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Research Article

Chemical and Sensory Evaluation of Complementary Mixes Made from Soybean (*Glycine max*), Unripe Plantain (*Paradisiacal normalis*), and Crayfish (*Euastacus Spp*)

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Abstract

The study evaluated the chemical and sensory evaluation of complementary mixes based on soy bean (*Glycine max*), unripe plantain (*Musa paradisiacal normalis*), and crayfish (*Euastacus spp*). The food staples (Unripe plantain, Soy bean and Crayfish) were purchased from Ogige Market, Nsukka, Enugu State, Nigeria. Unripe plantain were sliced, steam- blanched, dried and milled into flours, soy bean was boiled, fermented and roasted before milling separately into flours, crayfish was sorted, cleaned, sundried, milled and sieved into the ground form. The flours and the ground crayfish were combined at different ratios on protein basis to produce multi- mixes ($P_{70}S_{30}$, $P_{60}S_{30}C_{10}$, $P_{65}S_{25}C_{10}$, $P_{60}S_{25}C_{15}$) which were quantitatively analyzed for nutrient using AOAC (2010) methods and the methods of Onwuka (2005) then the porridges were organoleptically assessed for taste, flavour, texture, colour and for acceptability. All analyses were done in triplicates using standard methods. ANOVA and Duncan's multiple range tests were used to separate/ compare the means and significance set at P < 0.05. A nine point hedonic scale was used to rate the organoleptic attributes of the porridges made from the mixes. $P_{60}S_{25}C_{15}$ had significantly (P < 0.05) higher protein (24.09%), Zinc (2.08 mg), Calcium (314.51 mg) and Iron (7.36 mg) than the other samples. The Beta carotene values ranged from (129 mg) in $P_{60}S_{30}C_{10}$ to (166 mg) in $P_{65}S_{25}C_{10}$; the Vitamin C values ranged from 11.33 mg in $P_{65}S_{25}C_{10}$ to 15.0 mg in $P_{70}S_{30}$. The $P_{60}S_{30}C_{10}$ had the highest (300 μg) folate value while the $P_{65}S_{25}C_{10}$ had the least value (120 μg). The $P_{60}S_{30}C_{10}$, $P_{70}S_{30}$ $P_{60}S_{30}C_{10}$, $P_{70}S_{30}$ and $P_{60}S_{25}C_{15}$ had the highest ratings in terms of colour (7.20), taste (7.25), flavour (6.80), texture (7.50) and general acceptability (7.00) respectively. The study revealed that ready- to eat complementary food products formulated from locally available food commodities can meet the micro nutritional needs of infants and children. Introduction of nutrient rich soy bean and crayfish in food formulation calls for exploitation in complementary food.

Keywords: *Chemical; Sensory; Complementary; Mixes; Soybean; Unripe Plantain; Crayfish; Evaluation*

Introduction

Complementary foods as defined by Branca and Rossi [1] as those which are appropriately timed, nutritionally adequate and hygienically prepared foods are given. The objective of complementary foods is to complement neither ongoing breast feeding, neither displacing nor replacing breast milk. Complementary feeding typically covers the period from 6 months to 2 years of age and due to the potential for inappropriate feeding practices and risk of malnutrition, this is a very vulnerable period for infants and young children [2].

The aims of giving complementary foods to infants is to introduce smoothly a soft, digestible diet containing adequate calories, proteins and other micronutrients (especially iron, zinc, calcium, vitamins A and C and folate), free of contamination (pathogens, toxins or harmful chemicals) without much salt or spices, easy to prepare from family foods, easy to eat and easily accepted by the infant in an appropriate amount and at a cost that is acceptable by most families [3]. Interrupted breastfeeding and inappropriate complementary feeding heighten the risk of malnutrition, illness and mortality. Furthermore, it has been shown that even with optimum breast feeding, children will become stunted if they do not receive sufficient quantities of quality complementary foods after 6 months of age [4]. Inadequate complementary feeding lacking in quality and quantity can restrict growth and jeopardize child survival and development [5]. Therefore the essential role of infant and young child feeding is a major factor in child survival, growth and development.

