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# Effect of Processing Method on Proximate, Mineral and Anti-nutrients Composition of Complementary Foods Produced from Maize, Soybean and Pumpkin Seed

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors ATI and AR contributed to the design of the study. Authors AIA and AEO were involved in the purchase and processing of the complementary food samples. Authors ATI, AEO, AIA and AR wrote the final draft and they are responsible for the integrity of the work as a whole. All authors read and approved the final manuscript.*

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## ABSTRACT

**Background:** Complementary foods are formulated food mixtures meant to be fed along with breast milk for infants from 6months until completely weaned off of breast milk.

**Objective:** This study is therefore designed to assess the effect of processing method on nutrients and anti-nutrient composition of complementary foods from Maize, Soybean and Pumpkin Seed

**Methods:** Raw materials were purchased at Owena Market in Ondo state while a commercial complementary food was purchased Ayofem shopping mall and supermarket, Akure Ondo state. Maize, soy beans and pumpkin seeds were separately subjected to fermentation, sprouting and toasting, milled into powder and packaged. The flours were formulated into three (3) different samples using the ratio 70:20:10 for maize, soybean and pumpkin seed respectively. The complementary were labeled as follows, sample A (70% fermented maize: 20% fermented soybeans: 10% fermented pumpkin seed) B (70% roasted maize: 20% roasted soybeans: 10% roasted pumpkin) and C (70% sprouted maize: 20%sprouted soybeans: 10% sprouted pumpkin) were formulated. Samples of the complementary foods were subjected to chemical and instrumental analysis using standard methods. Analysis of variance (ANOVA) was performed using Statistical Package for Social Science (SPSS) version 23. Difference is considered statistically significant at *P<0.05.*

**Results:** Findings shows that sample B was significantly *(P<0.05)* lower in moisture content (8.18%) but higher than the control sample D (2.5%). The control sample was higher in crude fibre (4.5%), Ash (3.0%). Protein was significantly *(P<0.05)* higher in sample A (18.39%) while sample B (11.33%) has the highest fat and energy (410kcal) content. Sample D had the highest carbohydrate (65.0%) compared to other samples. Beta-carotene content varies from 0.203mg to 0.461mg.The oxalate, cyanide and phytate content was significantly (*P<0.05*) higher in sample C (21.350mg), 4.637mg and B (7.296mg) respectively. The mineral content of the samples is significantly different from one another. Sample A was significantly *(P<0.05)* lower in Ca (16.02mg), Mg (26.979), K (62.185), and P (125.12mg), while Sample C was significantly *(P<0.05)* higher in Ca (27.034), Mg (42.996mg), K (569.069mg), and P (281.162) respectively. The Iron (Fe) content was significantly (*P<0.05*) higher in sample A (14.008mg).

**Conclusion:** This study had shown that fermentation, toasting and sprouting improved the nutrients composition of the formulated complementary foods and can replaced the control sample for feeding infant age 6months and above.

*Keywords: Complementary food; processing methods; minerals; Phytochemical; pumpkin seed.*

## 1. INTRODUCTION

"Introduction It has been investigated that during the first six months of life, breast milk is the best meal for infants" [1,2]. "It has every vital vitamin and immune component a newborn needs to maintain good health and growth. But beyond six months, the nutrients in breast milk are no longer enough to support the baby's nutritional needs throughout transitions. As a result, complementary foods are offered, which in many developing nations usually span the age range of six to twenty-four months" [2]. "When the nutrients in breast milk are no longer sufficient to meet an infant's calorie and macronutrient needs, complementary foods are intentionally prepared and provided to them in addition to breast milk" [3].

When breast milk is no longer sufficient for a baby's needs, complementary foods become increasingly important in terms of the child's growth and development [4]. Nutrient-dense, low viscosity, bulk density, suitable texture, and a consistency that facilitates simple intake are all necessary for high-quality complementary foods [5].

