Proximate and Sensory Qualities of Complementary Foods Produced from the Blend of Yellow Maize, Soybeans, Periwinkle, Carrots, and "Oze" Seeds

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ABSTRACT

Background: *Poor nutrient intake increases the risk of stunting, wasting and micronutrient deficiencies in young children and the provision of fortified complementary foods is essential in promoting optimal growth and development.*

Objective: *The study evaluated the proximate and sensory qualities of complementary food blends formulated from indigenous staple crops and underutilized 'oze' seeds*

Methodology: *MSRo contained maize, soybean, roasted 'oze' seed (53%, 17%, and 10%), MSBo also contained maize, soybean and boiled 'oze' seed (50%, 15%, and 15%) while MSSo had maize, soybean and sprouted 'oze' seed (47%, 13% and 20%) respectively. All the formulations had 10% periwinkle and 10% carrot flour. Proximate analysis, energy composition and sensory properties were determined using Standard methods; Means, Standard deviations and ANOVA were all computed*

Results: *Proximate composition of the formulated foods (per 100 g) showed low moisture levels of 9.44% and highest energy of 363.72kcal in MSRo, decreased energy of 360.34 kcal in MSBo while MSSo had improved protein contents 13.84%, least fat 6.32% and crude fibre at 3.17%. There was significant difference $p < 0.05$ in some sensory attributes for the complementary foods including the overall acceptability. MSRo was more preferred for colour (8.39) and MSBo for taste (8.02) and aroma (8.22) when compared with the control but MSSo was the least accepted for all the sensory properties.*

Conclusion: *The blend MSBo was recommended for future formulations. Locally formulated complementary foods can potentially improve child nutrition and could help to alleviate malnutrition.*

Keywords: Complementary food, Formulation, Malnutrition and Underutilized crop

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INTRODUCTION

Complementary foods are the initial nutrient-providing foods given to infants alongside breast-milk to bridge the gap of increased nutrient demand after six months of age. In developing nations, children aged between 6-23 months often experience a continuous decline in length-for-age occurrences during the first 2 years of life [1], as a result of inadequate quantity and quality diets as well as poor feeding habits that enhance infection rates [2]. This alarming situation necessitates innovative approaches to enhance the nutritional quality of complementary foods using locally available, affordable, and sustainable resources. The complementary food requirements by age include; 202kcal /day for 6-8 months, 307kcal /day for 9-11 months, and 548kcal /day for infants aged 12-23 months [3]. Most infants and young children suffer from malnutrition not mainly because of poor economic status but also due to the inability to utilize available food sources to meet their daily requirements [4].

A lot of interest is focused on the possibilities of exploring underutilized plant food sources that can provide substitute sources of proteins, micronutrients, and vitamins, while promoting food security [5]. Some underutilized crops remain poorly classified, and limited knowledge of their nutritional prospects has led to their underutilization and devaluation.

Bosqueia angolensis, locally known as "Oze" in several West African communities, is a wild tree species belonging to the Moraceae family. It is rich in protein, micronutrients, and some amino acids needed in our daily diets [6], making them promising food crop for addressing protein-energy malnutrition. However, comprehensive nutritional characterization and safety evaluation of "Oze" seeds remain limited in scientific literature, creating a knowledge gap that hinders their integration into food systems. The formulation of nutrient-dense complementary foods using cereals, legumes, and oilseeds has been widely advocated as a cost-effective approach to combat childhood malnutrition [7]. Maize is a rich source of carbohydrates and has the potential of giving a nutritious complementary food when blended. Soybean protein is one of the least expensive sources of dietary protein. The protein is considered to be a good substitute for animal protein. Carrot (*Daucus carota)* is one of the important nutritious root vegetables, while Edible Periwinkle, a seafood scientifically known as *Tympanotonus fuscatus,* is high in protein, calcium, omega-3 fatty acids, and helps to improve brain health. While nutritional adequacy is paramount, the sensory acceptability of complementary foods is equally critical for their adoption and sustained consumption [8]. Processing methods such as roasting, soaking, and sprouting have been shown to improve the sensory qualities and nutritional characteristics of plant-based foods by reducing anti-nutritional factors, enhancing digestibility, and developing desirable flavours. The selection of appropriate processing techniques and optimal blending ratios is therefore essential in developing complementary foods that are both nutritious and organoleptically acceptable.

