to curb HBP, detoxification of the body and in blood clothing, weaning the infants with this formula is ought most important.

Table 4. Effect of substitution of millet flour with cricket flour on mean mineral contents of formulated complementary food

Sample codes	Fe (mg/g)	Ca (mg/g)	Na (mg/g)	K (mg/g)
ABC	7.54 ^{a}±0.10	31.50 ^{a}±4.39	9.35 ^{a}±0.29	30.92^{a}±0.03
AAA	9.33 ^{c}±0.15	34.98 ^{g}±0.10	14.21^{d}±0.02	56.40^{g}±010
BCA	9.30 ^{c}±0.10	34.62 ^{f}±0.08	14.08^{d}±0.03	55.97^{f}±0.06
CBC	9.16 ^{b}±0.05	33.42 ^{d}±0.10	14.47^{e}±0.06	53.34^{d}±0.05
BAC	8.86 ^{b}±0.05	32.45 ^{b}±0.15	12.21^{b}±0.20	48.90^{b}±0.10
ACB	10.25 ^{e}±0.05	33.79 ^{e}±0.01	13.22^{c}±0.10	54.23^{e}±0.15
BBB	9.07 ^{b}±0.03	32.61 ^{c}±0.10	13.19^{c}±0.02	49.83^{c}±0.06

Values are means ± SD of 3 replications. Means figures in a row followed by same superscripts are not significantly (p≤ 0.05) different. ABC = (100% millet flour as control), AAA = (95% millet, 5% cricket flour) BCA = (90% millet, 10% cricket flour), CBC = (85% millet, 15% cricket flour) BAC = (80% millet, 20% cricket flour), ACB = (75% millet, 25% cricket flour) BBB = (70% millet, 30% cricket flour)

Table 5. Functional properties of mixed flours of cricket and millet as complementary food formula.

Sample codes	Bulk density (g/cm^{3})	Water absorption capacity (g/ml)	Oil absorption capacity (g/ml)	Foam capacity (%)	Emulsification capacity (%)	Gelation capacity(g/ml)
ABC	0.46 ^{a}±0.08	0.94^{a} ±0.02	1.09^{a} ±0.00	0.95^{a}±0.05	30.58 ^{a}±0.02	8.99 ^{a} ±0.40
AAA	0.72^{b}±0.02	1.21^{b} ±0.02	1.77^{b} ±0.02	2.00^{b}±0.00	35.77 ^{c}±0.00	14.00^{b} ±0.00
BCA	0.73^{b}±0.01	1.36^{c} ±0.05	1.87^{c} ±0.03	3.00^{c}±0.00	34.13 ^{b}±0.46	16.00 ^{c}±0.00
CBC	0.73^{b}±0.00	2.13^{e} ±0.06	2.10^{d} ±0.01	5.00^{e}±0.00	36.06 ^{c}±0.02	16.00 ^{c}±0.00
BAC	0.73^{b}±0.01	2.00^{c}±0.00	1.90^{c} ±0.05	4.00^{d}±0.00	36.88 ^{d}±0.00	18.00^{d} ±0.00
ACB	0.74^{b}±0.01	2.30 ^{f}±0.00	2.17^{c} ±0.05	6.00^{f}±0.00	38.02 ^{f}±0.40	18.00^{d} ±0.00
BBB	0.74^{b}±0.00	2.46^{g}±0.05	2.08^{d} ±0.01	5.00^{e}±0.00	37.42±0.03^{e}	20.00 ^{e}±0.00

Values are means ± SD of 3 replications. Means figures in a row followed by same superscripts are not significantly (p≤ 0.05) different. ABC = (100% millet flour as control), AAA = (95% millet, 5% cricket flour) BCA = (90% millet, 10% cricket flour), CBC = (85% millet, 15% cricket flour) BAC = (80% millet, 20% cricket flour), ACB = (75% millet, 25% cricket flour) BBB = (70% millet, 30% cricket flour)