Most Nigerian families cannot afford the exorbitant cost of fortified, healthy, complementary food sold in the country [6]. These families frequently rely on traditional diets that have been under processed, primarily on unprocessed grain porridge produced from millet, sorghum, and maize [6] "Infants are at risk for malnourishment, infections, and death due to inadequate complementary feeding methods, safety, and low-quality complementary foods. Some of these staple crops have a high energy density and often lack other macronutrients such as protein and micronutrients" [7]. "Maize is a popular complementary food base in sub-Saharan Africa. It is made into a thin gruel, and it contains a low amount of essential amino acids such as lysine" [8]. "Traditional complementary foods from maize commonly given to infants are not enough to meet the daily nutrients, energy, and micronutrient requirements, and this has been the major cause of malnutrition in infants and young children in developing countries" [9,10]. In developing countries, it's a non-fact that animal sources of protein are inadequate to meet the rapid population growth considering their cost and availability, which is a major cause of food insecurity, and intense research efforts are currently directed towards the identification and evaluation of food grains that normally have considerable protein content [6]. "The addition of legumes to plant-based foods is reported to improve the protein content and provide deficient amino acids in complementary foods" [11,12]. "Enriching complementary foods with soybeans and pumpkin seeds is a convenient, inexpensive, and highly effective way to upgrade the quality of traditional complementary foods and provide the nutrition a growing child needs, and soybeans work together with cereals to achieve an overall increase in the value of the protein" [6]. "Like other seeds, they are rich in functional components such as vitamin E and pro-vitamin D and are good sources of magnesium, potassium, and phosphorus, as well as other minor minerals such as zinc, magnesium, iron, calcium, sodium, and copper" [13]. "They are also used for fortification up to 10%, which increases the protein, lysine, mineral contents, total sulfur amino acids, chemical score, protein digestibility, crude fat, and ash of the final product compared to using 100% wheat flour" [13, 14,15,16]. "The processing of grains could be in the form of milling (dry and wet milling), thermal processing, germination, fermentation, roasting or cooking, soaking, autoclaving or sterilization, or enzymatic treatment. A study had shown that the processing method of grains had some significant effects on their viscosity, dietary bulkiness, and nutrient density" [12]. The high cost of commercial complementary foods, coupled with household food insecurities and the global economic meltdown, now demands effective strategies for improving the nutritional status of infants and young children by promoting the use of high-quality complementary foods that could be of better nourishment, low in dietary bulkiness, and viscous at cottage-level production. Therefore, this study was designed to assess the effect of the processing method on the proximate, mineral, and anti-nutrient composition of complementary foods produced from maize, soybean, and pumpkin seed.

## 2. MATERIALS AND METHODS

### 2.1 Procurement of Raw Materials

The raw materials used for the production of the complementary foods are; dried yellow maize, Pumpkin seed and soybean. These raw materials were purchased from Owena Market, Idanre Local Government Area of Ondo State. The methods of processing of the flour into different samples in this study are fermentation, sprouting and toasting. Commercial complementary food was purchased Ayofem shopping mall and supermarket, Akure Ondo state to serve as the control sample for the formulation and production.

### 2.2 Production of Fermented Maize Flour

The yellow maize was sorted by removing stones and other contaminants. It was followed by cleaning the sorted maize in clean water, steeping into water for three (3) days for fermentation to occur in line with the method described by Ademulegun et al*.* [12]. "The fermented maize was washed with clean water and wet-milled using attrition milling machine. The wet-milled fermented maize was then sieved using muslin cloth and was allowed to settle down over night to form slurry. The maize slurry was put in clean muslin cloth and squeezed to remove water. This was air dried for three (3) days, milled and packaged in air tight container and kept in a refrigerator prior to analysis" (Chart 1) Ademulegun et al*.* [12].

### 2.3 Production of Sprouted Maize Flour

The yellow maize was sorted by removing broken maize, stones and other contaminants. It was followed by cleaning and soaking for 72hrs at ambient temperature. The hydrated maize was drained, spread thinly on a wet thin foam placed inside a tray and covered with another layer of wet thin foam in line with a method described by Ademulegun et al*.* [12]. The grains were germinated for four (4) days with constant watering between intervals. After four (4) days, the un-terminated maize was discarded while the sprouted maize was sun dried for three (3) days. After sun drying, it was de-vegetated before milling into flour, sieved and packaged in air tight container and kept in a refrigerator prior to analysis (Chart 1).

### 2.4 Production of Toasted Maize Flour

The yellow maize was sorted by removing stones and other contaminants. The sorted maize was toasted for fifteen minutes (15mins). The toasted maize was allowed to cool and attrition mill machine was used to mill it into fine particles. It was sieved and packaged in air tight container and kept in a refrigerator prior to analysis (Chart 1).

### 2.5 Production of Fermented Soybean Flour

The soybean was sorted by removing stones and contaminants. It was followed by cleaning the sorted soybean in clean water. It was followed by steeping it in water for three (3) days for fermentation to occur. The fermented soybean was washed with clean water and wet-milled using attrition mill. The wet-milled fermented soybean was then sieved using muslin cloth and was allowed to settle down over night to form slurry. The soybean slurry was put in clean muslin cloth and squeezed to remove water. This was sundried for three (3) days, milled and packaged in air tight container and kept in a refrigerator prior to analysis (Chart 2)

### 2.6 Preparation of Sprouted Soybean Flour

"The Soybean seeds were cleaned by hand, sorted and floated to remove broken grains and extraneous materials. The grains were soaked for 24hours at ambient temperature. The hydrated grains were drained and spread thinly on a wet jut bag and covered with another layer of jut bag. The seeds were germinated for three days with watering every six (6) hours. Un-germinated grains were discarded while the sprouted ones were oven dried ($50^{0C}$ for 12 hours) and de-vegetated before milling to flour, sieved and packaged in air tight container and kept in a refrigerator prior to analysis" (Chart 1) [12]

### 2.7 Preparation of Toasted Soybean Flour

"The soybean seeds were sorted and cleaned. The grains were soaked for 24hours at ambient temperature and dehulled and boiled for 2hours, drained and oven dried ($50^{0C}$ for 12 hours) Soybean seeds were toasted using frying pan on a cooking gas for 30minutes until golden brown coloration was achieved. The soybean was milled using attrition milling machine in ratio to fine particle, sieved and packaged in air tight container and kept in a refrigerator prior to analysis" (Chart 1) [12].