In Nigeria, the high cost of fortified nutritious propriety complementary food is always beyond the reach of most families; therefore many depend on inadequately processed traditional foods consisting mainly of unsupplemented cereal porridges made from maize, sorghum and millet [6]. Also, children are being weaned or introduced to complementary foods that are high starchy gruels, low in protein and other nutrients. About 40% of Nigeria population live below the poverty line and so cannot afford commercial feeding formula for their infants [7]. Consequently, the development of low cost high protein foods from underutilized readily available raw materials is a constant challenge for developing countries like Nigeria. Efforts have been made to improve the nutritional quality of the complementary foods, including fortifying the locally produced food with specific nutrients or blending them with other nutrients rich foods to form nutritious composite mixtures [8]. In order to improve the nutrient content of cereal or pulp fruit fiber/tuber based complementary diets, different types of economical protein rich plant mixtures can be used. These include soybean and groundnut [9]. Soybean is a good source of some micronutrients [10]. It can be used to reduce the prevalence of malnutrition in Nigeria. Soy product is normally used as a supplement in different forms of food for the purpose of improving protein quality [11]. Soybean unlike most oil seed is a dual purpose plant; the bean of the high yielding variety contains about 18% oil and 38% protein and the extraction residue represents more than 40% of the utilization value of the plant [10]. There are however, several fruit like staples including plantain, banana etc. that their nutrient composition and functionality recommends them as foods for fighting hunger and infant malnutrition.

In the view of the above, combining plantain flour and soybean flour (a versatile flour that is among the richest, cheapest and best source of vegetable protein available to mankind, containing high protein, high polyunsaturated fat and lactose, an excellent source of the essential amino acid for body growth, maintenance and reproduction) will give complementary diets the recommended nutrient density and functionality. Therefore, innovative processing and development of complementary foods high in protein will go a long way in mitigating infant malnutrition and hunger.

Materials and Methods

Materials

Green matured plantain (*Musa paradisiacal normalis*), Soybean (*Glycine max*) and Crayfish (*Euastacus* spp.) were purchased from Ogige market in Nsukka, Enugu State, Nigeria.

Preparation of materials

Plantain fruits (*Musa paradisiacal normalis*)

Green matured plantain fruits (*Musa paradisiacal normalis*) were washed to remove adhering soil particles, peeled and stored into thin thickness of about 2 cm. The sliced plantain pulp were blanched at 800C for some few minutes and sundried for 48 hours. The dried plantain slices were milled into flour a hammer mill and sieved through 250 μm aperture size. The flour were packed and sealed in poly ethene and then refrigerated until used.

Soybean (*Glycine max*)

Soybean seeds were handpicked to remove impurities, washed and parboiled at 100^0C for 30 minutes, (this helped in removing the seed coat) then dehulled and soaked in water for 24 hours (to ferment), drained and sundried. The dried seeds were roasted under moderate heat at 80^0C for 10 minutes (to obtain coloured grains and also improve the flavour), milled into fine flour and stored in an air tight container and thereafter were stored in the freezer until it is used.

Crayfish (*Euastacus* spp.)

The crayfish were sorted, cleaned and sun dried, milled and sieved with 30mm particle size sieve to form a fine ground crayfish that was stored in an air tight container and stored in the freezer until it is used.

Formulation of composite flours

The crude nitrogen (N) concentration of each food sample was determined by the micro kjeldahl procedure [12] before being used in the formulation of composite flours. Based on the value of crude N determination and the ratios of food protein sources, the total amounts required to supply 3.25g N per 100g (20g protein/day) for each composite was calculated. Altogether, there are 4 composites. Each derived 70% of its dietary N from the fruit pulp (unripe plantain flour) and 30% legume and animal source (soybean and crayfish) respectively.