Despite the nutritional potential of underutilized indigenous seeds and the crucial need for improved complementary foods, there is limited scientific information on the nutritional composition and sensory acceptability of "Oze" seeds (*Bosqueia angolensis*) in complementary food formulations. Hence, this study seeks to bridge this knowledge gap by investigating the nutrient composition and sensory quality of complementary food blends formulated from local staples and "Oze" seeds. The findings will contribute to evidence-based strategies for using indigenous food resources to address childhood malnutrition and enhance food security in resource-limited settings.

MATERIALS AND METHODS

Procurement and Identification of Raw Materials

The yellow maize *(Zea mays),* soybeans *(Glycine max),* edible periwinkle (*Tympanotonus fuscatus*), and carrots (*Daucus carota)* were bought at Nsukka's Ogige Market in Enugu State, Nigeria. Oze seeds *(Bosqueia angolensis)* were purchased from Orie Igboeze market at Iheaka Igboeze - South Local Government Area, Enugu State, and taken to the Botany Department, University of Nigeria, Nsukka for identification.

Processing of Flour Samples

Yellow maize (Zea mays) flour was obtained by fermenting for 48hrs, with water being replaced every 6 hrs, followed by oven drying at 60 ^{0}C for 12 hrs before the milling process. Soybeans (Glycine max) were soaked for 8hrs, boiled for 45minutes, dehulled, and oven-dried at 60 ^{0}C for 30minutes until they turned golden-brown, and then milled into flour. Fresh edible periwinkles (*Tympanotonus fuscatus*) were de-shelled, oven-dried at 50 ^{0}C for 12 hrs and milled into flour. Fresh carrots (*Daucus carota)* were peeled, grated, and oven-dried at 50 ^{0}C for 8 hours and milled into flour. 'Oze' seeds (*Bosqueia angolensis)* were divided into three portions. One part was washed, roasted for 30 minutes until soft, dehulled, milled, and sieved into flour (RO_F); the second portion was boiled for 45 minutes, dehulled and oven-dried at 50 ^{0}C for 48 hours, and milled and sieved into flour (BO_F). The last portion was soaked for 24 h, kept at room temperature to sprout for 96 h. Water was sprinkled at 8 hrs intervals, oven-dried at 50 ^{0}C for 48 hours, and milled and sieved into flour (SO_F).

