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Proximate and Micronutrient Composition of Complementary Food from Rice, Carrot, Banana and Peanut Flour Blends

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Abstract

The study determined the proximate and micronutrient composition of complementary foods formulated from rice, dried carrot, banana, and peanut flour blends as affordable alternatives to conventional maize pap for infant feeding. An experimental research design was adopted. Rice, dried carrot, banana, and peanut were processed into flour and blended in four different formulations: A, B, C, and D, while 100% yellow maize pap (Sample E) served as the control. Proximate composition was determined using the AOAC, (2010) standard methods, while selected vitamins (A, B_1, B_2, and E) and minerals (calcium, iron, zinc, and magnesium) were analyzed using standard laboratory procedures. Data obtained were analyzed using descriptive statistics and ANOVA at a 5% level of significance. The results showed that moisture content was 6.42 ± 0.33–8.67 ± 0.26%, protein 6.79 ± 0.62–22.07 ± 0.05%, fat 1.29 ± 0.01–1.95 ± 0.40%, fibre 0.55 ± 0.35–10.98 ± 0.28%, ash 0.20 ± 0.14–3.99 ± 0.84%, and carbohydrate 57.14 ± 0.50–82.30 ± 0.52%. Sample B recorded the lowest moisture content (6.42 ± 0.33%) and the highest protein (22.07 ± 0.05%), iron (2.22 ± 0.00 mg/100 g), zinc (1.91 ± 0.02 mg/100 g), magnesium (132.55 ± 0.49 mg/100 g), vitamin B_1 (0.38 ± 0.00 mg/100 g), vitamin B_2 (0.10 ± 0.01 mg/100 g), and vitamin E (1.22 ± 0.01 mg/100 g). Sample C contained the highest vitamin A (3.03 ± 0.01 mg/100 g) and calcium (130.44 ± 0.37 mg/100 g). The micronutrient composition showed that vitamin A was 0.00 ± 0.00–3.03 ± 0.01 mg/100 g, vitamin B_1 0.10 ± 0.00–0.38 ± 0.00 mg/100 g, vitamin B_2 0.05 ± 0.01–0.10 ± 0.01 mg/100 g, vitamin E 0.21 ± 0.01–1.22 ± 0.01 mg/100 g, calcium 6.42 ± 0.01–130.44 ± 0.37 mg/100 g, iron 0.47 ± 0.00–2.22 ± 0.00 mg/100 g, zinc 0.29 ± 0.01–1.91 ± 0.02 mg/100 g, and magnesium 27.55 ± 0.05–132.55 ± 0.49 mg/100 g. The formulated complementary foods generally exhibited superior nutritional quality compared with the control sample. The study concluded that complementary foods produced from rice, dried carrot, banana, and peanut flour blends, particularly Samples B and C, are nutrient-dense and nutritionally superior to conventional yellow maize pap, making them suitable for complementary feeding of infants and young children. It is recommended that caregivers and food processors promote the production and utilization of these locally available food blends to improve infant nutrition and reduce the prevalence of malnutrition.

Keywords: Complementary food, Proximate composition, Micronutrient analysis, Infant nutrition, Flour blend.

Introduction

Breast milk is the most important source of nutrition during infancy because it protects infants from infectious and non-infectious diseases while supporting optimal growth and development. With few exceptions, breast milk alone (with vitamin D supplementation) meets the nutritional needs of a healthy infant up to six months of age. The World Health Organization (2022) recommends exclusive breastfeeding for the first six months of life, accompanied by the introduction of complementary foods while breastfeeding continues for up to two years and beyond. After six

months, breast milk alone becomes insufficient to meet the increasing nutritional demands of the growing infant, making complementary feeding necessary (WHO/UNICEF, 2022).

Complementary feeding refers to the gradual introduction of solid, semi-solid, and liquid foods alongside breast milk or formula. It typically begins at six months and continues up to 24 months or beyond (Perez-Escamilla *et al,*2021). Complementary foods provide additional nutrients such as iron and zinc that may be inadequate in exclusive breastfeeding. The American Academy of Pediatrics (AAP, 2012) recommends the introduction of nutrient-dense solid foods after six months while discouraging the introduction of cow's milk before one year of age. Readiness for complementary feeding includes signs such as good head control and the ability to sit with support).