S/n	Composite Flour	Ratio
1	$P_{70}S_{30}$	70:30
2	$P_{60}S_{30}C_{10}$	60:30:10
3	$P_{65}S_{25}C_{10}$	65:25:10
4	$P_{60}S_{25}C_{15}$	60:25:15

Table 1: *Formulated complementary mixes.*

Chemical analysis

The moisture, ash, fat, protein and crude fibre content of the composite samples were determined using the method of [12] methods. Carbohydrate content was obtained by difference. The [12] standard methods were also used to determine calcium, iron (using phenanthroline method) and zinc (using dithizone method). Folate, Beta carotene and vitamin C content of the samples were determined using the method of [13].

Saponin and phytate determined by Obadoni and Ochuko [14], tannin determined by Harbone [15] while haemoglutin determined by Onwuka [16].

Estimation of energy value

Energy was calculated from protein, fat and carbohydrate values, using Atwater conversion factors [17].

Organoleptic Evaluation

Four porridges were produced from the composite flours for sensory evaluation. A panel of 20 judges (mothers) was drawn to assess the sensory attributes of the complementary foods formulated. The preference test on the porridges was scored for colour, flavour/ taste, texture, and general acceptability by judges using a nine-point hedonic scale. The porridges were displayed, coded and labeled appropriately in small plastic containers with lids. Spoons were provided for the judges. Water was provided for them to rinse their mouths and spoons after each sampling. The assessment forms were collected at the end of the testing sessions.

A nine point hedonic scale was adopted for sensory evaluation. Where: like extremely (9), like very much (8), like moderately (7), like slightly (6), neither like nor dislike (5), dislike slightly (4), dislike moderately (3), dislike very much (2) and dislike extremely (1).

Data Analysis

The Statistical Package for Social Sciences (SPSS), version 17 was used to analyse the data collected which were expressed as means and percentages where appropriate. One way analysis of variance (ANOVA) and Duncan's multiple range tests were used to separate/ compare the means obtained after each experiment. Differences were considered significant at $p < 0.05$.

Results

In table 2, the moisture content ranged from 7.87% in unripe plantain flour to 14.07% in ground crayfish. The ground crayfish had more ash (16.47%) than soy bean flour (2.60%); and unripe plantain flour (2.33%). The soy bean flour had higher fat content (29.80%) than unripe plantain flour (4.27%) and ground crayfish (8.27%). The ground crayfish had higher protein (54.7%) than soybean (46.76%) and unripe plantain flour (7.00%). The total carbohydrate ranged from 1.61% in ground crayfish to 70.64% in unripe plantain flour.

Parameters	Unripe Plantain	Soy Bean	Ground Crayfish
Moisture (%)	10.93 ± 0.90	7.87 ± 0.31[a]	14.07 ± 0.31[c]
Protein (%)	7.00 ± 0.44[a]	46.76 ± 2.06[b]	54.7 ± 0.45[c]
Fats (%)	4.27 ± 0.99[a]	29.80 ± 1.11[c]	8.27 ± 0.31[b]
Ash (%)	2.33 ± 0.12[a]	2.60 ± 0.20[a]	16.47 ± 0.23[b]
Fibre (%)	4.85 ± 0.34[b]	4.21 ± 0.34[a]	4.94 ± 0.19[b]
Total carbohydrate (%)	70.64 ± 0.00	14.75 ± 0.00	1.61 ± 0.00

Table 2: *Proximate composition of unripe plantain flour, soy bean flour and ground crayfish (per 100g).*

Means ± SD of 3 determinations. Mean values with different superscript in the row are significantly different at P < 0.05.

