Nutrients Composition and Sensory Evaluation of White Maize-Based Complementary Food Fortified with African Palm Weevil Larvae and Beetroot

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ABSTRACT

Background: *Cereal-based complementary foods are characterized by low protein quality contributing to high prevalence of malnutrition among children.*

Objective: *The study evaluated the chemical composition and sensory evaluation of white maize-based complementary food fortified with African palm weevil larvae and beetroot.*

Methods: *White maize and beetroot were obtained from the market in Abia state while African palm weevil larvae was obtained from a farm in Delta state. The white maize was processed into gruel form. The African palm weevil larvae and beetroot were processed into flour and added into the white maize in different ratios giving samples LMB (50% white maize, 40% larvae, 10% beetroot), BLM (50% white maize, 30% larvae, 20% beetroot), MLB (60% white maize, 20% larvae, 20% beetroot) and MOO (100% white maize, 0% larvae, 0% beetroot). White maize served as control. Proximate, vitamin and mineral contents of the pap were analyzed using standard methods. Sensory properties were evaluated using 9-point hedonic scale. Data was analyzed using analysis of variance.*

Results: *The fortified samples had higher protein content: LMB (12.90g), BLM (11.43g) and MLB (10.63g) compared to the control MOO (8.51g). Energy content of the fortified samples LMB, BLM and MLB were 252.49kcal, 242.00kcal and 192.37kcal respectively higher than the MOO 102.22kcal. However, sample MOO had the most preferred sensory attributes.*

Conclusion: *The inclusion of edible insects like the African palm weevil larvae and beetroot in complementary foods has shown prospects in combating child protein-energy malnutrition.*

Keywords: Entomophagy, larvae, maize, beetroot, malnutrition

Introduction

The period of transition from exclusive breastfeeding to family foods, referred to as complementary feeding, covers a child from 6-23 months of age, and is a very vulnerable period (1). It is the time when malnutrition starts in many infants, contributing to the high prevalence of malnutrition in children under two years of age.

However, malnutrition in young children can be prevented by feeding them enough nutritious and safe complementary foods. It is estimated that edible insects are part of the diet of at least two billion people and more than 1900 insect species are currently used as food (2). Edible insects contain high quality protein, fat, vitamins and minerals (3,4) and are also considered tasty and even delicious by those accustomed to eating them (2,5). Promoting *Rhynchophorous phoenicis* as a traditional food among the average people living in remote areas can help minimize malnutrition and disease problems across Africa (6). Several *Rhynchophorous spp* are edible at some stages of their life cycle (7) as they provide essential nutrients such as proteins, carbohydrates, fats, minerals and some vitamins for body development (8). In many developing countries and among various cultures throughout the world, *R. phoenicis* remain vital and preferred food source of protein, fat, minerals and vitamins (9). According to Ramos-Elordu (10), *R. phoenicis* contains 23-36g of protein. These quantities of protein have been estimated to be more than the protein in grounded beef (27.4g) and cod fish 28.5g (11,12).

White maize is used for human consumption in diverse forms, from specialized foods in developed countries (13), to a staple food in undeveloped countries (14). According to Sanusi *et al*. (15), hundred gram of white maize contains the following: 207.96 kilocalories, 10.82g carbohydrates, 0.50g fiber, 0.06g fat, 1.04g protein, 1.85mg calcium, 10mg phosphorus, 15mg potassium, 082mg sodium, 0.24mg zinc, 0.29mg copper 68mcg beta carotene equivalent, 0.02mg vitamin E, 0.02mg riboflavin, 0.1mg niacin, 0.01mg vitamin B6 and folate.

Beetroot (*Beta vulgaris*) is cultivated throughout the world for its roots, which are used as a food and as a source of natural dye (16). Besides other active chemicals, beetroots contain a unique class of water-soluble, nonphenolic antioxidants, the betalains, including two classes of compounds, red betacyanins (principally betanin) and yellow betaxanthines (17). This study evaluated the chemical composition and sensory evaluation of white maize based complementary food fortified with Africa palm weevil larvae and beetroot.

MATERIALS AND METHODS

Sample purchasing

White maize (*Zea mays*) and beetroot (*Beta vulgaris*) was purchased from Ubani and Oriugba market, respectively in Abia State. African palm weevil larva (*Rhynchophorus phoenics*) was purchased from Oghara Market in Delta State.

Sample preparation

The method as described by Okara and Lotoyi (18) was adopted to produce the white maize-based complementary food (*ogi*). The maize grains were washed thoroughly with tap water to remove dust particles and other impurities. The grains were then steeped in 1-liter water inside a plastic with lid for 3 days at room temperature (microbial fermentation takes place during the steeping). An electrically powered grinder was used to wet-mill the softened grains. Water was then added to the ground material to obtain slurry. The slurry was sieved by means of a finely porous cloth to remove parts of the hull. The filtrate which was almost pure starch was allowed to stand for 20 – 30 minutes for the sedimentation to take place. The starch porridge which was obtained was prepared into *ogi* porridge by introducing small quantity of hot water.