Traditional complementary foods such as pap (*ogi*/*akamu*) are commonly prepared from maize but often undergo processing that reduces nutrient density (Akinsola *et al.2021*). There is therefore a need to formulate nutrient-rich complementary foods using locally available ingredients. Rice (*Oryza sativa*) is a widely consumed staple with dietary fibre, vitamins, and minerals, and it is gluten-free, making it suitable for diverse populations (Zubair *et al.* 2023). Carrot (*Daucus carota*)is rich in beta-carotene and other antioxidants that support vision and immune function (Terao, 2023). Banana (*Musa species*) provides carbohydrates, potassium, and bioactive compounds that promote digestive health and energy supply (Singh *et al.*2023). Peanut (*Arachis hypogaea*) is a protein- and energy-dense legume that contains healthy fats, vitamins, and antioxidants, contributing to growth and cardiovascular health (Houston *et al.*2023).

Nutritional composition refers to the nutrients present in food, including proximate components (protein, carbohydrates, ash, and energy) and micronutrients such as vitamins and minerals. Food acceptability is equally important and refers to an individual's willingness to consume a food based on sensory attributes such as color, taste, aroma, and texture. Evaluating proximate composition and micronutrient content is therefore essential to determine the nutritional quality and consumer acceptability of the developed complementary food..

Statement of the Problem

Infant malnutrition remains a significant public health challenge in Nigeria, partly due to the poor nutritional quality of complementary foods introduced after six months of age. Although breast milk alone is no longer sufficient to meet the nutritional requirements of infants beyond this age, many commercially available complementary foods are either unaffordable or inaccessible to low-income households. Locally prepared complementary foods, particularly cereal-based products, are often low in protein, essential vitamins, and minerals required for optimal growth and development. Consequently, infants who depend on these foods are at increased risk of protein-energy malnutrition and micronutrient deficiencies. While rice, dried carrot, banana, and peanut are locally available and nutrient-rich food materials, limited information exists on their combined use in the formulation of complementary foods with acceptable nutritional quality. Therefore, this study was undertaken to formulate complementary food from rice, dried carrot, banana, and peanut flours and evaluate its proximate composition and micronutrient content as a potential affordable alternative for infant feeding.

Objective of the Study

This main purpose of the study was to formulate complementary food from rice, dried carrot, banana, and peanut flour blends and evaluate its proximate composition and selected micronutrient content for infant feeding

Hypothesis

H0₁: There is no significant difference in the proximate composition and selected micronutrient content of complementary foods formulated from different of ratios rice, dried carrot, banana, and peanut flour blends

Materials and Methods

Sample Procurement

Rice (*Oryza sativa*), fresh carrot (*Daucus carota*), ripe banana (*Musa* spp.), and peanut (*Arachis hypogaea*) were purchased from Ibagwa-Aka Market, Igbo-Eze South Local Government Area, Enugu State, Nigeria. The samples were sorted manually to remove damaged materials and foreign matter before processing.

Rice flour was prepared according to the method described by Yu et al. (2024) with slight modification. Rice grains were washed thoroughly, parboiled, drained, air-dried, roasted at low temperature, milled into flour, sieved through a 250-µm mesh, packaged in airtight polyethylene bags, and stored at room temperature until use.

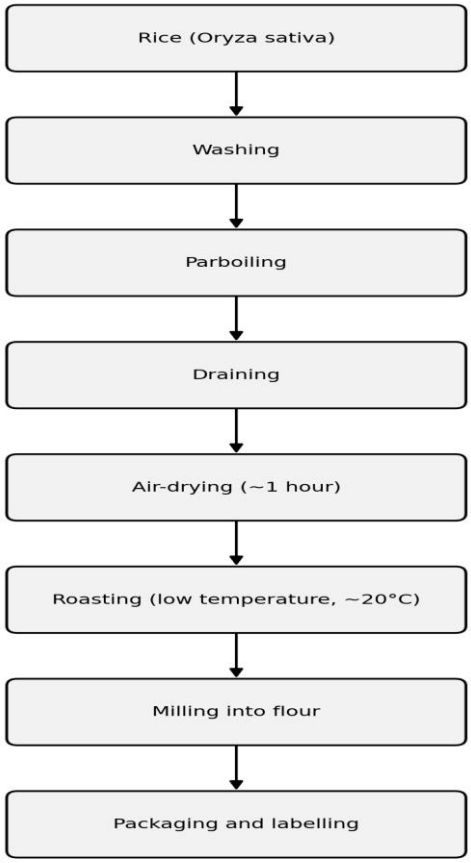


Figure 1: *Flow chart for the production of rice flour.*

Carrot powder was processed according to the method described by Sharma et al. (2022) with slight modification. Fresh carrots were washed, peeled, sliced into thin pieces, blanched, oven-dried at 60 °C to constant weight, milled into powder, sieved, packaged in airtight polyethylene bags, and stored until required.