The nutrient composition of the complementary mixes is presented in table 3. The moisture content of the mixes ranges from 9.97% in $P_{70}S_{30}$ blend to 10.6% in $P_{60}S_{25}C_{15}$. The ash content was lowest in $P_{70}S_{30}$ (2.41%). The $P_{60}S_{25}C_{15}$ had the highest ash content (4.52%) followed by $P_{60}S_{30}C_{10}$ (3.88%) and $P_{65}S_{25}C_{10}$ (3.81%). The fat content ranged from 12.33% in $P_{60}S_{30}C_{10}$ to 11.05% in $P_{65}S_{25}C_{10}$. Fiber content of the mixes was highest in $P_{60}S_{25}C_{15}$ (5.19%), the $P_{65}S_{25}C_{10}$ (4.69%), $P_{60}S_{30}C_{10}$ (4.67%) and the $P_{70}S_{30}$ (4.66%) had comparable values. The protein content of the blends ranged from (18.93%) in $P_{70}S_{30}$ to (24.09%) in $P_{60}S_{25}C_{15}$. The carbohydrate value ranged from 46.31% in $P_{60}S_{25}C_{15}$ to 53.87% in $P_{70}S_{30}$. The $P_{70}S_{30}$ (3395.57 kcal) had the highest energy, followed by $P_{60}S_{30}C_{10}$ (393.61 kcal). The $P_{60}S_{25}C_{15}$ had the least energy value (382.85 kcal).

Samples	$P_{70}S_{30}$	$P_{60}S_{30}C_{10}$	$P_{65}S_{25}C_{10}$	$P_{60}S_{25}C_{15}$
Energy (Kcal)	395.57	393.61	385.33	382.85
Moisture (%)	9.97	10.32	10.5	10.6
Ash(%)	2.41	3.83	3.81	4.52
Fats and oil(%)	11.93	12.33	11.05	11.25
Fibre (%)	4.66	4.67	4.69	5.19
Protein(%)	18.93	23.69	21.71	24.09
Carbohydrate(%)	53.87	46.97	49.76	46.31
β- carotene(mg)	160 ± 2.3[a]	129 ± 9.37[a]	166 ± 0.40[b]	150 ± 3.89[ab]
Vitamin C(mg)	15.0 ± 0.46[c]	14.73 ± 1.32[bc]	11.33 ± 0.35[a]	11.77 ± 2.91[ab]
Folate (mg)	0.20 ± 0.17[a]	0.30 ± 0.23[a]	0.12 ± 0.11[a]	0.19 ± 0.00[a]
Zinc (mg)	1.91 ± 0.15[a]	1.80 ± 0.19[a]	1.82 ± 0.47[a]	2.08 ± 0.06[a]
Calcium(mg)	50.19 ± 7.57[a]	122.35 ± 16.97[b]	99.93 ± 10.49[b]	314.51 ± 23.57[c]
Iron (mg)	3.53 ± 0.79[a]	4.45 ± 0.015[a]	3.68 ± 0.015[a]	7.26 ± 0.05[b]

Table 3: *Nutrient composition of the formulated mixes per 100g.*

$P_{60}S_{30}C_{10}$: Unripe Plantain Flour$_{60}$/Soy Bean Flour$_{30}$/Ground Crayfish$_{10}$; $P_{65}S_{25}C_{10}$: Unripe Plantain Flour$_{65}$/Soy Bean Flour$_{25}$/Ground Crayfish$_{10}$; $P_{70}S_{30}$: Unripe Plantain Flour$_{70}$/Soy Bean Flour$_{30}$; $P_{60}S_{25}C_{15}$: Unripe Plantain Flour$_{60}$/Soy Bean$_{25}$/Ground Crayfish$_{15}$.

The folate content of the blends varied and ranged from 0.12 mg in $P_{65}S_{25}C_{10}$ to 0.30mg in $P_{60}S_{30}C_{10}$. The beta carotene content of the blends ranged from 129 mg in $P_{60}S_{30}C_{10}$ to 166mg in $P_{65}S_{25}C_{10}$ while the vitamin C content ranged from 11.33 mg in $P_{65}S_{25}C_{10}$ to 15.0 mg in $P_{70}S_{30}$.

The zinc content of the mixes was highest in $P_{60}S_{25}C_{15}$ (2.80 mg) and least in $P_{60}S_{30}C_{10}$ (1.80 mg). Calcium was higher in $P_{60}S_{25}C_{15}$ (315.51 mg) than the rest of the samples. The $P_{60}S_{25}C_{15}$ had the highest iron content (7.26 mg) followed by the $P_{60}S_{30}C_{10}$(4.45 mg). The $P_{70}S_{30}$ had (3.53 mg) the lowest iron content.