### 2.8 Production of Fermented Pumpkin Seeds

The pumpkin fruits were broken in other to extract the pumpkin seeds. The extracted pumpkin seeds were sun dried for two (2) hours and dehulled. Cleaning of the dehulled pumpkin seeds were done with clean water and it was sliced into small pieces and fermented for 72hours. The fermented pumpkin seeds were washed with clean water and wet milled using attrition milling machine. The wet-milled fermented pumpkin seed was then sieved using Muslin cloth and allowed to settle down over night to form slurry. The pumpkin seeds slurry was put in a clean muslin cloth and squeezed to remove water. This was sundried for three (3) days, milled and packaged into fine particles.

### 2.9 Preparation of Toasted Pumpkin Seeds

The pumpkin fruits were removed from the seed pod. It was sundried for 2hrs, dehulled and sliced into small pieces. The sliced pumpkin seeds were sundried for 48hrs and it was toasted for about fifteen minutes (15mins). The toasted pumpkin seed was allowed to cool and attrition milling machine was used to mill it into fine particles. It was sieved and packaged.

### 2.10 Preparation of Sprouted Pumpkin Seeds

The pumpkin fruits were removed from the seed pod. The seeds were arranged in layers of a saw-dust inside a medium rubber basket. It was wetted daily for 8day. The sprouted pumpkin seeds were sorted, washed and dehulled. The dehulled pumpkin seeds were sliced and sundried for 3days. It was milled and packaged.

### 2.11 Formulation of Maize-Soybean Complementary Food Blends

Table 1 shows the flour formulation of the maize –soybean flour complementary food in 70:20: 10 ratios respectively.

### 2.12 Proximate analysis of the formulated complementary foods

The ash, protein, crude fibre, fat and moisture contents of the formulated complementary foods were determined using the standard methods described by AOAC [17]. "Total carbohydrate was calculated as the difference between 100 and the sum of the percentages of ash, protein, crude fibre, fat and moisture" [18]. "The sample energy value was calculated from the percentages of crude protein, total carbohydrates, and total fat. The conversion factors used were 9kcal/g for total fat, 4kcal/g for protein and carbohydrates respectively" [19].

### 2.13 Determination of Beta Carotene

2g of the sample was weighed into a 250ml volumetric flask, 50ml of petroleum ether: Acetone (2:1v/v) mixture was added to the extract the ß-Carotene. The flask containing the mixture was placed on a shaker to shake at 200rpm for 20min to ensure uniform mixing at room temperature. The mixture was later centrifuged at 4000rpm for 10min and the supernatant collected and made up to 50ml with the solvent mixture. The supernatant was transferred to a 250ml separatory funnel to separate the organic layer (upper layer). The aqueous layer was discarded and the organic layer was transferred into the 50ml volumetric flask and made up with solvent mixture for reading of ß-carotene. Working standard of ß-carotene of range 0-50ppm or /ml were prepared from stock Beta carotene solution of 100ppm concentration. The absorbances of samples as well as working standard solutions were read on a Cecil 2483 UV Spectrophotometer at a wavelength of 450nm against blank [17].

$$\text{B} - \text{carotene}\ (\mu\text{g}/100\text{g}) = \frac{\text{Absorbance of sample x Average Gradient x Dilution Factor}}{10000}$$

### 2.14 Determination of Phytate

This was determined using McCance-Widdowcon method as modified by Wheeler and Ferrel [20]. 2g of the defatted samples were extracted with 3% Triochloroacetic acid (TCA) was precipitated with 4ml of ferric chloride solution. The precipitated ferric phytate was converted to ferric hydroxide with 4ml 1.5M sodium hydroxide each and was then dissolved in hot 40ml 3.2M $HN0_3$ and then diluted with 20ml of 1.5M KSCN. The iron was determined colorimetrically.