The method as described by Adeboye *et al*. (19) with slight difference was adopted to produce palm weevil larvae flour. Fresh Africa palm weevil larvae were gutted using a sharp knife, washed in salted water and dried in a D-50 electric oven at 50^0C for 6hrs until constant weight was achieved. The dried larvae were then milled using a kitchen dry milling blender. It was properly stored for further use.

The method as described by Dhawan and Sharma (20) was adopted to produce beetroot flour. Beetroot was washed with water, dried and then diced to thin slices. The sliced product was subsequently placed on a stainless-steel mesh belt and dried on a commercial forced-air dryer at 60^0C and 40% relative humidity. Drying time was 24 hours and maximum product temperature was 60^0C. Dried product was then ground using mechanical grinder to make beetroot flour.

The white maize was processed into gruel. The African palm weevil larvae and beetroot were processed into flour and was then added into the white maize in different ratios giving samples LMB (50% white maize, 40% larvae, 10% beetroot), BLM (50% white maize, 30% larvae, 20% beetroot), MLB (60% white maize, 20% larvae, 20% beetroot) and MOO (100% white maize, 0% larvae, 0% beetroot). White maize served as control.

Chemical analysis

AOAC (21) method were used for chemical analysis. Protein was determined by micro-kjeldahl method; crude fiber by acid hydrolysis; fat by soxhlet extraction method; ash by drying method, moisture was determined by the air oven method (21). Carbohydrate was determined by difference while minerals (iron, calcium, zinc, potassium) and vitamins (A and E) of the food was chemically analyzed by multiple nutrient wet acid digestion method.

Sensory evaluation of the complementary food was conducted using a 30 semi-trained panelist comprising of nursing mothers of children within 6 - 12 months at the World Bank Primary Health Care Centre, Umuahia. A nine-point hedonic scale was used to evaluate the samples for color, taste, flavor and mouthfeel. One teaspoon of sugar was added to the samples. Spoons and water to be used for rinsing of mouth in-between evaluations on each tasting session were given to the mothers.

Statistical analysis

The data generated from the samples' chemical analysis were subjected to Analysis of Variance (ANOVA) using the Statistical Package for Social Science (SPSS) Version 20. The means were separated, and statistical significance was considered at p-values ≤ 0.05.

Results

The moisture content of the complementary foods produced was high, ranging from 50.17 - 73.49%. LMB recorded the least moisture value (50.17%) while MOO (control) recorded the highest value of moisture content (73.49%). The crude protein value varied significantly from each other and ranged from 8.51 – 12.90%. Fat ranged between 0.86 – 13.33% with LMB having the highest value (13.33%) and MOO which is the control with the lowest value of (0.86%). Fiber content of MLB (0.58%) was not significantly different from that of BLM (0.55%). Ash varied in all the samples, MOO (1.69%), MLB (2.28%), BLM (2.68%) and LMB (3.01%). Carbohydrate value obtained in this study ranged from 15.11 – 22.88%. The value for sample BLM which recorded the highest is (22.88%) while the control (MOO) recorded the least value (15.11%). The energy content of these samples were significantly ($p<0.05$) different from each other. The values ranged from 102.22 – 252.49 kcal.

Table 2 shows the vitamin composition of the complementary food. There was significant difference ($p<0.05$) in the vitamin A and E content of the complementary food.

The Vitamin A value was highest in the control sample (MOO) and lowest in sample BLM, LMB had a highest Vitamin E value while MOO had the lowest.

The result of the mineral composition of the complementary food is presented in Table 3. There were significant differences ($p<0.05$) for calcium, iron, zinc and phosphorus values. The values for the calcium ranged from 237.47-408.26mg/100g, Iron content values ranged from 26.20 – 37.07mg/100g while zinc content derived from these samples ranged from 17.58 – 21.34mg/100g. The phosphorus content ranged from 10.35 – 276.06mg/100g with MOO

Table 1: Energy (Kcal) and proximate composition (%) of the complementary food

SAMPLES	MOISTURE CONTENT	CRUDE PROTEIN	FAT	CRUDE FIBRE	ASH	CARBOHYDRATE	ENERGY
MOO	73.49 ± 0.01^a	8.51 ± 0.01^d	0.86 ± 0.00^d	0.34 ± 0.0^b	1.69 ± 0.01^d	15.11 ± 0.01^d	102.22 ± 0.01^d
MLB	59.01 ± 0.01^b	10.63 ± 0.00^c	8.01 ± 0.00^c	0.58 ± 0.0^a	2.28 ± 0.07^c	19.44 ± 0.01^c	192.37 ± 0.01^c
LMB	50.17 ± 0.01^d	12.90 ± 0.00^a	13.33 ± 0.00^a	0.36 ± 0.0^b	3.01 ± 0.01^a	20.23 ± 0.01^b	252.49 ± 0.01^a
BLM	50.82 ± 0.01^c	11.43 ± 0.01^b	11.64 ± 0.00^b	0.55 ± 0.0^a	2.68 ± 0.01^b	22.88 ± 0.01^a	242.00 ± 0.01^b

Values are mean ± standard deviation of duplicate samples.