Functional Properties

The effect of cricket flour in millet flour on the functional properties of complementary food formulation is shown in table 3 below. Bulk density value of the control sample was significantly (P≤0.05) lower than all other samples. High bulk density of powdered food is desirable for packing, since it allows more weight to be contained in a limited volume, (Hansen et al., 1989). However, high bulk density can limit the caloric and nutrient intake per feed of a child resulting in growth faltering (Onimawo and Egbekun 1998). Although the bulk density of the formula increased upon addition of cricket flour, the increments were not so high as to affect the nutrient intake. Bulk density is generally affected by the particle size and the density of the flour and it is very important in determining the packaging requirement, material handling and application in the food industry, (Karuna et al., 1996).

The water absorption capacity gives an indication of the amount of water available for gelatinization, (Kulkarni et al., 1990). There were significant differences (P≤0.05) in the water absorption of the formulated samples. The values ranged between 1.09±0.00 - 2.46 ± 0.05 g/ml increasing with increased addition of cricket flours. Fermentation of the millet grain might have accounted for the increased in water absorption capacity (Fasasi 2009). Water absorption capacity gives an indication of the amount of water available for gelatinization, (Onabanjo et al., 2009) and is important in the development of ready to-eat-food from cereal grains, since a high-water absorption capacity may assure product cohesiveness (Housou and Ayernor 2002). Increased absorption here shows that more water was made available as more cricket flour was added.

Oil absorption capacity, a critical assessment of flavor retention and improved palatability (Kinsella, 1976) is equally important for energy density of complementary foods (Baruk et al., 2015). The oil absorption in this current study increased with increasing supplementation with cricket flour. This might have contributed to high energy content of the formulations in this study (Table 1). The oil absorption also shows that the complementary formulations are laden with potentials necessary for growing infants (Iyenagbe et al., 2017).

The values of the gelation capacity of the samples were significantly different (P≤0.05) ranging from 30.58±0.02 - 38.02±0.40 %. The sample ABC containing 100% millet flour had the lowest value while sample BBB had the highest value. Infants formula that form gel at low concentrations are not ideal for weaning foods because they would require a lot of dilution in an attempt to improve digestibility in relation to volume, (Hansen et al, 1989) as well as swallow ability.

Gelation is one of the most important functional properties which determine the suitability of incorporation of a particular substance into food products (Adebowale et al., 2005). The level of gel formation observed in this study was an indication of suitability of cricket in millet as weaning formula.

Addition of cricket generally increased the emulsification capacity of the samples ranging from 30.58 – 38.02% with sample ACB having the highest value and sample ABC having the lowest. There were no significant differences (P≤0.05) between AAA and CBC but are significantly different from other samples which are different from one another at the same level of probability. The emulsion formed might be due to strong protein – to – protein interactions at oil – water interface. It might also be due to high concentration of protein in the formulated complementary food (Onoja et al., 2014) and could acts as flavor retainer/enhancer, and as well as promotes mouth feel and taste of complementary food (Oyarekua and Adeyeye 2009).

Table 6. Effect of cricket flour on hydrogen ion concentration of complementary foods from wheat flour

Sample codes	pH
ABC	5.60 ^{a} ± 0.06
AAA	6.15^{abc} ± 0.01
BCA	6.17^{bc} ± 0.02
CBC	6.20 ^{d} ± 0.02
BAC	6.17 ^{c} ± 0.01
ACB	6.14^{ab} ± 0.02
BBB	6.13^{a} ± 0.02

Values are means ± SD of 3 replications. Means figures in a row followed by same superscripts are not significantly (p≤ 0.05) different. ABC = (100% millet flour as control), AAA = (95% millet, 5% cricket flour) BCA = (90% millet, 10% cricket flour), CBC = (85% millet, 15% cricket flour) BAC = (80% millet, 20% cricket flour), ACB = (75% millet, 25% cricket flour) BBB = (70% millet, 30% cricket flour).

Table 7. Sensory properties of cricket/millet blended complementary gruel.