**Table 1. Formulation of Maize-Soybeans- pumpkin seed complementary foods**

| Samples | Maize (%) | Soybean (%) | Pumpkin seed (%) |
|---|---|---|---|
| A | 70% fermented maize flour | 20% fermented soybean | 10% sprouted pumpkin seed |
| B | 70% toasted maize flour | 20% tasted soybean | 10% sprouted pumpkin seed |
| C | 70% sprouted maize flour | 20% sprouted soybean | 10% sprouted pumpkin seed |

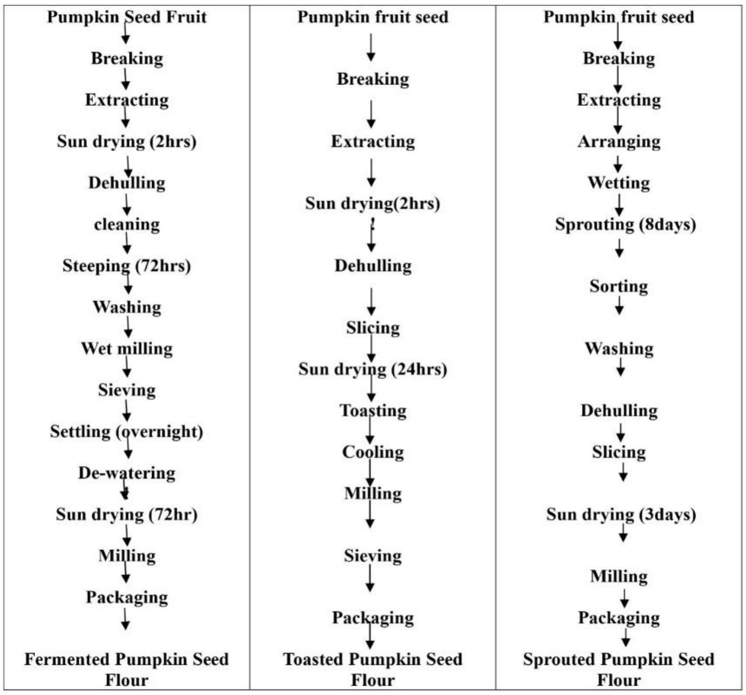


**Chart 1. Flow chart for the production of pumpkin seed flour using different processing method**

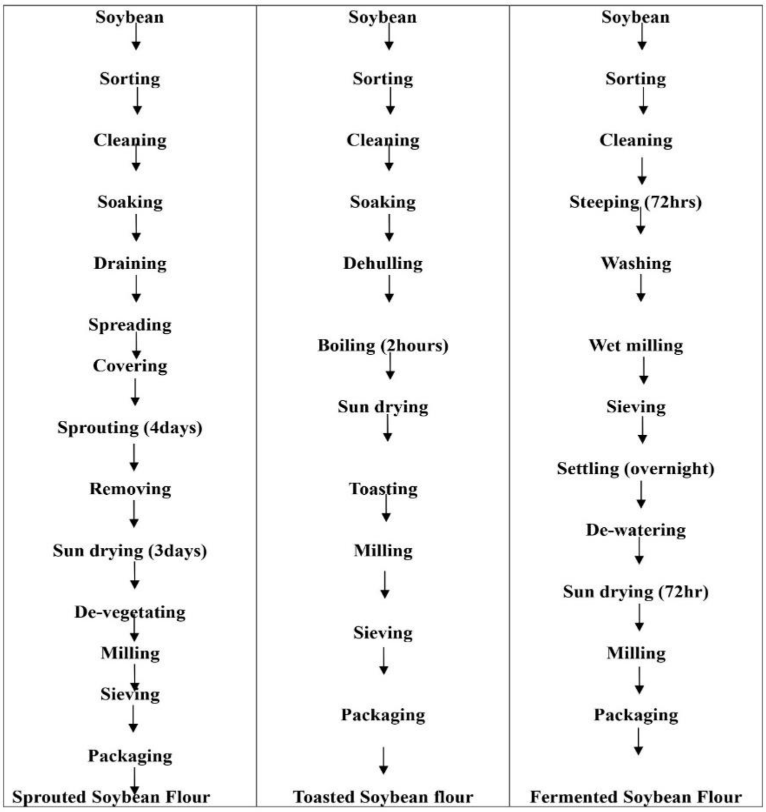


**Chart 2. Flow chart for the production of soybean flour using different processing method**

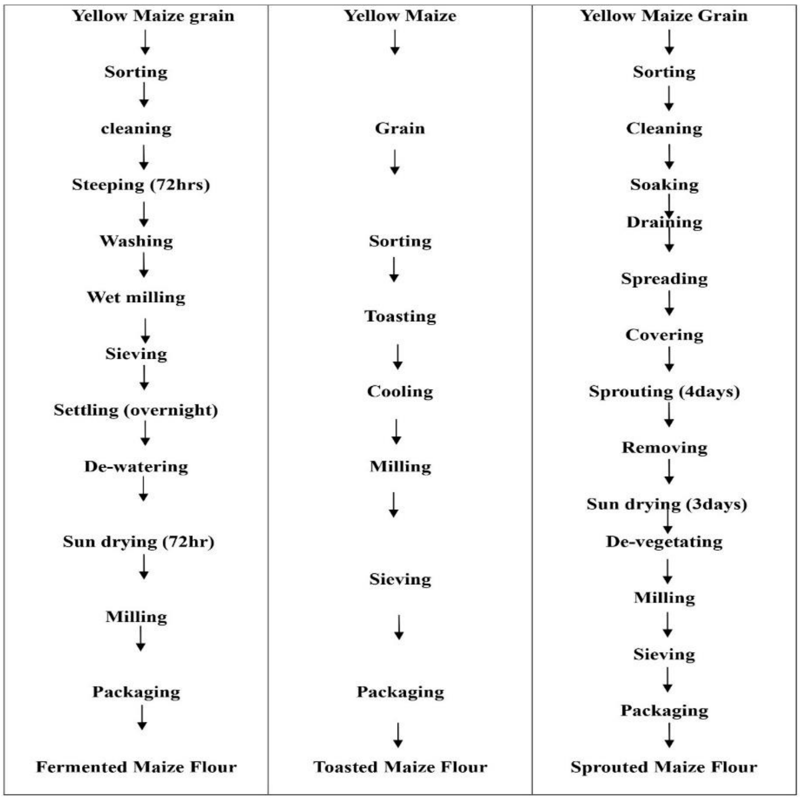


**Chart 3. Flow chart for the production of maize grain flour using different processing method**

### 2.15 Cyanide Determination

The measurements of total cyanide contents in the samples were performed according to the auto-enzymatic method. The samples (1g) were incubated in 20 ml acetate buffer (pH 5.5) at 37°C for 18 hours. After incubation, the samples were cooled at room temperature (20°C) and then, 4 ml of NaOH were added. The samples were placed into a distillation flask round bottom containing distilled water. The flask was heated at 100°C in a digital temperature-controlled dry bath and its central neck was connected to the condenser glass directly attached to two bubbler in series containing each 10ml of 0.1M $K_2CO_3$. After, which 10 ml of $H_2SO_4$were added to the flask by one of the two side necks to facilitate evaporation of HCN in sample. In the second lateral neck, a very thin tube was inserted, directly immersed into the solution and allowing the entry of air. The air flow was controlled by vacuum pump placed after the second bubbler. During distillation, the HCN released was constantly carried through the glass condenser and trapped in the first bubbler. The second is considered as a control measure. After 15 minutes, the solution of the first bubbler was collected in a flask (50 ml) and made to volume with 0.1 M $K_2CO_3$. The anion CN- was measured using a polar graph (Metrohm E 506 with Stand Polar record 663 VA Stand) in differential pulse mode. Oxygen dissolved in the solution was removed by bubbling nitrogen (inert gas) for 5 minutes. Finally, the registration of the polar gram was done in an unstirred solution. The residual cyanide contents in the samples measurements were performed according to the method described above with slight modification by adding the commercial linamarase [17].