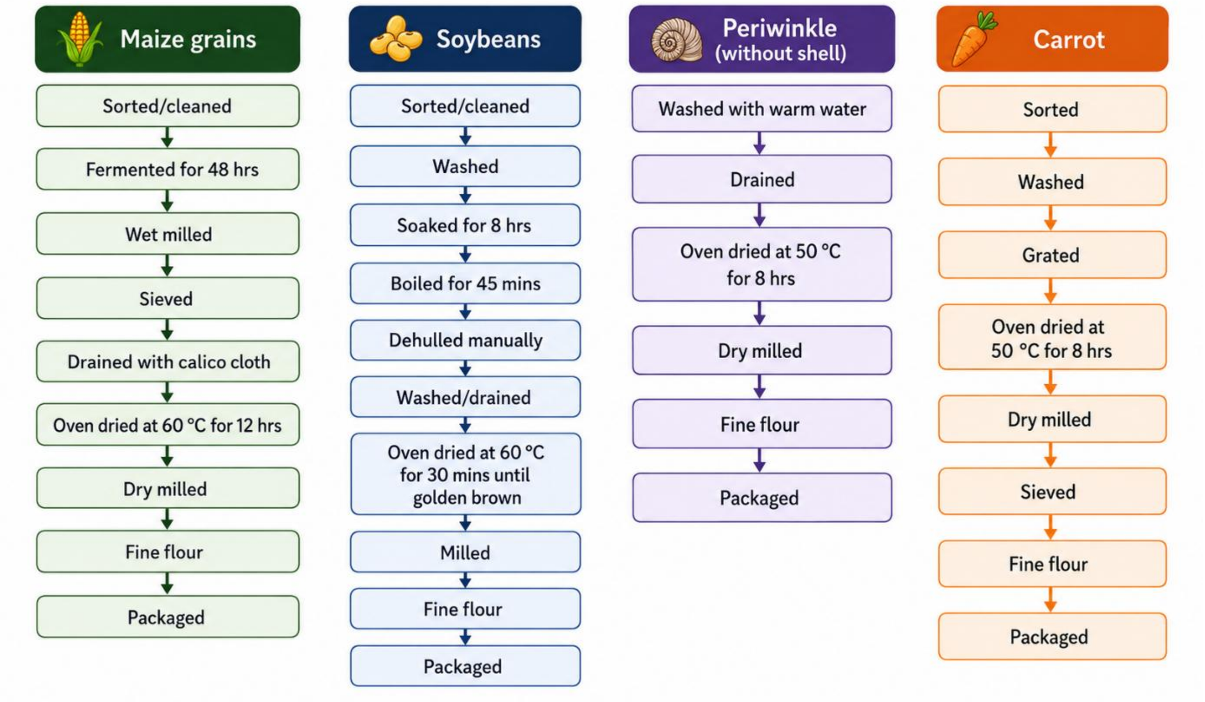

Figure 1: Flow- Chart for Processing Yellow Maize, Soybean, Periwinkle and Carrot Flours

Figure 2: Flow-Chart for Processing Oze Flours

Composite Flour Formulation

The complementary blends were formulated with yellow maize, soybean, oze seeds, periwinkle, and carrot (processed into flour). The flours were subjected to protein content analysis using standard methods. The flours were then combined in different ratios to form composite flours. Pearson's method of diet formulation, which involves the use of a predetermined protein level and some fixed ingredients, was adopted for the study. It was used to furnish a 15% protein target. The formulated complementary foods consisted of (MSRo), (MSBo), and (MSSo). Each food contained roasted 'oze', boiled 'oze', and sprouted 'oze', respectively. Other ingredients included maize, soybean, periwinkle, and carrots. The blend formulation was based on the recommended standards for complementary foods for infants and young children [9].

According to the standard, complementary foods should supply a minimum of 4 kcal/g from carbohydrate on a dry weight basis. Additionally, protein should contribute between 6% and 15% of the total energy of the product, while dietary fiber should not exceed 5 g per 100 g of the food [9]. The flours were combined in different ratios, as shown in Table 1. A commercial instant complementary food consisting mainly of maize served as the control blend.

Table 1. Formulated complementary foods and corresponding flour ratios/ingredients

Formulated Blends	Composite flours	Ratios
(MSRo)	Maize, soybean, oze, periwinkle and carrots	53:17:10:10:10
(MSBo)	Maize, soybeans, oze, periwinkle and carrots	50:15:15:10:10:
(MSSo)	Maize, soybeans, oze, periwinkle and carrots	47:13:20:10:10
Control	Commercial complementary blend	-

Preparation of Complementary Food

The recipe used was modified [10]. About 400 ml of water was boiled at 100 ^{0}C; paste was made by adding 150 ml cold water to 100 g composite flour, which was then added to the boiling water and allowed to cook for about 10-15 minutes while stirring occasionally, and left to cool at room temperature to a serving state of (40 ^{0}C).

Ethical Clearance

Ethical approval was obtained from Kogi State Ministry of Health, Lokoja, Kogi State, with the ethical clearance number MOH/PRS/465/V.1/021 to enable the researcher to engage nursing mothers attending FAREC Women Clinic to participate in the study.

Sensory Evaluation

The sensory evaluation of the complementary food prepared was carried out at FAREC Women Clinic, Lokoja, Kogi State. Forty (40) nursing mothers attending the Clinic were randomly selected for the study. A nine-point hedonic scale ranging from "liked exceedingly" (9) to "disliked excessively" (1) was developed and used for data collection. The panelists were taken in two batches of 20 each, following Covid -19 regulations. They were seated in a well-lit and ventilated hall. The complementary foods and the control were prepared and coded X, G, H, and B, and served in a cup with a spoon at room temperature. The hedonic scoring sheet was given to each of the panelists after a short briefing on the intended exercise, and record their preferences for sensory attributes including colour, texture, aroma, taste, and general acceptability. Water was provided to rinse their mouth after each taste. The forms were collected for evaluation at the end of the exercise.

Proximate Analysis

Moisture determination was done using the Association of Official Analytical Chemists (AOAC) (2019) [11] technique. The samples were in the oven at 105 ^{0}C for 5 hours to a constant weight and cooled in desiccators prior to taking the weight of the dried sample and dish. The final weight was subtracted from the initial weight, divided by the total weight of the sample, and then multiplied by 100 to get the percentage moisture.

