# Chemical Evaluation and Sensory Properties of Complementary Foods from Blends of Maize, Lima Beans, Trifoliate Yam Flours Sweetened with Date Palm

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**Abstract**

The chemical and sensory properties of complementary food made from fermented maize, fermented lima beans, trifoliate yam flours sweetened with date palm was evaluated. Both maize grains, lima beans, trifoliate yam and date palm fruit were processed into flours by fermenting the maize and lima beans, soaking trifoliate yam and date palm fruit. The flours were mixed in varying proportions to produce five (5) blended flour samples, A, B, C, D and E with percentage fermented maize: fermented lima beans, trifoliate yam and date palm flours proportions 100:0:0:0, 80:5:5:10, 70:10:10:10, 60:20:10:10 and 50:25 15:10 respectively. Result of the proximate composition showed that moisture content ranged from 6.80% (Sample E) to 9.70% (Sample A), ash content ranged from 2.22% (Sample A) to 4.34% (Sample D), protein content ranged from 6.20% (Sample A) to 8.22% (Sample E), crude fibre ranged from 2.20% (Sample A) to 2.90% (Sample E). Crude fat content ranged from 2.28% (Sample A) to 2.74% (Sample E), carbohydrate content ranged from 74.89% (Sample D) to 77.40% (Sample A). The study showed that the substitution of maize-based complementary foods with fermented lima beans flour, trifoliate yam flour and date palm flour improved the protein, fat, fibre, and amino acid profile of the products as well as improved functional properties. The sensory scores obtained were highly acceptable complementary gruel and the formulated complementary food blends produced were found to be safe.

**Keywords**

Chemical Evaluation, Sensory Properties, Complementary Foods, Date Palm

## 1. Introduction

The process of gradually switching from an exclusively breast milk-based diet to a complementary one is called weaning. Weaning is the process of introducing soft meals that are simple to swallow and digest in order to support an infant's early feeding. Additionally, it is during this stage when a baby's breastfeeding is gradually replaced with semi-solid foods to replenish the nutrients found in breast milk [1]. Careful planning is necessary to ensure that the diets include all nutrient classes in the right amounts for the child's growth and development. Foods other than breast milk or infant formula (liquid, semisolid, and solid) that are given to a baby in order to supply nutrition are known as complementary foods. When breast milk alone is no longer adequate to meet an infant's nutritional and developmental needs, complementary foods play a critical role in the growth and development of the kid [2]. These foods can often be satisfying without meeting children's nutritional needs. During the weaning stages, when both macro and micronutrients may be insufficient to support growth and development, children's nutritional health is most at risk.

In many poor nations, there has been a lot of interest in the creation of nutrient-dense supplementary foods using easily accessible, locally sourced ingredients. Both domestic and foreign organisations have increased their research, development, and extension activities in response to the pervasive issue of newborn malnutrition in the developing countries. As appropriate alternatives to high-quality protein, legumes are progressively displacing milk and other costly and scarce animal protein sources. Cereals, which are comparatively poor sources of protein, provide more than 70% of the dietary protein in developing nations [3]. Legumes' high lysine content enhances the nutritional value of cereals by balancing their limiting amino acids (whereas lysine is limiting in cereals and rich in legumes, sulfur-containing amino acids are limiting in legumes and comparatively high in cereals). Numerous blends that use legumes separately or together have been tested [4].

In accordance with national newborn feeding recommendations, which also take into account the accessibility and cost of infant quick cereal formulae, complementary feeding is implemented. Cereals like wheat, maize, and rice; roots and tubers; and legumes like soybeans, lima beans, cowpeas, and others are the main ingredients used to make complementary foods [5]. According to reports from the Food and Agricultural Organisation and the World Health Organisation, protein energy malnutrition is a major issue in many poor nations that impacts newborns throughout the transitional phase of supplemental feeding [6]. In addition to having high calorie, protein, and micronutrient contents, a high-quality supplemental food should also have low viscosity, bulk density, high nutritional density, and the right texture for ease of absorption. Infant supplemental food, which primarily consists of unsupplemented cereal pap produced from maize, sorghum, and/or millet, is woefully deficient in several macro- and micronutrients in Nigeria and

the majority of other developing nations [7]. Malnutrition issues could be avoided by improving nutritional intake by proper processing and careful mixing of foods that are readily available in the area.
In Nigeria, foods including bananas, trifoliate yams, maize, and lima beans are easily accessible. Their nutritional qualities are promising. The plants known as lima beans (Phaseolus lunatus) provide starchy fruits that must be processed before eating. The protein and energy needs of many Nigerians are significantly met by lima bean seeds, which have a protein content of 22-25%. Niacin, thiamine, and riboflavin are abundant in lima beans [8]. They are known to have significant concentrations of calcium, iron, phosphorus, and magnesium. In common cultivars, 8-11% of the kernel weight is made up of maize protein [9]. The protein is low in lysine and extremely low in tryptophan, but it contains considerable levels of sulfur-containing amino acids, methionine, and cystine. The trifoliate yam, sometimes referred to as the bitter yam, is a tropical tuber that is still underutilised despite being high in phytonutrients, especially proteins. Trifoliate yam has no industrial use, despite its potential for use in the pharmaceutical and baking sectors [9].