Sample	Colour	Taste	Aroma	Texture	General Acceptability
ABC	6.50 ^{a} ±0.18	6.44 ^{a} ±0.21	6.00 ^{a} ±0.17	6.34 ^{a} ±0.12	6.47 ^{a} ±0.00
AAA	7.55 ^{b} ±0.26	7.90 ^{b} ±0.12	7.55 ^{b} ±0.19	7.60 ^{b} ±0.21	7.55 ^{b} ±0.25
BCA	7.47 ^{b} ±0.21	7.30 ^{b} ±0.12	7.35 ^{b} ±0.16	7.56 ^{b} ±0.21	7.70 ^{b} ±0.17
CBC	7.35 ^{b} ±0.23	7.00 ^{b} ±0.19	7.60 ^{b} ±0.15	7.62 ^{b} ±0.20	7.85 ^{b} ±0.19
BAC	6.30 ^{c} ±0.26	7.02 ^{b} ±0.18	7.30 ^{b} ±0.19	7.07^{ab} ±0.18	7.05^{ab} ±0.18
ACB	6.32 ^{c} ±0.26	7.20 ^{b} ±0.17	7.15^{ab} ±0.20	7.10^{ab} ±0.21	7.30^{ab} ±0.19
BBB	6.35 ^{b} ±0.32	6.75 ^{b} ±0.21	7.15^{ab} ±0.18	6.85^{ab} ±0.15	7.23^{ab} ±0.19

Values are means ± SD of 3 replications. Means in a row followed by different superscripts are significantly (p≤ 0.05) different. ABC = (100% millet flour as control), AAA = (95% millet, 5% cricket flour) BCA = (90% millet, 10% cricket flour), CBC = (85% millet, 15% cricket flour) BAC = (80% millet, 20% cricket flour), ACB = (75% millet, 25% cricket flour) BBB = (70% millet, 30% cricket flour)

There was increased foam formation with increasing supplementation of cricket flour in millet flour. This observation was an indication that the formulated food is laden with protein and is evident in the protein content of the food (Table 1). The foam might have some effect on the texture of the food (Table 6). Akubor (2008) earlier reported that foams are used to improve on the texture, consistency and appearance of foods. Increased form formation (0.95 – 6.00) with increasing cricket addition could be an indication that cricket flour led to reduced tension of protein molecules of the flour (Egwujeh et al., 2016b).

For a protein to have superior foaming properties, it must possess high solubility in the liquid phase as well as the ability of quickly forming a film around the air bubbles in the food system (Kinsella 1981).

Hydrogen Ion Concentration (pH)

The pH values of the formulated complementary food ranged from 5.40±0.06 - 6.20±0.02 and are presented in Table 6.

The control and sample BBB showed lower pH values than the rest of the samples, indicating they are more acidic than other samples. However, they are not statistically different from AAA and ACB which were equally not different from one another. Although all the samples tended toward neutrality, sample CBC tended more. The low pH is important in reducing microbial growth in the protein rich foods since cricket is a high protein food which might support microbial growth. Porridge made from fermented grains shows high nutritional values so much that it reduces the risk of disease in children (Egwim et al., 2013). The pH value tending to neutrality was an advantage as feeding the infant with the food will have no adverse effect on the lining of their stomach.

Sensory Properties

The sensory attributes of the complementary food sample are presented in Table 7 below. The evaluation showed that addition of cricket flour affected the sensory quality of the gruel.

The colour of the samples was significantly (p≤ 0.05) improved by the addition of cricket flour to 15% levels. Samples AAA, BCA and CBC containing 5%, 10% and 15% respectively of cricket flours were not significantly different from each other in colour but are different from the control which contained no cricket and samples BAC, ACB and BBB containing 20%, 25% and 30% of cricket flours respectively. The observed drop in sensory scores as above 15% of cricket was added was an indication that more of cricket flour in the millet resulted to unappealing colour.