As shown in table 4, the tannin content varied from 98.53 mg in $P_{65}S_{25}C_{10}$ to 207 mg in $P_{60}S_{30}C_{10}$. The $P_{70}S_{30}$ and $P_{60}S_{30}C_{10}$ had same saponin content values (588.00 mg) each and they had the highest saponin content value followed by the $P_{60}S_{25}C_{15}$ (586.67 mg) and the lowest value had 581.33 mg; the $P_{65}S_{25}C_{10}$. The phytate content varied. It ranges from 42.96 mg in $P_{70}S_{30}$ to 188.76 mg in $P_{60}S_{25}C_{15}$. The $P_{60}S_{25}C_{15}$ had the lowest haemagglutinin content (1.87 Hu/g) followed by the $P_{65}S_{25}C_{10}$ (2.47Hu/g). The $P_{70}S_{30}$ (4.77 Hu/g) had the highest haemagglutinin content.

Samples	$P_{70}S_{30}$	$P_{60}S_{30}C_{10}$	$P_{65}S_{25}C_{10}$	$P_{60}S_{25}C_{15}$
Tannin	123.50 ±10.91^{b}	2.07 ±5.70^{d}	98.53± 4.15^{a}	168.67 ±5.03^{c}
Saponin	588.00± 3.46^{a}	588.00± 3.46^{a}	581.33 ±13.61^{a}	586.67± 5.03^{a}
Phytate	42.96± 8.38^{a}	113± 23.45^{b}	58.20± 4.10^{a}	188.76 ±6.19^{c}
Hemagglutinin	4.77± 1.63^{b}	3.40± 0.87^{ab}	2.47 ±0.61^{a}	1.87± 0.61^{a}

***Table 4:** The antinutrient content of the mixes per 100g.*

Means ± SD of 3 determinations. Means with different superscript on the same column are significantly different (P < 0.05). $P_{60}S_{30}C_{10}$: Unripe Plantain Flour$_{60}$/Soy Bean Flour$_{30}$/Ground Crayfish$_{10}$; $P_{65}S_{25}C_{10}$: Unripe Plantain Flour$_{65}$/Soy Bean Flour$_{25}$/Ground Crayfish$_{10}$; $P_{70}S_{30}$: Unripe Plantain Flour$_{70}$/Soy Bean Flour$_{30}$; $P_{60}S_{25}C_{15}$: Unripe Plantain Flour$_{60}$/Soy Bean$_{25}$/Ground Crayfish$_{15}$.

Table 5 presents the sensory and acceptability test of the porridges from formulated complementary mixes. There were variations in colour. The $P_{60}S_{30}C_{10}$ (7.20) had the highest colour rating, followed by $P_{70}S_{30}$ (7.15) and $P_{60}S_{25}C_{15}$ (6.60) with the least being $P_{65}S_{25}C_{10}$ (6.45). The $P_{70}S_{30}$ (7.25), $P_{60}S_{30}C_{10}$ (7.05) and the $P_{60}S_{25}C_{15}$ (6.70) had comparable taste rating with the $P_{65}S_{25}C_{10}$ (6.05) rated the least. The $P_{70}S_{30}$ (6.95), $P_{60}S_{30}C_{10}$ (6.80), $P_{65}S_{25}C_{10}$ (6.00) and $P_{60}S_{25}C_{15}$ all had comparable flavour rating. The $P_{6}S_{25}C_{10}$ had the least texture rating relative to the other samples. The $P_{70}S_{30}$ (7.50) had the high5est texture rating followed by $P_{60}S_{30}C_{10}$ (7.45) and $P_{60}S_{25}C_{15}$ (6.55). The $P_{70}S_{30}$ had the highest general acceptability rating (7.05), followed by $P_{60}S_{25}C_{15}$ (7.00), $P_{60}S_{30}C_{10}$ (6.90) and $P_{65}S_{25}C_{10}$.