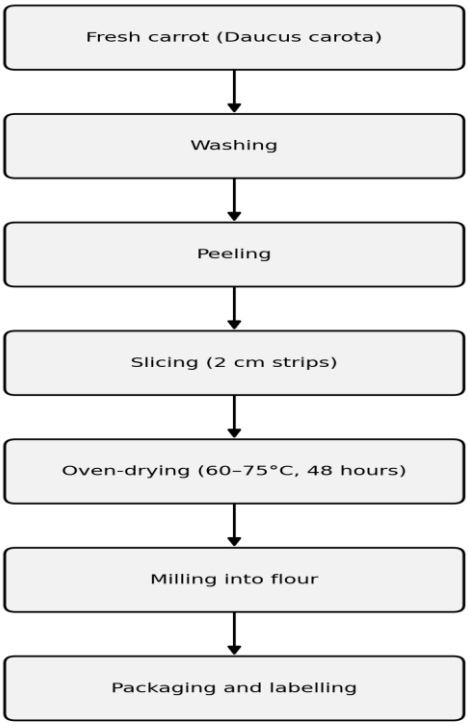


Figure 2: *Flow chart for the production of dried carrot flour.*

Banana powder was prepared according to the method described by Okafor et al. (2026) with slight modification. Bananas were washed, peeled, sliced uniformly, oven-dried, milled into flour, sieved, packaged in airtight polyethylene bags, and stored until formulation.

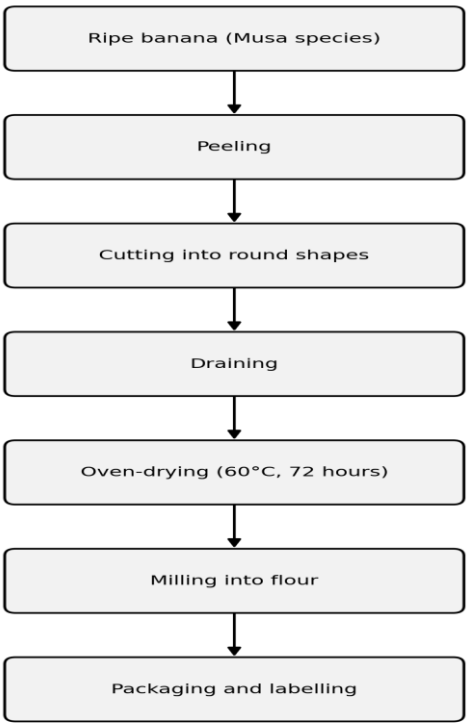


Figure 3: *Flow chart for the production of ripe banana flour.*

Peanut flour was prepared according to the method described by Barbalho et al. (2024) with slight modification. Peanut seeds were sorted, washed, roasted, manually dehulled, cooled, milled into flour, sieved through a 250-µm mesh, packaged in airtight polyethylene bags, and stored at room temperature until use.

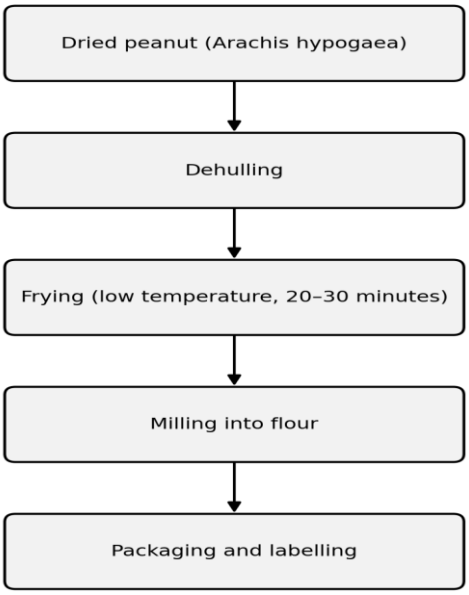


Figure 4: *Flow chart for the production of peanut flour.*

Formulation of Complementary Food Flour Blends

The complementary food formulations were prepared by blending rice, dried carrot, banana, and peanut flours in different proportions as shown in **Table 1**. A commercially available maize pap served as the control.