The mean scores for taste of the weaning food ranged from (6.44±0.21 - 7.90±0.12). All the samples were rated higher than 5 indicating that the taste of infant formula was affected negatively by the addition of cricket flour. Similar trend was observed in aroma and texture of the formulation

The general acceptability scores of the complementary food ranged from (6.47±0.00 - 8.05±0.18). There was observable effect of cricket on the overall acceptability of the weaning food. Acceptability of the formulations containing cricket flours was significantly (P≤ 0.05) higher than the control sample.

Conclusion

Complementary food was prepared from cricket and millet flours and analysed for chemical, functional and sensory properties. The study finds that addition of cricket to millet lead to improvements on the functional, organoleptic properties and the chemical compositions of the complementary food. The work equally showed that cricket flour could be used up to 20% levels in millet without any adverse effect on the sensory attributes of the complementary food. Utilization of such a protein and energy dense complementary food as this would go a long way in eradicating protein deficiency malnutrition in children, especially in developing countries where animal protein are insufficient. The pH values of the formulations are within healthful levels but capable of discouraging microbial growth in the protein rich foods since cricket is a high protein food which might support microbial growth.

Recommendation

The authors recommend that cricket be used up to 20% in millet for the production of complementary foods for the enhancement of the nutritional requirements of growing children. Further studies might be carried out to determine the vitamins such as vitamins A and B_s contents of the formulation.

Conflict of interest

The authors certify that there are no conflicts of interest with any organizations, financial, or others regarding the materials discussed in the manuscript as well as journal of interest.

Acknowledgement

The authors wish to thank the management of the Department of Food, Nutrition and Home Sciences, Department of Soil and Environmental Management, and Department of Biochemistry for making their laboratories available for the success of this research work. We also appreciate Mr. Are E., Abuh, M.A., Olupinyo, S. and Abuh, S. for their technical assistance. The professional contributions and moral advice of Professor Orishagbemi C.O., that made the work achievable is highly appreciated.

References

Adebayo AG, Akintoye AH, Olufolaji AO, Aina OO, Olatunji M, Shokalu OA. 2011. Assessment of organic amendments on vegetative development and nutrient uptake of moringa Oliefra lam in the nursery. Asian Journal of Plant Sciences 10(1): 74 – 79. DOI: 10.3923/ajps.2011.74.79

Adebowale YA, Adeyemi IA, Oshodi AA. 2005. Functional and physiochemical propertiesof flours of six *Mucuna species*. Afr. J. Biotechnol. 4:1461–1468.

Adeyeye EI, Awokunmi EE. 2010. Chemical composition of female and male giant African cricket, *Brachytrypes membranaceus L*. International Journal of Pharma and Bioscience. ISSN 0975 – 6299. 1(4): 125 – 136

Akgül H, Korkmaz N, Dayangaç A, Sevindik M. 2020. Antioxidant Potential of Endemic *Salvia absconditiflora*. Turkish Journal of Agriculture-Food Science and Technology, 8(10): 2222-2224.

Akinjayeju O. 2010. Human and Applied Nutrition. Concept publications Ltd, 77Shipeolu Street, Palmgrove, Lagos.

Akubor PI. (2008). Effect of processing treatments on the chemical, functional and bread making properties of pigeon pea (Caganus cagan) seed. J. Mgt Tech. 8: 102 – 109.

Anu Sehgal S, Kwatra A. 2006. Nutritional evaluation of pearl millet based songe cake. Journal of Food Science and Tecnology43(3): 312 – 313.

A.O.A.C. 2010. Official methods of Analysis, Association of official Analytical chemist 17th Edition, Washington.

Ayinde K, Ayinde OE,Muchie M, Omotesho OA, Adewunmi MO. (2012). Multi-risk model of small – scale agricultural entrepreneurs in central Nigeria; selected poster prepared for presentation at the International Association of Agricultural Economists (IAAE) Triennial Conference, Foz do Iguca, Brazil August 18 – 24.