Samples	Colour	Taste	Flavour	Texture	General Acceptability
A	7.15 ± 1.23^{a}	7.25 ± 1.59^{a}	6.95 ± 2.21^{a}	7.50 ± 1.36^{a}	7.05 ± 1.88^{a}
B	7.20 ± 0.95^{a}	7.05 ± 1.43^{a}	6.80 ± 1.99^{a}	7.45 ± 1.39^{a}	6.90 ± 1.89^{a}
C	6.45 ± 1.61^{a}	6.05 ± 1.88^{a}	6.00 ± 1.65^{a}	6.40 ± 2.16^{a}	6.00 ± 2.13^{a}
D	6.60 ± 1.47^{a}	6.70 ± 1.59^{a}	6.15 ± 2.25^{a}	6.55 ± 1.70^{a}	7.00 ± 1.78^{a}

***Table 5:** Sensory and acceptability test of the porridges from formulated complementary mixes.*

Mean values with same superscripts in the same row are significant at P < 0.05. $P_{60}S_{30}C_{10}$: Unripe Plantain Flour$_{60}$/Soy Bean Flour$_{30}$/Ground Crayfish$_{10}$; $P_{65}S_{25}C_{10}$: Unripe Plantain Flour$_{65}$/Soy Bean Flour$_{25}$/Ground Crayfish$_{10}$; $P_{70}S_{30}$: Unripe Plantain Flour$_{70}$/Soy Bean Flour$_{30}$; $P_{60}S_{25}C_{15}$: Unripe Plantain Flour$_{60}$/Soy Bean$_{25}$/Ground Crayfish$_{15}$.

Keys:

Sample A-$P_{60}S_{30}C_{10}$

Sample B-$P_{65}S_{25}C_{10}$

Sample C-$P_{70}S_{30}$

Sample D-$P_{60}S_{25}C_{15}$

Discussion

The results indicated that, ground crayfish had higher moisture content than the other samples. The moisture content of the sample could be attributed to the relative humidity of the air as at the time of the preparation of the sample. The higher protein content of ground crayfish (57.7%) than the other samples showed that it is a better source of the nutrient than the other samples. This is expected because it is known generally that animal products are high source of protein. Anthropods are insect group that are known to be rich in crude protein and minerals [18,19]. Soy bean had the highest fat content among the samples. This could be attributed to the fact that soy bean is an oil seed. The fat level of 28.9% of the soy bean is comparable with the value reported in literature [20]. The ash content was highest in ground crayfish and this indicates that it contains more minerals than the other samples. Plantain had the highest carbohydrate content (70.64%). This is as a result of the fact that unripe plantain is a fruit pulp and as such it is a starchy food source [21]. The carbohydrate content of the unripe plantain (70.64%) was not comparable with the 83.1% in [22]. This could be as a result of the varying nutritive value of plantain which depends on their ripeness, variety, climatic conditions and soil of crop production [23].

Chemical composition of the Complementary mixes

Research has shown that the traditional complementary foods in developing countries, Nigeria included, are devoid of essential nutrients like proteins but are energy dense [24]. Therefore, this study formulated and evaluated the nutrient content of complementary foods from locally available food materials.

The protein content of $P_{60}S_{25}C_{15}$ was higher than the other samples. This could be attributed to the percentage increase in crayfish added to it. Crayfish is a rich protein source and as such, can be used to complement the protein in the soy bean to boost the protein content of the mixes. The moisture content of the mixes could be as a result of the relative humidity of the air during the period of preparation of the mixes. The samples could be further dried at a higher temperature (80^0C) in order to decrease the moisture content of the mixes. High moisture content could affect the shelf life of the samples and equally increase the microbial load of the samples making it unsafe for consumption. The ash content of the samples ranges from 2.41% in $P_{70}S_{30}$ to 4.52% in the $P_{60}S_{25}C_{15}$. The higher the ash content of the sample, the higher the mineral content in it. Therefore, the $P_{60}S_{25}C_{15}$ had the highest mineral content which could be attributed to the percentage increase of ground crayfish added to it. According to other studies [18,19], arthropods are known to be rich in crude protein and minerals. The highest fat content was in the $P_{60}S_{30}C_{10}$. This could be attributed to the higher percentage of soy bean added to it. According to literature, soy bean is an oil seed and it is rich in protein (40%) and fats (20%), [25]. Therefore, it can be used to formulate complementary foods because it adds protein and fat to it. Carbohydrate content of the mixes ranges from 46.31% in $P_{60}S_{25}C_{15}$ to 53.87% in $P_{70}S_{30}$. The higher carbohydrate content of $P_{70}S_{30}$ could be attributed to the higher percentage of unripe plantain flour that was added to the sample.