### 2.16 Determination of Oxalate

“This was determined using Dye method. 2g each of the samples was extracted with dilute HCl, 10ml concentrated ammonia and then precipitated with calcium chloride as calcium oxalate. The precipitate was then washed with 25ml of hot 25% H2SO4 and dissolved in hot water and titrated with 0.05M KMnO4 to determine the concentration of oxalate” [21].

### 2.17 Determination of Mineral Contents of the Formulated Complementary Foods

The mineral contents were determined in a dilute solution of the ash samples according to the method outlined in AOAC [17] by Atomic Absorption Spectrophotometer (AAS) (210 bulks scientific) for Calcium, Copper, Magnesium, Iron, phosphorus, Zinc while potassium was by flame photometry and phosphorus was determined by colorimetric method.

### 2.18 Statistical Analysis

Statistical analysis of the data was carried out using the one-way Analysis of Variance (ANOVA) technique (SPSS 17.0 for windows), and the differences were separated using Duncan’s Multiple Range Test (DMRT) at a level considered to be significant at $p < 0.05$.

## 3. RESULTS

### 3.1 Proximate Composition of Complementary Food

The moisture content of the formulated sample was significantly lower in sample B (8.18%), but, higher than the 2.5% of the control sample. The protein content ranged from 14.09 to 18.3%. Sample C had the least protein (14.09%) content lower than the Sample D while sample had the highest protein content (18.39%). The fat content of formulated blends revealed that sample B was significantly ($P<0.05$) higher in fat (11.33%) than any other sample formulated including the control. The crude fibre content was low in the formulated samples and they were all significantly ($P<0.05$), lower than the control sample (4.50%) and ranged between 1.35%and 1.69% for sample A and C respectively. Ash and carbohydrate content of the samples were significantly ($P<0.05$) higher in the control sample respectively. Sample A had the least energy (357kkcal) content while sample B (419kcal) had the highest energy content and it was significantly ($P>0.05$) higher than any other samples including the control sample.