Fat analysis adopted the [12] method. Ground samples were weighed and transferred into a rolled filter paper and placed inside the extraction thimble. The extractor contained the thimble and the extraction solvent, petroleum ether. The condenser and the flask were connected to the extractor. The whole unit was placed on a heating mantle for 4 hours to obtain the petroleum ether. The oil collected in the flask was dried in an oven at 105 °C and weighed to calculate the percentage fat.

The AOAC (2019) [11] technique was used to determine the protein content of the formulated blends. The method involves digestion and titration. Anhydrous sodium sulfate weighing 2.5 grams, catalyst weighing 0.5 grams of copper sulfate, 5 mL concentrated sulfuric acid, 10ml of 60% concentrated sodium hydroxide, and 0.01 standard hydrochloric acid were used for the procedure. Ash contents of the blends were evaluated using the AOAC technique (2019) [11] using a muffle furnace. After heating the ashing crucible and weighing the samples, ashing was completed at 600 °C for 6 h. The crucible was taken out of the furnace, cooled in desiccators, and reweighed to calculate the percentage ash.

Crude fibre determination was done to determine the amount of material that is not digestible. Organic solvents, dilute mineral acids, and sodium hydroxide were applied to the raw waste under typical conditions; crude fiber obtained as an inorganic residue was left behind.

The blends' carbohydrate content was calculated by difference. This was done by subtracting the sum of moisture, ash, protein, crude fibre, and fat from the total weight of 100.

$$
\begin{aligned}
Percentage\ total\ carbohydrate \\
&= 100 - \%\,(moisture + ash \\
&\quad + protein + crude\ fibre + fat).
\end{aligned}
$$

The Atwater factor technique $(9 \times \%\, fat) + (4 \times \%\, protein) + (4 \times \%\, carbohydrate)$ was used to compute energy value.

Statistical Analysis

The data generated were analyzed using Statistical software, Statistical Product and Service Solutions (SPSS) Version 23. Percentages, means, and standard deviations were used as descriptive statistics. Means got from nutrient analysis and sensory evaluation of the gruels were compared using Analysis of Variance (ANOVA) and separated using the Duncan New Multiple Range test. A $p < 0.05$ was accepted as the level of significance.

RESULTS

Proximate and Energy Composition of the Formulated Complementary Food

The results in Table 2 recorded a significant difference ($p < 0.05$) across the proximate values in the formulated blends. MSRo contained the lowest values for moisture at 9.44% and the highest amounts of energy (366.14kcal), ash (4.22%), and fat (7.82%), while a significant amount of protein (13.84%) was seen in MSSo with moderate energy levels (360.34kcal). MSBo had the lowest of all proximate values except for moisture at 12.08%.

Table 2. Proximate and Energy Composition of the formulated complementary food per 100g

Formulated foods	Moisture (%)	Fat (%)	Crude Protein (%)	Ash (%)	Crude Fibre (%)	CHO (%)	Energy (Kcal)
MSRo	$9.44^c \pm 0.08$	$7.82^a \pm 0.20$	$12.81^b \pm 0.02$	$4.22^a \pm 0.02$	$4.59^a \pm 0.01$	$61.13^b \pm 0.11$	$366.14^a \pm 0.37$
MSBo	$12.08^a \pm 0.04$	$7.50^b \pm 0.20$	$12.47^c \pm 0.01$	$4.11^b \pm 0.02$	$3.44^b \pm 0.02$	$60.74^c \pm 0.06$	$360.34^c \pm 0.11$
MSSO	$10.04^b \pm 0.05$	$6.32^c \pm 0.03$	$13.84^a \pm 0.03$	$4.08^c \pm 0.02$	$3.17^c \pm 0.03$	$62.87^a \pm 0.04$	$363.72^b \pm 0.27$
Control	NA	10	14.5	NA	2.8	64	401

Values are expressed as mean±standard deviation of duplicate determinations. Means in the same column bearing different superscripts are significantly ($p \leq 0.05$) different. Blend 1MSRo: Maize, Soybean, Roasted oze, periwinkle and carrot flour; Blend 2MSBo: Maize, Soybean, Boiled oze, periwinkle, sugar and carrot flour; Blend 3MSSo: Maize, Soybean, sprouted oze, periwinkle, sugar and carrot flour; Control: maize-soybean commercial complementary food (Cerelac). NA – not available.

Percentage Contribution of the Macronutrients in the Formulated Complementary Food Flour

The results in Table 3 showed the percentage contribution of macronutrients to the energy composition of the formulated complementary foods. MSRo and MSBo had the same level of protein (14%), fat (19%), and carbohydrate (67%), respectively, while MSSo contributed a higher amount of protein (15%) and carbohydrates (69%) and the least contribution from fat at 16%.