The result indicated that the energy content of the samples was highest in $P_{70}S_{30}$ (395.57 kcal), with the least being the $P_{60}S_{25}C_{15}$ (382.85 kcal). The energy value of (395.57 kcal) in $P_{70}S_{30}$ was expected because of the higher percentage of the unripe plantain flour in it. As the percentage of the unripe plantain flour in the samples increased, the energy content also increased. According to [26], plantain is among the basic food crops that are cheap source of energy. Dewey, [ref] stated that the energy needs from complementary foods for healthy and breast fed infants from 6 to 12 months are approximately 615 kcal to 894 kcal daily. The samples were not able to meet up to the recommended intake; it met up with 50% average recommended kilocalories of the infants per day.

Minerals

The $P_{60}S_{25}C_{15}$ had highest mineral content than the other samples. It had (2.08 mg), (314.51 mg) and (0.73 mg) for zinc, calcium and iron respectively. This could be attributed to the high mineral content of the ground crayfish which was in a higher percentage in the $P_{60}S_{25}C_{15}$. According to Rondo., *et al*. [3], foods of animal origin have a better iron availability and have some advantage over milk and its derivatives due to their iron content and bioavailability.

The Recommended Nutrient Intake for zinc, calcium and iron are 4.1 mg, 500 mg and 7.0 mg per day respectively [27]. The mixes did not meet the recommended calcium and zinc and then only the $P_{60}S_{25}$C15 met the recommended iron per day. Therefore, fortification of the mixes with appropriate micronutrient or micro nutrient dense foodstuffs will be necessary.

Vitamins

The $P_{60}S_{30}C_{10}$ (300 µg) had the highest folate content when compared to the other samples. This value was able to meet up to the Recommended Nutrient Intake which is 160µg daily for folate [27]. Folate or folic acid is needed in infants and young children for normal cell division, proper growth and optimal functioning of the bone marrow. Vitamin C was highest in the $P_{70}S_{30}$ (15 mg). This value met up to 50% of the RNI for infants and young children daily. The most prominent role of vitamin C is its immune stimulating effect which is important for the defence against infections. It acts as powerful antioxidant that neutralizes harmful free radicals. It aids wound healing and iron absorption. The $P_{65}S_{25}C_{10}$ (166 µg) met 41.5% of the Recommended Nutrient Intake of beta carotene which is 400µg. The mixes were not able to meet the recommended vitamin C and folate per day. Therefore, fortification with appropriate micronutrient or micronutrient dense foodstuffs will be necessary.