Banjo AD. Lawal OA. Sangonuga EA. 2006. The nutritional value of fourteen species of edible insects in South Western Nigeria.African Journal of Biotechnology. 5(3): 298-301.

Baruk BD. Kebede A. Esayas K. 2015. Effect of Blending Ratio and Processing Technique on Physicochemical Composition, Functional Properties and Sensory Acceptability of Quality Protein Maize (QPM) Based Complementary Food. International Journal of Food Science and Nutrition Engineering, 5(3): 121-129.

Bray A. 2010. Vietnam's most challenging foods, CNN: Travel. Retrieved 2 June 2015.

CODEX CAC/GL 08, (1991). Codex Alimentarius: Guidelines on Formulated Supplementary Foods for Older Infants and Young Children. Vol. 4, FAO/WHO Joint Publications, 144.

Egwim E, Amanabo M, Yahaya A, Bello M. 2013. Nigerian Indigenous Fermented Foods: Processes and Prospects, license In Tech.

Egwujeh SID, Ariahu CC. 2014. Effects of pretreatment on moisture sorption characteristics of velvet bean (Mucuna flagelipse) flours. Journal of Applied Agricultural Research: Agricultural Research Council of Nigeria. 6(1) 313–324. ISSN 2006-750X.

Egwujeh SID, Ariahu CC, Orishagbemi CO, Onuh JO. 2016a. Effect of boiling and toasting on pasting and functional properties of African oak (Afzelia africana) seed flours. NSUK Journal of Science and Technology 6(2):166 – 171.

Egwujeh SID, Ariahu CC, Orishagbemi CO. 2016b. Effects of processing variable on chemical composition of African oak (Afzelia Africana) seed. International Journal of Agricultural and Veterinary Sciences 2(2) 73 – 82. ISSN2407 – 8708.www.ijavs.org

Egwujeh SID, Onuh OJ, Yusufu PA, Yakubu A. 2018. Production and evaluation of physic-chemical and sensory properties of biscuit from wheat and cricket flours.ACTA Scientific Nutritional Health 2(1) 3-7

Ejoh AR, Mbiapo FT, Fokou E. 2006. Nutrient composition of the leaves and flowers of *Colocasia esculenta* and the fruits of Solanummelongena. Plant Foods for Human Nutrition; 49:107-112.

Fasasi OS 2009. Proximate, Antinutritional Factors and Functional Properties of Processed Pearl Millet (*Pennisetum glaucum*). Journal of Food Technology7(3): 92– 97.

Hansen M, Pedersen B, Munck L, Eggum BO. 1989. Weaning foods with improved energy and nutrient density prepared from germinated cereals.

Housou P, Ayernor GS. 2002. Appropriate processing and food properties of maize flour. African Journal of Food Science and Technology (AJST) 3(12): 126 – 131.

Igyor MA, Yusufu PA, Sengev IA. 2011. Evaluation of physicochemical, Functional and sensory properties of fermented fura powder supplemented with soy. Nigerian Food J 28: 113-121.

Ihekoronye AI, Ngoddy PO. 1985. Integrated Food Science and Technology for the Tropics. 1st Edn., Macmillan Publishers, pp: 236-265, 283-292.

Ijarotimi OS, Keshinro OO. 2012. Formulation and Nutritional Quality of Infant Formula Produced from Popcorn, Bambara Groundnut and African Locust Bean Flour. Journal of Microbiology, Biotechnology and Food Sciences. 1 (6):1358-1388.

Institute of Medicine. 2004. Dietary Reference Intakes for Water, Potassium, Sodium, Chloride and Sulfate. Washington, DC: National Academy Press.

Iwe MO. 2002. Hand Book of Sensory Methods and Analysis. Rejoint Communication Services Ltd. 65, Adelabu St, Uwani – Enugu.

Iyenagbe, OD, Malomo AS, Idowu OB,Badejo AA,Fagbemi MT. 2017. Effect of thermal processing on the nutritional and functional properties of conophor nut (Tetracarpidium conophorum) flour and protein isolate. Food Science and Nutrition; Wiley Online Library 5(6): 1170 – 1178.