Table 3. Percentage contribution of the macronutrients in the formulated complementary food flour per 100g

Formulated Foods	Total energy (kcal)	Protein (%)	Fat (%)	Carbohydrates (%)
MSRo	366.14	14	19	67
MSBo	360.34	14	19	67
MSSo	363.72	15	16	69
Control (Cerelac)	**400**	**6-15**	**20-30**	**60-70**

Values are expressed as mean±standard deviation of duplicate determinations. Means in the same column bearing different superscripts are significantly ($p \leq 0.05$) different. Blend 1MSRo: Maize, Soybean, Roasted oze, periwinkle and carrot flour; Blend 2MSBo: Maize, Soybean, Boiled oze, periwinkle, sugar and carrot flour; Blend 3MSSo: Maize, Soybean, sprouted oze, periwinkle, sugar and carrot flour; Control: maize-soybean commercial complementary food (Cerelac). NA – not available.

Sensory Properties of the Formulated Complementary Food Flour

The results in Table 4 showed significant differences ($p<0.05$) in all the sensory characteristics evaluated. MSBo recorded the highest mean values for taste (8.02), texture (7.78), aroma (8.22), and overall general acceptance (8.19) when compared with other formulated blends. MSSo had the lowest scores for all the sensory properties studied, although much improved values were seen in the control blend

Table 4. Sensory properties of the formulated comp blends per 100g

Formulated food blends	Colour	Taste	Texture	Aroma	General Acceptability
MSRo	$8.39^{a}\pm0.15$	$7.27^{b}\pm0.18$	$7.17^{bc}\pm0.18$	$7.32^{b}\pm0.19$	$7.26^{b}\pm0.19$
MSBo	$7.35^{b}\pm0.15$	$8.02^{a}\pm0.16$	$7.78^{ab}\pm0.21$	$8.22^{a}\pm0.15$	$8.19^{a}\pm0.14$
MSSo	$6.37^{c}\pm0.21$	$6.20^{c}\pm0.22$	$6.80^{c}\pm0.25$	$6.46^{c}\pm 0.30$	$6.30^{c}\pm0.25$
Control (Cerelac)	$8.56^{a}\pm 0.15$	$8.37^{a}\pm0.16$	$8.20^{a}\pm0.15$	$8.56^{a}\pm0.12$	$8.41^{a}\pm0.87$

Values are expressed as mean±standard deviation of duplicate determinations. Means in the same column bearing different superscripts are significantly ($p \leq 0.05$) different. Blend 1MSRo: Maize, Soybean, Roasted oze, periwinkle and carrot flour; Blend 2MSBo: Maize, Soybean, Boiled oze, periwinkle, sugar and carrot flour; Blend 3MSSo: Maize, Soybean, sprouted oze, periwinkle, sugar and carrot flour; Control: maize-soybean commercial complementary food (Cerelac). NA – not available.

DISCUSSION

The moisture content of the formulated complementary food is in agreement with the 10 % suitable for suppressing the growth of microorganisms and favourable for storability. This could be attributed to the processing method employed, which resulted in the retained moisture. Flours and flour products with less than 14 % are highly stable from moisture-dependent deterioration during storage and more resistant to microbial proliferation [13]. The moisture content of any food is an index of its water activity, which also determines its shelf life [14]. The result of this study is higher than the amount in the proximate composition of complementary food from maize, plantain, and soybean blend [15]. Higher protein levels were seen with the increased proportion of sprouted oze seeds and also in formulations containing larger quantities of soybeans. The result is in line with levels reported for complementary flour formulated from barley, maize, and roasted pea flour [16]. Inclusion of periwinkle flour in the formulations may have improved the protein values, as they all fell within the targeted range. The values obtained in this study met the RDA of 13 g recommended for infants 1-3 years of age. The result recorded for fat content indicated that formulations with increased quantities of maize and soybean had significant values. Soybean, being an oilseed, increased the fat content of the blends and is proven to be beneficial in complementary foods. The amount observed in this study is also within the range of fat contents reported for rice, soybean, tiger nut, and millet composite flours [17] and is also higher than the range observed in cassava-cowpea-orange fleshed sweet potato blends [18]. For infants and young children to achieve various physiological and metabolic processes needed for their growth, development, and health, as well as to provide energy, fats are essential [19]. The value in this study is comparable to the level found in proximate composition and selected functional properties of complementary foods from teff fortified with soybean [20]. Low fibre contents observed in the study met the Codex recommendation for fibre (<5 % of total energy) in complementary foods. The similarity in the carbohydrate contents of the complementary foods could be attributed to similar ingredient compositions and the method of formulation. The high carbohydrate levels were an advantage, as a high energy level is required in complementary foods [21].