Antinutrients

Tannin was most present in $P_{60}S_{25}C_{15}$ with a value of 168.67 mg. Tannins are polyphenolic compounds found in many plants. This could be attributed to the percentage of unripe plantain and soybean in the sample. Tannin often lowers the absorption of some materials into the body. Consuming foods rich in Vitamin C helps in neutralizing tannin's effect on iron absorption [28]. Tannin may be employed medically in antidiarrheal, haemostatic and anti-hemorrhoidal compounds. They have been reported to have antiviral and anti-bacterial effects [29]. Saponin level was highest in the $P_{70}S_{30}$ and $P_{60}S_{30}C_{10}$ (588 mg) than the other samples. Saponins are steroids or compounds found in a variety of plants. The high saponin content of these samples could be attributed to the percentage of soy bean in the samples. Soy saponins have been reported to display diverse health effects [30]. haemagglutinin level of the samples ranges from 1.84hu/g in $P_{60}S_{25}C_{15}$ to 4.77hu/g in $P_{70}S_{30}$. Haemagglutinin refers to a substance that causes the Red Blood Cell to aggluginate. This process is called haemagglutination [31]. The phytate level of the mixes ranges from 428.96mg in $P_{70}S_{30}$ to $P_{60}S_{25}C_{15}$ (188.76 mg). The phytic acid concentration of this sample was attributed to the soy bean in it. Phytic acid is found in legumes, nuts and oil seeds and is associated with proteins and is often isolated or concentrated with protein fraction of these foods [32]. Processing methods such as soaking, cooking, germination and roasting reduces the level of anti-nutritional factors in food thereby bioavailability of nutrients in food products is enhanced. According to [33], an excess of 800 mg phytic acid per day is not a good idea. It has also been reported that phytic acid is not readily absorbed by human and that phytates affects mineral bioavailability only in combination with mineral poor diets [33]. Therefore, the phytate levels of the mixes are within the safe levels and thus will not pose any health challenge.

Sensory evaluation

The $P_{60}S_{30}C_{10}$ were found to be more appealing followed by the $P_{70}S_{30}$. This could be attributed to the higher percentage of soy bean in the formulation which influenced the product appearance. Generally, the mean scores of all formulations were accepted showing that judged by this sensory evaluation, inclusion of soy bean and crayfish at the levels used in this study will not pose problems regarding appearance of the resulting product. The mean scores for taste were generally acceptable. However, in comparison with other formulations, the $P_{70}S_{30}$ was much preferred perhaps due to the absence of the ground crayfish. The mean scores for flavour were generally comparable to each other. The $P_{65}S_{25}C_{15}$ had the least mean score for flavour. As the proportion of the crayfish increased in the formulation, there was a decrease in acceptability of the taste. Conversely, ground crayfish interfered with the taste of the porridge. The $P_{60}S_{25}C_{15}$ had the least mean score for texture as the proportion of ground crayfish increased, the acceptability of the texture decreased. Formulations with a considerable amount of ground crayfish were least liked judged by this sensory attribute. The general acceptability also showed that there was no formulation that was generally rejected. Soy bean and Crayfish (a cheap source of protein) has a role to playing achieving good nutrition and health.

Legumes have played an important role in the traditional diets of many regions throughout the world. Soy bean in particular are unique among these legumes because in addition to its benefits, they are concentrated source of phytochemicals that reduce the risk of certain diseases like cancer [10].

Conclusion

It was observed from the study that formulations with high levels of ground crayfish and soybean had more protein, and reduced carbohydrate. The study also revealed that the complementary mixes formulated met some of the nutritional needs of infants and young children of 6 to 24 months of age. However, the mixes did not meet the calcium, zinc, vitamin C and folate requirements of infants and young children. It is concluded that, local food resources have great potentials in the formulation and preparation of complementary foods. The study showed that the formulated food samples, particularly the soy bean flour and the ground crayfish could be added to complementary food in order to prevent Protein Energy Malnutrition in the developing countries.

What is already known on this topic

Complementary mixes in South Eastern Nigeria has been studied by many interdisciplinary experts with a view of finding out the best mix with optimal nutrient density that will be adequate for infants especially those under 24 months. Formulation of these mixes are not quite exhaustive and many indigenous foods that are readily available for both the urban and rural communities are yet to be exploited.

What the study added

The use of mixture of soybean, unripe plantain and crayfish has not been studied. These crops are indigenous to this region of the country and many times, there are a lot of post-harvest losses due to lack of diversity of these food crops. A more comprehensive and adequate complementary gap can be filled with the use of these foods which are available and can get to the resource poor communities in order to reduce the high prevalence of undernutrition in children innovative processing and development of complementary foods high in protein will go a long way in mitigating infant malnutrition and hunger.

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