Table 1: Formulation of rice, dried carrot, banana, and peanut flour blends

Sample	Rice (%)	carrot (%)	Banana (%)	Peanut (%)
A	20	20	40	20
B	20	20	20	40
C	20	40	20	20
D	25	25	25	25
E (Control)	100% Maize pap	–	–	–

Each formulation was thoroughly mixed to obtain a homogeneous flour blend, packaged in airtight polyethylene bags, appropriately labelled, and stored at room temperature prior to proximate and micronutrient analyses. The proximate composition of food product was determined using the Association of Official Analytical Chemist (AOAC), (2010) procedure.

Design of the Study

This study employed an experimental design to formulate complementary foods from rice, carrot, banana, and peanut flour blends and evaluate their nutrients composition. Four formulations and one control sample were prepared and analyzed. Proximate composition and selected micronutrients were determined using standard analytical methods. This is as follows:

Proximate Analysis

The proximate composition of the formulated complementary foods, including moisture, crude protein, crude fat, ash, crude fiber, carbohydrate, and energy value, was determined according to the standard methods of AOAC, (2019). Moisture content was determined by oven drying the samples at 105 °C to constant weight (Method 925.10). Crude protein was determined using the Kjeldahl method (Method 979.09), and the nitrogen content obtained was multiplied by a conversion factor of 6.25 to estimate protein content. Crude fat was determined by Soxhlet extraction using petroleum ether as the extraction solvent (Method 920.39). Ash content was determined by incinerating the samples in a muffle furnace at 550 °C until a light grey ash was obtained (Method 923.03). Crude fiber was determined by sequential acid and alkali digestion followed by incineration (Method 962.09). Carbohydrate content was calculated by difference as: Carbohydrate (%) = 100 − [Moisture (%) + Protein (%) + Fat (%) + Ash (%) + Crude fiber (%)].

Micronutrient Compositions

The micronutrient composition of the formulated complementary foods was determined by quantifying selected vitamins (A, B_1, B_2, and E) and minerals (calcium, iron, zinc, and magnesium) using standard AOAC (2019) analytical procedures. Vitamins A and E were determined by high-performance liquid chromatography (HPLC) following appropriate solvent extraction procedures, while vitamins B_1 (thiamine) and B_2 (riboflavin) were determined by HPLC after acid extraction and enzymatic hydrolysis. Mineral analysis was carried out after wet digestion of the samples using a nitric acid, perchloric acid mixture. Calcium, iron, zinc, and magnesium contents were quantified using Atomic Absorption Spectrophotometry (AAS) according to AOAC (2019) methods. All determinations were carried out in duplicate, and the results were expressed as mean ± standard deviation.

Table 2 Table 2 shows the proximate composition of the formulated complementary food samples and the control. Moisture content ranged from 6.42 to 8.67%. Sample B had the lowest moisture content, whereas Samples A, C, D, and E did not differ significantly ($p > 0.05$). Protein content ranged from 6.79 to 22.07% and differed significantly ($p < 0.05$) among all samples. The highest protein content was observed in Sample B, while the control (Sample E) recorded the lowest value. Fat content ranged from 1.29 to 1.95%. The control sample contained significantly ($p < 0.05$) more fat content than the formulated samples, whereas no significant difference ($p > 0.05$) was observed among Samples A, B, C, and D. Fiber content ranged from 0.55 to 10.98%, with Samples C and D exhibiting the highest values and the control the lowest. Ash content varied from 0.20 to 3.99%, with all formulated samples having significantly higher ash contents than the control ($p < 0.05$). Carbohydrate content ranged from 57.14 to 82.30%. The control sample had the highest carbohydrate content, whereas the formulated samples contained significantly lower carbohydrate levels ($p < 0.05$).

Table 2: Proximate composition of complementary food from rice, carrot, banana and peanut flour blends

Proximate composition (%)

Sample	Moisture	Protein	Fat	Fiber	Ash	CHO
A	8.18^{a}±0.01	15.45^{d}±0.21	1.29^{b}±0.01	6.29^{c}±0.06	3.44^{a}±0.34	65.37^{b}±0.62
B	6.42^{b}±0.33	22.07^{a}±0.05	1.36^{b}±0.01	9.39^{b}±0.66	3.39^{a}±0.00	57.39^{d}±0.28
C	8.67^{a}±0.26	16.59^{c}±0.37	1.32^{b}±0.00	10.54^{a}±0.33	3.99^{a}±0.84	58.90^{c}±0.42
D	8.35^{a}±0.45	19.42^{b}±0.09	1.30^{b}±0.00	10.98^{a}±0.28	2.84^{a}±0.76	57.14^{d}±0.50
E	8.22^{a}±0.20	6.79^{e}±0.62	1.95^{a}±0.40	0.55^{d}±0.35	0.20^{b}±0.14	82.30^{a}±0.52

Values are expressed as mean ± standard deviation of duplicate determinations (n = 2). Means with the same superscript within a column are not significantly different (p > 0.05). A–D represent the formulated complementary food samples, while E represents the control (100% yellow maize pap). The compositions of samples A–D are presented in Table 1.