Complementarity of cereal and legume yielded high energy densities in the formulations. However, their energy values slightly fell short of the Codex standard (400 kcal/100 g). Despite being marginally below the reference standard, these energy levels are still adequate to meet the daily needs of infants aged 6-8 and 9-11 months whose requirements for complementary foods are 202 and 307 kcal, respectively [22]. The slightly lower energy content may be attributed to the incorporation of oze seeds and vegetables (carrot), which typically have lower caloric density compared to pure cereal-based products [23]. The minor variations in energy content across the blends may have resulted from the different processing methods applied to oze seeds. However, inclusion of oil in formulated complementary foods would improve energy composition and also increase acceptability. The results obtained in this study are also consistent with the amount documented for sorghum African yam bean-soybean complementary food blends [24]. All formulated blends demonstrated protein contributions within the recommended range of 6-15 %. The improved protein in the formulations can be attributed to the inclusion of protein-rich ingredients, particularly soybean and oze seeds, both of which are excellent plant-based protein sources. The fat levels found in the formulated blends are slightly below the targeted range, but the increased percentage contribution to the energy composition of the complementary foods suggests that roasting and boiling are more effective at preserving lipid content compared to sprouting, while the low contents observed in MSSo indicates that germination activates lipases that hydrolyse stored fats to provide energy for seedling growth [25]. The amounts of energy from carbohydrates observed in the blends fell within the recommended range. This may be attributed to the predominance of maize flour as the base ingredient in all formulations.

The higher mean value recorded for colour in general acceptability across the formulated complementary food showed no significant difference ($p > 0.05$) from the control. This may be attributed to the roasting process applied to the oze seeds, which enhanced browning that appealed to the panelists, while the significantly lower mean score for colour observed in MSSo could be due to sprouting, which resulted in a less appealing product. This may be as a result of poor coloration during germination, which has been reported in other sprouted grain products [25]. Taste is the one crucial factor that influences the acceptability of any product for consumption and determines the quality of ingested food [26]. The highest mean value for taste was observed in MSBo is comparable to the control (Cerelac), although the least amount recorded in MSSo, could be attributed to the development of "beany" flavours during sprouting, which could have negatively affected its sensory acceptability [27]; while the improved mean score in texture for the formulated products might be due to dual de-hauling, milling and sieving techniques applied during flour preparation for enhanced complementary food smoothness. The mean score recorded in the control and MSBo showed significant acceptability by the panelists, and significant mean values were also seen in aroma. This indicates high acceptability, and a product having a pleasing aroma is more likely to be accepted by the children. Boiling has been shown to promote the formation of pleasant aromatic profiles [28]. Moreover, the roasting process in MSRo produced a favorable aroma score; however, the mean score observed in MSSo suggests that sprouting may have generated musty or earthy smells that were less acceptable to panellists. The formulated products demonstrated significantly higher overall acceptance; however, the values were still lower than the control. This finding aligns with previous studies showing that appropriate processing is crucial for enhancing consumer acceptance of legume-fortified products [29]. Despite the lower scores compared to the control, all the formulated blends achieved acceptability ratings above 6.0 on the 9-point hedonic scale, showing moderate to good consumer acceptance, and are generally considered acceptable for commercial viability [29]. Based on the findings in this study, the formulated products were found to have improved nutrient profiles and energy. The panelists largely agreed that rural mothers could feed their infants and young children with the designed complementary foods during the weaning period. MSBo, which contained composite flour of 50% maize, equal amounts of soybean and boiled “oze” of 15% each, and 10% each of periwinkle and carrot flours, could be judged to be most acceptable to the panelists since it recorded the best sensory properties, as well as high proximate and energy values. Based on the findings of this study, locally formulated complementary foods can contribute significantly in providing nutrients needed for optimal growth in children, and “oze” seeds as an underutilized food could contribute substantially to complementary food formulations.

LIMITATIONS OF THE STUDY

The cost-effectiveness of the products was not evaluated, and this may limit the economic feasibility of its production and large-scale utilization.

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