### 3.2 Minerals content of complementary food

The Calcium content of the commercial complementary food (sample D) (600mg/100g), was significantly ($P<0.05$) higher than any of the formulated samples. The formulated samples had an appreciable amount of magnesium. Although, sample A was significantly ($P<0.05$) lower that sample B and C. Potassium content of the commercial complementary food (sample D) (635mg/100g), was significantly

(P<0.05) higher than any of the formulated samples. Sample A had least potassium (62.185mg/100g). Phosphorus was significantly (P<0.05) high in sample C (281.162mg/100g) while sample A had the least value (125.12mg/100g). All the formulated samples had an appreciable amount of iron higher than the control sample (6.0mg/100g). There was no significant difference (P<0.05) between sample A (6.238mg/100g) and sample D (7.0mg/100g) which the control in terms of zinc content. Copper content of the sample B was significantly (P<0.05) higher in the than any other samples.

### 3.3 Beta-Carotene and Anti-Nutrients Content of Complementary Foods

The samples were low in beta-carotene compared to the commercial complementary food (sample D) (24.6mg/100g). On the anti-nutrient composition, sample C had the highest value of oxalate (21.35mg/100g) while sample B had 12.18mg/100g. Phytate was significantly (P<0.05) higher in sample B (7.29mg/100g) sample A had the least value (7.48mg/100g) and significant difference (P<0.05) existed samples. Cyanide (4.637mg/100g) was higher in sample C than any other formulated samples.

**Table 2. Proximate composition of complementary food**

| Parameter | Sample A | Sample B | Sample C | Sample D |
|---|---|---|---|---|
| Moisture (%) | 10.58±0.023$^{b}$ | 8.18±0.035$^{c}$ | 12.15±3.348$^{a}$ | 2.50±0.01$^{d}$ |
| Crude protein (%) | 18.39±0.045$^{a}$ | 16.68±1.769$^{b}$ | 14.09±0.020$^{d}$ | 15.0±0.01$^{c}$ |
| Crude fat (%) | 4.49±0.010$^{d}$ | 11.33±0.045a | 11.00±0.035$^{b}$ | 10.0±0.01$^{c}$ |
| Crude fibre (%) | 1.35±0.005$^{d}$ | 1.48±0.020$^{c}$ | 1.69±0.020$^{b}$ | 4.50±0.01$^{a}$ |
| Total ash (%) | 0.59±0.015$^{d}$ | 0.68±0.015$^{b}$ | 2.18±0.015$^{b}$ | 3.00±0.01$^{a}$ |
| NFE (%) | 64.58±0.255$^{b}$ | 62.630±0.007$^{d}$ | 63.31±0.025$^{c}$ | 65.0±0.01$^{a}$ |
| Energy (Kcal) | 357.03±1.035$^{c}$ | 419.38±37.97$^{a}$ | 408.36±.135$^{b}$ | 410.10±0.101$^{b}$ |

*Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same column are statistically not significant at (P<0.05). Key: A (70% fermented maize: 20% fermented soybeans: 10% fermented pumpkin seed) B (70% roasted maize: 20% roasted soybeans: 10% roasted pumpkin) and C (70% sprouted maize: 20%sprouted soybeans: 10% sprouted pumpkin: D commercial complementary food*

**Table 3. Minerals content of complementary food**

| Parameter | Sample A | Sample B | Sample C | |
|---|---|---|---|---|
| Ca (mg/100g). | 16.020±0.445$^{c}$ | 23.526±0.149$^{b}$ | 27.034±0.141$^{a}$ | 600.0±0.010$^{a}$ |
| Mg (mg/100g). | 26.979±0.045$^{b}$ | 42.916±0.030$^{a}$ | 42.996±0.039$^{a}$ | NA |
| K (mg/100g). | 62.185±0.032$^{d}$ | 544.754±0.355$^{c}$ | 569.067±0.167$^{b}$ | 635.0±0.010$^{a}$ |
| P (mg/100g). | 125.120±0.012$^{c}$ | 256.337±0.122$^{b}$ | 281.162±0.058$^{a}$ | NA |
| Fe (mg/100g). | 14.008±0.358$^{a}$ | 11.311±0.019$^{b}$ | 13.730±0.093$^{a}$ | 6.00±0.010$^{a}$ |
| Cu (mg/100g) | 1.051±0.004$^{b}$ | 1.431±0.003$^{a}$ | 0.464±0.008$^{c}$ | NA |
| Zn (mg/100g). | 6.283±0.022$^{a}$ | 3.133±0.006$^{b}$ | 2.322±0.025$^{c}$ | 7.00±0.010$^{a}$ |

*Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same column are statistically not significant at (P<0.05). Key: A (70% fermented maize: 20% fermented soybeans: 10% fermented pumpkin seed) B (70% roasted maize: 20% roasted soybeans: 10% roasted pumpkin) and C (70% sprouted maize: 20%sprouted soybeans: 10% sprouted pumpkin: D commercial complementary food*

**Table 4. Beta-carotene and anti-nutrients content of complementary foods**

| Parameter | Sample A | Sample B | Sample C |
|---|---|---|---|
| Beta-carotene(mg/100g) | 0.203±0.002$^{c}$ | 0.416±0.003$^{b}$ | 0.461±0.003$^{a}$ |
| Oxalate(mg/100g) | 7.483±0.035$^{b}$ | 12.187±5.277$^{b}$ | 21.350±0.37$^{a}$ |
| Phytate(mg/100g) | 6.690±0.112$^{b}$ | 7.296±0.0014$^{a}$ | 6.748±0.109$^{b}$ |
| Cyanide(mg/100g) | 0.439±0.003$^{c}$ | 2.016±0.028$^{b}$ | 4.637±0.043$^{a}$ |

*Values are mean ± standard deviation of triplicate analyses. Values with the same superscript in the same column are statistically not significant at (P<0.05). Key: A (70% fermented maize: 20% fermented soybeans: 10% fermented pumpkin seed) B (70% roasted maize: 20% roasted soybeans: 10% roasted pumpkin) and C (70% sprouted maize: 20%sprouted soybeans: 10% sprouted pumpkin: D commercial complementary food*