Johnson DV. 2010. The contribution of edible forest insects to human nutrition and to forest management. Proceedings of a Workshop on Asia-Pacific Resources and Their Potential for Development, 19-21 February 2008, Chiang Mai, Thailand. Bangkok: Food Agric. Organ. United Nations, pp. 5-22.

Karuna D, Noel G, Dilip K. 1996. Food and Nutrition Bulletin 17(2), United NationsUniversity. Tokyo, Japan.

Kinsella JE. 1976. Functional properties of proteins in foods; critical review. Food Science and Nutrion 1(3): 219 – 280.

Kinsella JE. 1981. Functional properties of proteins: possible relationship between structure and function in foams. Food Chemistry 7(4): 273 – 288.

Kiprotich F, Mwendia MC, Cheruiyot KE Wachira NF. 2015 "Nutritional suitability of bred sorghum (Sorghum bicolor) accessions from East Africa." African Journal of Food Science 9, no. 5: 326-334.

Kulkarni KD, Kulkarni DN, Ingle UM. 1990. Sorghum malt-based weaning food fformulation: preparation, functional properties and nutritive value. Food and Nutrition Bullettin 13(4), 322-328.

Malik M, Singh U, Dahiya S. 2002 Nutrient composition of pearl millet as influenced by genotypes cooking methodS. Journal of Food Science and Technology,39(5):463-468.

Melese T, Negussie R, Etalem T. 2016. Pre-Gelatinized taro flour for development of weaning food in Ethiopia.International Journal of Food Science and Nutrition; Volume 1; Issue 1; Page No. 12-23.

Mohammed FS, Günal S, Şabik AE, Akgül H, Sevindik M. 2020. Antioxidant and Antimicrobial activity of *Scorzonera papposa* collected from Iraq and Turkey. Kahramanmaraş Sütçü İmam Üniversitesi Tarım ve Doğa Dergisi 23(5): 1114-1118.

Mohammed FS, Kına E, Sevindik M, Dogan M, Pehlivan M. 2021. *Datura stramonium* (Solanaceae): Antioxidant and Antimicrobial Potentials. Turkish Journal of Agriculture-Food Science and Technology 9(4): 818-821.

Moris A, Pajot A, Blanchet F, Guivel-hassine F,Sacedo M, Schwartz O. 2006. Dendritic cells and HIV-specific CD4T cells: HIV antigen presentation, T-cell activation and viral transfer. Immunobiology; Blood 108(5): 1643 – 1651.

Nnamani CV, Oselebe HO, Agbatutu A. 2009 Assessment of nutritional values of some underutilized indigenous leafy vegetable of Eboyi State Nigeria. African Journal of Biotechnology 8 (9), 2321-2324.

Nonaka K. 2010. Cultural and commercial roles of edible wasps in Japan. Proceedings of a Workshop on Asia-Pacific Resources and Their Potential for Development, 19–21 February 2008, Chiang Mai, Thailand. Bangkok: Food Agric. Organ. United Nations, pp. 123–30

Obilana AB, Taylor JRN. 2002. Status and development needs of processing and utilization technologies for sorghum and millets: experiences from southern and implications for West and Central Africa (WCA). Presented to the CFC expert meeting to identify and prioritize research and development needs and activities for WCA. Bamako, Mali pp: 23-36.

Olaitan NI, Eke MO. Uja EM. 2014. Quality evaluation of unripe caricapapaya, unripe Musa paradisiaca and mucunaconchichinensis, weaning food formulation. European Journal of Biology and Medical sciences UK. 1(1), PP: 6-15.

Olayiwola IO, Folaranmi F, Adebowale A, Onabanjo OO, Sanni SA, Afolabi WAO. 2012. Nutritional composition and sensory quality of cocoyam –based recipes enriched with cowpea flour. Journal of Nutrition and Food Science 2(10): 1 – 6. Doi:10:4172/2155-9600.1000170.