[a-d] means with different superscripts along the same row are significantly different from each other ($P < 0.005$)

Note: MOO (100: 0: 0) = White maize 100%

MLB (60: 20: 20) = White maize 60: African palm weevil larva 20: Beetroot 20

LMB (50: 40: 10) = White maize 50: African palm weevil larva 40: Beetroot 10

BLM (50: 30:20) =White maize 50: African palm weevil larva 30: Beetroot 20

Table 2: Vitamin composition of the complementary food

SAMPLES	VITAMIN A (μg/100g)	VITAMIN E (mg/100g)
MOO	1.62 ± 0.02^{a}	0.13 ± 0.01^{d}
MLB	1.26 ± 0.02^{b}	1.94 ± 0.02^{c}
LMB	1.17 ± 0.02^{c}	2.17 ± 0.02^{a}
BLM	1.15 ± 0.02^{c}	2.11 ± 0.02^{b}

Values are mean ± standard deviation of duplicate samples.

$^{a-d}$ means with different superscripts along the same row are significantly different from each other ($P < 0.005$)
Note: MOO (100: 0: 0) = White maize 100
MLB (60: 20: 20) = White maize 60: African palm weevil larva 20: Beetroot 20
LMB (50: 40: 10) = White maize 50: African palm weevil larva 40: Beetroot 10
BLM (50: 30: 20) =White maize 50: African palm weevil larva 30: Beetroot 20

Table 3: Mineral composition (mg/100g) of the complementary food

SAMPLES	CALCIUM	IRON	ZINC	PHOSPHORUS
MOO	408.26 ± 0.02^{a}	37.07 ± 0.02^{a}	21.34 ± 0.02^{a}	10.35 ± 0.02^{d}
MLB	370.43 ± 0.02^{b}	26.20 ± 0.03^{d}	18.26 ± 0.02^{c}	82.12 ± 0.02^{c}
LMB	261.34 ± 0.02^{c}	33.46 ± 0.03^{b}	17.58 ± 0.02^{d}	276.06 ± 0.03^{a}
BLM	237.47 ± 0.16^{d}	27.45 ± 0.02^{c}	20.67 ± 0.02^{b}	208.92 ± 0.01^{b}

Values are mean ± standard deviation of duplicate samples.

$^{a-d}$ means with different superscripts along the same row are significantly different from each other ($P < 0.005$)
Note: MOO (100: 0: 0) = White maize 100
MLB (60: 20: 20) = White maize 60: African palm weevil larva 20: Beetroot 20
LMB (50: 40: 10) = White maize 50: African palm weevil larva 40: Beetroot 10
BLM (50: 30:20) =White maize 50: African palm weevil larva 30: Beetroot 20

(control) the lowest value and LMB (276.06mg/100g) the highest value.

Table 4 shows the sensory attributes of the complementary food. The sensory values ranged from 4.00 – 8.33% color, 4.10 – 7.97% taste, 3.60 – 8.23% texture, 3.67 – 8.07% mouthfeel, 3.67 – 7.67% flavor, 3.83 – 8.05% general acceptability. There was no significant difference ($p<0.05$) in the taste, texture, mouthfeel, flavor and general acceptability for samples MLB, LMB and BLM

Table 4: Sensory attribute of the complementary food

SAMPLES	COLOUR	TASTE	TEXTURE	MOUTHFEEL	FLAVOUR	GENERAL ACCEPTABILITY
MOO	8.33±0.99^{a}	7.97±1.16^{a}	8.23±1.52^{a}	8.07±1.31^{a}	7.67±1.56^{a}	8.05±1.07^{a}
MLB	5.33±2.31^{b}	4.53±2.40^{b}	4.30±2.29^{b}	4.10±2.68^{b}	4.03±2.47^{b}	4.46±1.96^{b}
LMB	4.60±2.50^{bc}	4.10±2.32^{b}	3.73±2.18^{b}	3.87±2.24^{b}	4.07±2.55^{b}	4.07±1.96^{b}
BLM	4.00±2.89^{c}	4.20±2.83^{b}	3.60±2.49^{b}	3.67±2.47^{b}	3.67±2.48^{b}	3.83±2.34^{b}

Values are mean ± standard deviation of duplicate samples.