Table 3 presents the vitamin composition of the formulated complementary food samples and the control. Vitamin A content ranged from 0.00 to 3.03 mg/100 g and differed significantly ($p < 0.05$) among the samples. Sample C recorded the highest vitamin A content, whereas no detectable vitamin A was observed in the control (Sample E). Vitamin B_1 (thiamine) content ranged from 0.10 to 0.38 mg/100 g, with Sample B having the highest concentration and the control the lowest. Similarly, vitamin B_2 (riboflavin) content ranged from 0.05 to 0.10 mg/100 g. Sample B exhibited the highest riboflavin content, while Samples A and C did not differ significantly ($p > 0.05$) but both contained higher levels than the control. Vitamin E content ranged from 0.21 to 1.22 mg/100 g and varied significantly ($p < 0.05$) among the samples. Sample B contained the highest vitamin E concentration, followed by Sample D, whereas the control recorded the lowest value. Overall, the formulated complementary food samples contained significantly higher levels of vitamins A, B_1, B_2, and E than the control sample.

Table 3: Micronutrients composition of complementary food from rice, carrot, banana and peanut flour blends

Selected Vitamins composition (mg/100g)

SAMPLE	A	B1	B2	E
A	1.53^{d}±0.00	0.21^{c}±0.00	0.09^{ab}±0.01	0.63^{c}±0.01
B	1.56^{c}±0.01	0.38^{a}±0.00	0.1^{a}±0.01	1.22^{a}±0.01
C	3.03^{a}±0.01	0.17^{d}±0.00	0.09^{ab}±0.00	0.67^{c}±0.01
D	2.29^{b}±0.01	0.26^{b}±0.01	0.08^{b}±0.00	0.79^{b}±0.03
E	$0^{e.}$ 00±0.00	0.10^{e}±0.00	0.05^{e}±0.01	0.21^{d}±0.01

Values are expressed as mean ± standard deviation of duplicate determinations (n = 2). Means with the same superscript within a column are not significantly different (p > 0.05). A–D represent the formulated complementary food samples, while E represents the control (100% yellow maize pap).

Table 4 presents the mineral composition of the formulated complementary food samples and the control. Calcium content ranged from 6.42 to 130.44 mg/100 g and differed significantly ($p < 0.05$)

among the samples. Sample C recorded the highest calcium content, whereas the control (Sample E) had the lowest value. Iron content ranged from 0.47 to 2.22 mg/100 g, with Sample B containing the highest concentration and the control the lowest. Zinc content also varied significantly ($p < 0.05$), ranging from 0.29 to 1.91 mg/100 g. Sample B exhibited the highest zinc content, while the control contained the lowest level. Similarly, magnesium content ranged from 27.55 to 132.55 mg/100 g and differed significantly ($p < 0.05$) among the samples. Sample B recorded the highest magnesium content, whereas the control had the lowest value. Overall, the formulated complementary food samples contained significantly higher concentrations of calcium, iron, zinc, and magnesium than the control sample.

Table 4: Micronutrients composition (selected Minerals) of complementary food from rice, carrot, banana and peanut flour blends

Selected mineral composition (mg/100g)

SAMPLE	Ca	Fe	Zn	Mg
A	78.24^{d}±0.01	1.76^{b}±0.01	1.63^{b}±0.00	96.06^{b}±0.01
B	118.30^{b}±0.42	2.22^{a}±0.00	1.91^{a}±0.02	132.55^{a}±0.49
C	130.44^{a}±0.37	1.69^{c}±0.01	1.47^{d}±0.01	82.59^{d}±0.24
D	113.66^{c}±0.55	1.48^{d}±0.01	1.53^{c}±0.01	88.76^{c}±0.40
E	6.42^{e}±0.010	0.47^{e}±0.00	0.29^{e}±0.01	27.55^{e}0.05

Values are expressed as mean ± standard deviation of duplicate determinations (n = 2). Means with the same superscript within a column are not significantly different ($p > 0.05$). A–D represent the formulated complementary food samples, while E represents the control (100% yellow maize pap). The compositions of samples A–D are presented in Table 1.