Onabanjo OO, Oguntona CRB, Dixon BM, Olayiwola IO, Oguntona EB, Dixon AGO. 2009. Nutritional evaluation of four optimized cassava based complem -entary foods. African Journal of Food Science, 2:136-142.

Onimawo AI, Egbekun KM. 1998. Comprehensive Science and Nutrition. Macmilan Press, Ibadan.

Onoja US, Akubor PI, Gernar DI, Chinma CE. 2014. Evaluation of complementary food formulated from local staples and fortified with calcium iron and zinc. Journal of Nutrition and Food Science 4(6): 1- 6.

Onwuka GI. 2005. Food Analysis and Instrumentation: Theory and Practice. Naphthali Prints, Surulere, Lagos, Nigeria.

Otte D. 2007. Australian Crickets (*Orthoptera Gryllidae*). Acadamic of Natural Sciences. 17–24.

Overstreet RM. 2003. Flavor buds and other delights. J. Parasitol. 89(6): 1093–107.

Oyarekua MA, Adeyeye EI. 2009. Comparative evaluation of the nutritionalquality, functional properties and amino acid profile of co – fermented maize/ cow pea and sorghum/cow pea ogi as infant complementary food. Asian J. Chem. Nutr. 1: 31 – 39

Sevindik M, Akgul H, Pehlivan M, Selamoglu Z. 2017. Determination of therapeutic potential of *Mentha longifolia* ssp. *longifolia*. Fresen Environ Bull 26(7): 4757-4763.

Solomon M. 2005. Nutritive value of three potential complementary foods based on cereals and legumes. Afri. J. Food, Nutri. Sci; 5: 2:1-14.

USAID. 2002. Commodities Reference Guide- Part II, Module I: Material Child Health and Nutrition; Weaning practices in deprived environments: theweaning dilemma: Pediatrics: 1985; 75(1 pt. 2), 194-198.

Van Huis A. 2013. Potential of insects as food and feed in assuring food security. Annual Review of Entomology 58: 563-583.

Van Huis A, Van Itterbeeck J, Klunder H, Mertens E, Halloran A, Muir G. Vantomme P. 2013. Edible insects: future prospects for food and feed security. FAO Forestry Paper 171. FAO, Rome, Italy

Vanisha S, Nambiar JJ, Dhaduk NS, Tosha S, Rujuta D. 2011. PotentialFunctional Implications of Pearl millet (*Pennisetum glaucum*) in Health and Disease.Journal of Applied Pharmaceutical Science 01 (10); 2011: 62-67.

Villapando S. 2008. Feeding mode, infections and anthropometric status in early childhood.Pediatrics, 106: 1282-1283.

Walker AF. 1990. The contribution of weaning foods to protein-energy malnutrition. Nutrition (*Gryllustestaceus walker)* Research Review; 3:2547.

Wang D, Bai YT, Li JH, Zhang CX. 2004. Nutritional value of the field cricket (). Journal of Entomologia Sinica, 11: 275–283.

WHO. 2002. Global Strategy for Infant and Young Child Feeding.WH/A55/2002/REC/1 Annex 2, Geneva.

WHO. 2003). Feeding and nutrition of infants and young children: guidelines for WHO European Region with Emphasis on the former Soviet Countries, Who Region Publication, European Series. 87.

World Bank. 2013. Infant and Young Child Feeding: World Bank Nutrition report. siteresources. worldbank.org /NUTRITION/Resources/Tool2-Chap5.

Yusufu PA, Netala J, Opega GL 2016. Chemical, sensory and microbiological properties of cookies produced from maize, African yam bean and plantain composite flour. Indian Journal of Nutrition. 3: 01- 05

Yusufu PA, Egbunu FG, Egwujeh SID, Opega GL, Adikwu MO. 2013. Evaluation of Complementary Food Prepared from Sorghum, African Yam Bean (*Sphenostylis stenocarpa*) and Mango Mesocarp Flour Blends. Pak J.Nutr 12: 205-208.