$^{a-d}$ means with different superscripts along the same row are significantly different from each other (P < 0.005)

Note: MOO (100: 0: 0) = White maize 100

MLB (60: 20: 20) = White maize 60: African palm weevil larva 20: Beetroot 20

LMB (50: 40: 10) = White maize 50: African palm weevil larva 40: Beetroot 10

BLM (50: 30:20) =White maize 50: African palm weevil larva 30: Beetroot 20

Discussion

The moisture values obtained in this study were higher compared to moisture content of African palm weevil larva as reported by Elemo *et al*. (22). The reason for this high moisture content could be as a result of addition of water during preparation. The crude protein value varied significantly from each other and ranged from 8.51 – 12.90%. Crude protein increased with increasing level of African palm weevil larvae while sample MOO (control) which had no African palm weevil larvae recorded the least protein content. This was as a result of high protein content of African palm weevil larvae as reported by Ojinnaka *et al*. (23). Fat ranged between 0.86 – 13.33% with LMB having the highest value (13.33%) and MOO which is the control with the lowest value of (0.86%). These values did not meet the recommended nutrient intake 30g/100g for 7 – 12 months. Research has shown that frying of African palm weevil larvae increases the fat content (24) and this could be the reason for the lower values as the method of processing differed. Dietary fats have an important role in promoting good health and enhancing the sensory qualities of foods (25). Fiber content of MLB (0.58%) was not significantly different from that of BLM (0.55%), however it was lower than the value reported for *R. phoenicis* in Nigeria (22). The reason for this low content was from the production process of maize as activities of microbial enzymes during fermentation reduce the fiber content of maize and that would have reduced its percentage contribution (26). However, low fiber content will encourage high digestibility and absorption of the diets by the infants (27). Ash varied in all the samples, MOO (1.69%), MLB (2.28%), BLM (2.68%) and LMB (3.01%). The value obtained from this study falls within the recommended value for weaning foods for ash content which must not exceed 5% (28). Nutritionally, ash aids in the metabolism of other organic compounds such as carbohydrate and fat (29). Carbohydrate value obtained in this study ranged from 15.11 – 22.88%. The values from this study is lower than the values reported by (19) on cookies made with *R.phoenicis* and this can be attributed to the processing technique of the maize production as fermentation has been reported (30) to reduce the carbohydrate content of cereals. The energy content increased with increase in African palm weevil larvae ratio and this increase was due to the high content of palm weevil larvae and agrees with the finding of (19).

The values obtained from the Vitamin A and E content of this research was lower than the recommended nutrient intake for 7-12 months old which is 500mg/day and 5mg/day respectively (31). The reason for this could be because the raw materials used are not good sources of Vitamin A and E. Antioxidant vitamins like vitamin A and E play a significant role in fighting free radicals in human body and fortifies the immune cells (32). Samples LMB, MLB AND MOO met the recommended nutrient intake for 7 – 12 months (31) for calcium except sample BLM. All the samples met the recommended nutrient intake for iron and zinc which is 11mg/100g and 260mg/100g respectively (31). The Iron and Zinc values obtained in this study were high and the reason for this increase can be attributed to the processes and preparation used as fermentation has been found to increase its content (33). This is in contrast to the lower values for calcium, iron and zinc reported by (34). However, the study did not include any fermentation process. Minerals play enormous roles in human metabolic processes (35). Only sample LMB met the recommended phosphorus nutrient intake of 275mg/100g for 7 – 12 months (31) and this is because of the increased ratio of the larvae to 40% which is in line with the studies as reported (23). Though phosphorus is widely distributed in natural foods, the inadequate intake or mal-absorption of phosphorus results in hypophosphatemia; the symptoms of which include anorexia, anemia, muscle weakness, bone pain, rickets and loss of appetite (36). There was no significant difference ($p<0.05$) in the taste, texture, mouth-feel, flavour and general acceptability for samples MLB, LMB and BLM as this is in line with the study of (19) on the sensory evaluation of cookies made from African palm weevil larvae blends. The sensory attributes of this study is contrary to the findings of (34) on the nutritional composition and acceptability of biscuits fortified with palm weevil larvae and orange flesh sweet potato. This could be as a result of the ratio of different fortificants used in the study of (34). There was significant difference for the color between the various samples as this could be the effect of beetroot which is commonly used in manufacturing as a food coloring agent (37,38). Samples BLM and LMB where less preferred for the general acceptability while samples MLB and MOO where more preferred.

Conclusion

The study showed that sample LMB (50 maize: 50 African palm weevil: 50 beetroot) compared favorably in protein and energy content than sample MOO. The inclusion of edible insect (African palm weevil) and beetroot can improve the quality of complementary foods. However, behaviour change approaches should be adopted to encourage its adoption and acceptance by caregivers.

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