Discussions

Sample B is the most protein-rich (highest among A–E), which aligns with Pobee *et al*., (2017) due to soybean addition boosted protein to 10.7–15.24 g/100 g) and Sogo-Temi *et al*., (2023) (12.18% protein). All studies show that protein levels can be significantly influenced by the type and proportion of protein-rich ingredients (e.g., soybeans, velvet beans, crayfish). Like Pobee *et al*., (2017) (68.44–73.87 g/100 g) and Sogo-Temi *et al*., (2023) (82.93%), samples (especially Sample E) also show high carbohydrate content, which is typical for complementary foods based on cereals or plantains. While both Pobee *et al*., (2017) and Sogo-Temi *et al*., (2023) reported deficiencies (iron and calcium in Pobee *et al*.), some samples (Sample E with very low protein and ash) also show imbalanced nutrient distribution.

There is significant moisture difference, with Sample B being significantly drier. This is similar with the finding of Sogo-Temi *et al*. (2023) which shows low moisture (6.49%), supporting long shelf life while showing moisture differences across samples. The Protein levels in this study vary widely (B > D > C > A > E), showing clear statistical differences. This is clearly different as in the protein content of Pobee *et al*. (2017) which shows more uniform across the samples- RSM-5, RSM-10, RSM-15. Also, the protein content of the study varies with that of Sogo-Temi *et al*. (2023) as the samples display greater protein variability, suggesting more diverse ingredient contributions.

Sample E has significantly higher fat while in Pobee *et al*. (2017) and Sogo-Temi *et al*. (2023) have similar low-fat levels-(6.22–7.61 g/100 g) and (1.50%) respectively. Hence, sample E demonstrates a much higher fat level which could improve energy density but reduces protein balance. Sogo-Temi *et al*. (2023) revealed a very low fiber (0.35%) which is suitable for infants. This is different from the study's fiber content as it shows fiber variability, while Sogo-Temi kept fiber minimal for

digestibility. Most samples especially sample E shows a clear Ash (Mineral) Content deficit while maintaining balanced in the study of Sogo-Temi *et al*. (2023) and Pobee *et al*. (2017). The carbohydrate level in Sample E is highly rich, whereas B and D are lower. This aligns with high carbohydrates contents of the studies of Pobee *et al*. (2017) (68–73 g/100 g) and Sogo-Temi *et al*. (2023) (82.93%). However, the samples in this study show broader variation compared to the more consistent carbohydrate levels in the two studies.

Sample C (40% carrot flour) had the highest vitamin A (3.03 mg/100 g), while Sample E (100% yellow maize pap) had 0.00 mg/100 g and was significantly lower than all others ($p < 0.05$). The Carrot-/β-carotene–rich blends raise vitamin A. This is similar with the finding of Marcel *et al.* (2022) where vitamin A density was high due to β-carotene in carrot. Plain (non-biofortified) maize pap is poor in vitamin A. Sample E's 0.00 mg/100 g agrees with Akinsola et al. (2021) conclusion that *regular* maize pap offers negligible vitamin A unless biofortified or co-formulated with carotenoid-rich foods. The study by Akinsola et al. (2021) showed that Provitamin A in maize still met ~18.3% of children's vitamin A requirement per serving despite processing losses. This underscores that, compared with the formula set by thus study, using (provitamin A) PVA maize (or carrot/OFSP) is an alternative path to elevate vitamin A in cereal-based complementary foods.

Vitamins B1 (thiamine) and B2 (riboflavin) were found to be high in Sample B due to the "peanut effect". Sample B (40% peanut) was highest in B1 (0.38 mg/100 g) and B2 (0.10 mg/100 g) and significantly higher than others ($p < 0.05$ for both), except for the modest, non-significant differences among A–D for B2. Marcel, *et al.* (2022) reported significant processing and ingredient effects on micronutrient density (including vitamins) and this is consistent with the statistically significant separations among blends ($p < 0.05$) of the present study. According to Sen *et al.* (2017), traditional African complementary foods tend to have markedly lower thiamine (~2–10× lower) and riboflavin (~4–10× lower) than human milk. However, the Vitamin B1 and B2 content of the present study breaks that pattern, illustrating how food-to-food fortification with B-vitamin–rich ingredients (like groundnut/peanut) can correct these deficits.