## 4. DISCUSSION

"The moisture content of all the formulated complementary food samples reported in this study was within the recommended moisture contents of dried foods" [22,23] "High moisture content in food has been shown to encourage microbial growth" [24]. "The values obtained in this study were within the range reported to have no adverse effect on the quality attributes of the product" [25]. Bolarinwa et al. [26], reported that "the lower the moisture contents of a product, the better the shelf stability of the food product". "However, low residual moisture content in food is advantageous in that microbial proliferation is reduced and storage life may be prolonged if stored in appropriate packaging materials under ambient conditions" [27]. Protein is one of the major classes of macronutrients and is needed for tissue replacement, deposition of lean body mass, growth, and development, and in infancy, it's obvious [1].The high levels of protein found in these samples could be a result of fermented and roasted soybeans, which promote and don't destroy lysine and tryptophan. All the food samples had a high amount of protein; this agreed with the previous study of Ademulegun et al. [12]. The increase in protein level was a result of the inclusion of pumpkin seed and soybean. The protein was higher when compared to the Recommended Daily Allowance (9.1–13 g per day) for infants within the age bracket of 6–24 months [28]. The protein values were higher than those reported by Ojinaka et al. [29], which ranged from 3.9 to 3.97%. The formulated samples had an appreciable amount of fat similar to that of the commercial complementary food (control). This might be due to the effect of roasting and sprouting on soybeans. Studies have shown that roasting and sprouting increase the fat content of food [30]. "Fat is important in the diet of infants and young children because it provides essential fatty acids, facilitates the absorption of fat-soluble vitamins, and enhances dietary energy, density, and sensory quality" [31]. "It has been recommended that, during the complementary feeding period (6–12 months), a child's diet should derive 30–40% of energy from fat" [32]. According to a joint WHO/FAO/UNU study, "the energy requirements for a 6-month-old female involved in moderate physical activity are 340 kJ/kg body weights" [33]. "An infant weighing 7.34 kg would need 2495 kJ of energy daily. The fat composition of this complementary food will only meet 2.5–16.4% of the energy requirement. This, however, can be enhanced with available oil to increase the recommended fat ratio. The samples had varying ash contents ranging from 2.8% to 1.45% for samples C and G, respectively. The general trend observed in this study was that of an increase with an increase in soy flour substitution. Fat is also important in the diets of infants and young children as it provides essential fatty acids like Omega-3 and Omega-6 polyunsaturated fatty acids (PUFAs) that are needed in the body for proper neural development" [34]. The fibre content of the formulated samples was very low. This might be due to the fermentation and toasting methods, which have been proven to reduce fibre content. This low fibre content was also reported by Arawande and Borokini [35] in a similar study on complementary foods made from maize, soy beans, and carrots. Fibre plays a role in the increased utilization of nitrogen and the absorption of some other micronutrients. Complementary food should contain low fibre as high fibre can lead to high water absorption and displacement of nutrients and energy needed for the growth of children younger than two years [32,36]. The ash content of a food material could be used as an index for estimating the mineral constituents of the food [26]. In this study, Sample C had the highest value of ash content. This may be due to the effect of sprouting. A study has shown that sprouting increases the ash content of food [12,28]. The ash content obtained in this study was lower than the ash content (3.47–4.53%) of complementary foods prepared from maize, sesame, and crayfish flour blends reported by Egbujie, & Okoye. [37]. This might be due to the inclusion of animal protein in their sample. The nitrogen-free energy content, also known as the carbohydrate content, was abundant in all the formulated complementary foods, and similar to the carbohydrate content of commercial complementary foods, the levels of carbohydrate in all the complementary food samples are nutritionally adequate as children require energy to carry out their rigorous playing and other activities as growth continues. The values obtained in this study were in range of the carbohydrate content (55.86–70%) of complementary foods formulated from fermented maize, soybean, and carrot flours reported by Barber et al. [38]. The energy value ranged from 357.03 to 392.51 kcal, with all samples having no significant difference ($P > 0.05$), respectively. The processing methods had no effect on the energy content of the complementary food. The energy values of the formulated samples met the FAO/WHO [39] specification guidelines for complementary food formulations for young children. The loss in the levels of calcium, magnesium, potassium, and phosphorus in the processed samples may be attributed to the loss in ash contents during fermentation, and it is due to a reduction in anti-nutritional factors. Similar works by Oyarekua and Eleyinmi [40] and Chamba et al. [41], reported that more than 50% of the ash in sorghum was leached out of the steep water and washed away. A decrease in the levels of Ca, P, Zn, and Fe in processed samples was reported [42]. Iron (Fe) in the fermented product was recorded to be higher than products from toasting and sprouting, though the value for the sprouted product was similar. The changes that occur during fermentation may be a result of enzymatic activities [43]. The activity of desirable microorganisms and/or their enzymes on foods during fermentation leads to biochemical changes that significantly modify food products. Oboh et al. [44] reported that the low-weight organic acids produced during fermentation enhance iron and zinc. The copper content of the fermented product was reported to be intermediate between the toasted and sprouted products; this may be a result of enzymatic activities during fermentation. The Zn content of the fermented product was reported to be the highest compared to the results from toasted and sprouted products. The effect of toasting in this study is reported to be a significant increase in the mineral content (i.e., Ca, Mg, K, P, Fe, Cu, and Zn), which agrees with the work of Oboh et al. [45], who stated that there was an increase in the mineral content (Ca, Zn, Mg, and Na) after toasting yellow and white maize. This may be due to an increase in the ash content of the toasting processing method. This study also shows that sprouting has the highest mineral (Ca, Mg, K, P, and Fe) content compared to toasting and fermentation, though the iron (Fe) from fermentation is similar to that of sprouting. This could be as a result of sprouts from the grains, which is a unique food safety concern due to the ease of microbiological contamination and the inherent ability of the sprouting process to support microbial growth [46]. The beta-carotene content of fermented maize, fermented soybean, and fermented pumpkin seed was lower compared to the flours from toasted and sprouted maize, soybean, and pumpkin seed, respectively. This might be due to the fact that fermentation reduces the anti-nutritional factors, which was similar to the work reported by Muhimbula, et al. [47]. This study shows that phytate and cyanide were reduced by fermentation. Onimawo & Offurum [48], also reported that phytic acid or phytate and cyanide compounds are removed during fermentation. Sprouting, germination, and malting are similar processing methods that involve soaking, germination under controlled conditions, and drying of cereals, grains, or pulses [49]. Germination induces biochemical modifications that lead to improved nutritional quality in food. This study revealed that the results from sprouting are higher in oxalate, beta-carotene, and cyanide but lower in phytate; it may be as a result of their concentration in the testa, which is higher in sprouted seeds. Saleh et al. [50] also reported that germination may be attributed to a reduction in anti-nutrients such as tannin and phytic acid that may form complexes with proteins. Toasting is a dry heat treatment process that leads to irreversible structural changes in food [51]. Normally, roasting is supposed to reduce some of the Phytochemical because of the heat treatment, but some may not be reduced because they may be resistant to heat. In this study, the phytate increased more in roasting than in other processing methods (fermentation and sprouting). This may be because phytate is heat resistant, which is why it was not reduced by heat but reduced by fermentation and sprouting.

## 5. CONCLUSION

This study revealed that complementary foods formulated from maize, soybean and pumpkin seed which was processed using three (3) different processing method (fermentation, sprouting and toasting) can be consumed by children from 6months of age. The results carried out shows that the processing method of sprouting increases majority of the minerals (Ca, Mg, k, P and Fe) but there was reduction in Cu and Zn. The minerals composition of the blended complementary food can help in the growth and development of children in addition to regular breast feeding. Since maize, soybean and pumpkin seed are easily available and affordable raw material, it can be used by mothers as home-based complementary food.

## ETHICAL APPROVAL

Ethical approval reference number RUGIPO/NUD/2023/100 was obtained for the study from the Ethic committee of the department of Nutrition and Dietetics Rufus Giwa Polytechnic, Owo, Ondo State

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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