Peanut-rich Sample B had the highest vitamin E (1.22 mg/100 g) and cereals alone (Sample E) were much lower (0.21 mg/100 g) and significantly different ($p < 0.05$). Cereals are generally poor in vitamin E. Review by Udeh *et al.* (2021) on cereal vitamins note that cereals tend to be limited in vitamin E, and fortification/enrichment is commonly needed. Thus, the findings that pure maize pap (E) was the lowest fits that broader pattern, while the peanut-driven rise in E in Sample B is biologically expected given groundnut's natural tocopherol content.

Calcium (Ca) value in (Sample C, 130.44 mg/100 g) far exceed Oguizu and James, (2022)'s best Ca (28.7 mg/100 g) about 4.5× higher because of 40% carrot flour is calcium-rich, whereas their blends relied mainly on maize, soybean, and groundnut with modest Ca yields. The Ca value also outperformed that of Marcel *et al.* (2022) (70.5 mg/100 g), likely because their highest-Ca mixture still centered on amaranth/soy/pumpkin/OFSP, none of which matches carrot's Ca density in your matrix. However, the orange fleshed sweet potatoes-soybean–date blends of Abuengmoh *et al.* (2024) delivered 261.8–351.3 mg/100 g, 2–3× the Ca value in the present study, showing that aggressively Ca-dense ingredient mixes (and possibly differing moisture bases / processing) can push Ca value much higher than either the present study or Marcel et al. achieved.

The best value of Fe (2.22 mg/100 g) was found in peanut-heavy Sample B and this is lower than Oguizu & James (2022)'s 2.91 mg/100 g despite both studies using groundnut/peanut—suggesting your overall matrix (carrot/maize proportions, processing) didn't concentrate Fe as effectively. Marcel, *et al.* (2022) reported much higher Fe (up to 18.4 mg/100 g) in amaranth–soy–pumpkin–orange fleshed sweet potatoes porridges; extrusion + germination and Fe-rich amaranth/pumpkin seeds likely explain the order-of-magnitude jump. Abuengmoh *et al.* (2024) also reported 10.73–19.91 mg/100 g Fe, again which is greater than 2.22 mg/100 g of this study, showing that

legume/seed/Orange fleshed sweet potatoes/date formulations can deliver iron densities closer to WHO targets without pharmaceutical fortification.

The top Zn (1.91 mg/100 g) is less than half of Oguizu & James (2022)'s Zn value (4.71 mg/100 g), despite the peanut enrichment in the present study. Their higher soybean + groundnut share in Maize-Soybean-Groundnut and Date (415) likely boosted Zn more effectively. Marcel *et al.* (2022) achieved 9.5 mg/100 g Zn, and Abuengmoh *et al.* (2024) reached 5.33–25.34 mg/100 g, both far above the Zn level of the present study, again pointing to zinc-dense seeds (amaranth/pumpkin), legumes, and processing as the levers.

Magnesium (Mg) value of this study (132.55 mg/100 g) are ~8.7× higher than Oguizu & James (15.31 mg/100 g) a clear peanut effect, since groundnut is Mg-rich and you used 40%. Also, Marcel *et al.* (2022) reported an even higher Mg (186.6 mg/100 g), reflecting the very Mg-dense pumpkin seed and amaranth in their blends showing that adding pumpkin seed/amaranth could push Mg even higher.

Conclusion and Recommendations

The study established that complementary food formulated from rice, carrot, banana, and peanut flour blends provide improved nutritional quality and acceptable sensory properties compared to traditional 100% maize pap. The inclusion of peanut flour enhanced protein content, micronutrients, and shelf-life stability, while dried carrot improved vitamin A and mineral composition. Banana contributed positively to taste and overall acceptability. In contrast, the conventional maize pap was nutritionally less adequate and less preferred. The findings demonstrate that locally available ingredients can be effectively combined to produce affordable, nutrient-dense, and acceptable complementary food suitable for infants and young children.

The use of rice, dried carrot, banana, and peanut flours in complementary food formulation should be encouraged as a cost-effective strategy for improving infant nutrition, particularly in resource-limited settings.

References

Abuengmoh, P., Gernah, D. I., & Ahure, D. (2024). Complementary food formulated from orange flesh sweet potato, soybean and date palm flour blends improve on the functional, vitamins and mineral properties children's formulas. *Asian Journal of Food Research and Nutrition, 3*(3), 609–620.

Akinsola, O. T., Alamu, E. O., Otegbayo, B. O., Menkir, A., & Maziya-Dixon, B. (2021). Nutritional properties of ogi powder and sensory perception of ogi porridge made from synthetic provitamin A maize genotype. *Frontiers in Nutrition, 8*, 685004. https://doi.org/10.3389/fnut.2021.685004

American Academy of Pediatrics (AAP). (2012). Breastfeeding and the use of human milk. Pediatrics, 129(3), e827–e841. Retrieved April 27, 2012, from https://pediatrics.aappublications.org/content/129/3/e827

AOAC, (2010). *Official methods of analysis* (17th ed.). Association of Official Analytical Chemists. Washington, D.C., U.S.A.

Association of Official Analytical Chemists (AOAC) International. (2019). *Official methods of analysis of AOAC international* (21st ed.). AOAC International

Barbalho, S. M., et al. (2024). *Peanut (Arachis hypogaea L.) seeds and by-products in metabolic syndrome and cardiovascular disorders: A systematic review of clinical studies*. Phytomedicine, 124, 155170. https://doi.org/10.1016/j.phymed.2023.155170

Houston, L., Probst, Y. C., Singh, M. C., & Neale, E. P. (2023). Tree nut and peanut consumption and risk of cardiovascular disease: A systematic review and meta-analysis of randomized controlled trials. *Advances in Nutrition, 14*(5), 1029–1049. https://doi.org/10.1016/j.advnut.2023.05.004

Marcel, M. R., Chacha, J. S., & Ofoedu, C. E. (2022). Nutritional evaluation of complementary porridge formulated from orange-fleshed sweet potato, amaranth grain, pumpkin seed, and soybean flours. *Food Science & Nutrition, 10*(2), 536–553. https://doi.org/10.1002/fsn3.2675

Okafor, C., et al. (2026). *Development and characterization of fortified ready-to-eat banana porridge flour: A multi-age nutritional intervention*. Journal of Food Processing and Preservation. https://doi.org/10.1155/jfpp/9211449 (DOI)

Pereira A & Maraschin M (2015). Banana (Musa spp) from peel to pulp: ethnopharmacology, source of bioactive compounds and its relevance for human health. Journal of Ethnopharmacology. 2015 Feb 3; 160:149-63.

Pérez-Escamilla, R., Yakes Jimenez, E., & Dewey, K. G. (2021). Responsive feeding recommendations: Harmonizing integration into dietary guidelines for infants and young children. *Current Developments in Nutrition, 5*(6), nzab076. https://doi.org/10.1093/cdn/nzab076

Pobee RA,Johnson PNT, Akonor PT & Buckman, SE,(2017) . the nutritional, pasting and sensory properties of weaning food from rice(Oryza sativa, soybeans(Glycine max) and Kent mango(Magnifera indica) flour blend. Vol.17(1). African Journal of Food, Agricultue, Nutritionand Development.

Putnick, D. L., Ghassabian, A., Clayton, P. K., Sundaram, R., & Yeung, E. H. (2025). *Developmental readiness for complementary feeding: Associations with initiation before age 6 months*. The Journal of Pediatrics, 286, 114722. https://doi.org/10.1016/j.jpeds.2025.114722

Sharma, S., Kaur, M., & Kaur, J. (2022). *Development and quality evaluation of carrot powder using hot-air drying technology*. Journal of Food Processing and Preservation.

Sogo-Temi CM, Idowu OA & Lateef AM,(2023). Nutritional quality assessment of complementary food from plantain, velvet bean and crayfish. *International Journal of Scientific Research and Management*,11(10). DO i - 10.18535/ijsrm/v11i10.ft01

Terao, J. (2023). Revisiting carotenoids as dietary antioxidants for human health and disease prevention. *Food & Function, 14*(16), 7799–7824. https://doi.org/10.1039/D3FO02330C

Udeh, F. N., Akinola, S. A., & Alabi, O. (2021). Vitamins in cereals: A critical review of content, health effects, processing losses and bioavailability. *Frontiers in Nutrition, 8*, 586815. https://doi.org/10.3389/fnut.2021.586815

World Health Organization (WHO). (2022). *Indicators for assessing infant and young child feeding practice part 3: Country profile.* Geneva.

Zubair, M., Anwar, F., Arshad, I., Malik, S., & Zafar, M. N. (2023). Rice nutraceuticals and bioactive compounds: Extraction, characterization and antioxidant activity: A review. *Combinatorial*

Chemistry & High Throughput Screening, 26(15), 2625–2643. https://doi.org/10.2174/1386207326666230512144834