The date palm, or Phoenix dactylifera, is a flowering plant that is mostly grown for its fruit. It is a member of the Arecaceae family of palms. Although the origin of date fruits is still up for question, they are a staple diet for people in the Middle East and North Africa. Nowadays, the majority of its cultivation takes place in tropical and subtropical areas worldwide. Furthermore, it is currently eaten as food in many regions of the world, particularly in Europe [10]. The pericarp, mesocarp, endocarp, and a seed (pit or kernel) comprise the date fruit. The greatest portion is the mesocarp, which is made up of parenchymatous cells that are divided into an inner and an outer mesocarp, with tanniferous cell layers in between [11]. According to reports, date fruits have 6.5% to 11.5% total dietary fibre (of which 10% is soluble and up to 90% is insoluble), 1% fat, 2% proteins, and 2% ash. Rich in sugar, protein, vitamins, minerals, flavonoids, and phenolic substances, the fruits are nutrient-dense. Date palm fruits are rich in antioxidants and have strong bioactivities against a variety of bacterial infections because they contain phenolic compounds. Numerous bioactivity potentials, such as antibacterial, antioxidant, anticancer, and antidiabetic properties, are present in dates. The inclusion of phytochemicals including carotenoids, phenolic acid, flavonoids, tocopherol, phytosterols, etc., enhances these bioactivities. They support health by giving the body proteins, fats, minerals, and several vital vitamins in addition to carbs (including soluble sugars).

The two main nutritional issues affecting newborns in Nigeria and other Sub-Saharan African nations are protein-energy malnutrition and a deficiency in micronutrients. Poor complementary feeding practices and the use of low-nutrient-dense local supplementary foods are two of the main reasons for the high occurrences seen in youngsters. The World Health Organisation (WHO) developed recommendations for supplemental foods for infants aged 6 to 24 months. Many homemade or conventional supplemental foods lack sufficient nutrients, which puts children under five at risk for illnesses or malnutrition. During the transition from breastfeeding to a family diet, growing children in underdeveloped nations frequently experience nutritional issues due to inadequate intake of vital micronutrients such iron, calcium, zinc, iodine, and vitamin A. As a result, offering a minimally acceptable diet is a significant problem in both developed and poor nations. For middle-class and lower-class rural and urban parents, many commercially prepared foods made using extrusion and roller-drying technologies that are sold in Nigeria and other nations are too costly. As a result, many families rely on traditional supplementary foods that are of poor quality and insufficiently prepared for their kids. Therefore, creating inexpensive supplemental meals to enhance baby nutrition is one way to close the food gap that causes protein-energy malnutrition in young children in low-resource nations [12].

Traditional complementary foods in Nigeria and other developing nations are mostly made from cereal grains and tubers, with little to no protein from legumes. This limits the food's ability to include the necessary amounts of micronutrients and high-quality protein. Poor complementary feeding practices in impoverished nations are caused by a lack of understanding about the nutritional value of various nutrient-dense legumes and processing techniques. In Nigeria and the majority of developing nations, several strategies have been implemented to address the issue of "hidden hunger," including food-based strategies like diet diversification, food fortification, and bio-fortification. The most economical options might be food and bio-fortification. As a result, complementary foods that are appropriately formulated and processed using regional food-based methods are required. Composite flours made from fermented maize, lima beans, and trifoliate yam have not been used in complementary food formulation, according to a comprehensive literature search, which is why this study was conducted.

Numerous studies suggest that in order to create composite mixes for babies and kids, more local, nutrient-dense, and readily available underutilised commodities such vegetables, grains, legumes, and tubers should be identified and used. the use of inexpensive, locally produced items in complimentary dishes. The growing of several crops that can be utilised in the creation of such inexpensive supplemental foods has been supported by numerous studies. The community accepts these meals in addition to the fact that their development is sustainable in Nigeria and other Sub-Saharan nations. The creation of these foods will not only solve infants' nutritional issues but also enhance eating habits and dietary diversity. To decrease the anti-nutrients and raise the protein and mineral bioavailability, a variety of processing methods (a combined strategy) were used. As a result, the processing methods being used are affordable and suitable for environments with limited resources. Designing suitable policies to enhance supplemental feeding habits in underdeveloped nations can be done with the help of this knowledge. Therefore, it is encouraging to formulate and evaluate a supplemental diet based on maize that is nutritionally adequate and enhanced with nutrients from date palm, lima beans, and trifoliate yam.

## 2. Materials And Methods

### 2.1 Sample Procurement

The yellow variety of maize (*Zea mays*), lima beans (*Phaseolus lunatus*), trifoliate yam (*Dioscorea dumetorum*) and dates (*Phoenix dactylifera*) fruit were purchased from Relief market Owerri, Imo State, Nigeria. The flour processing equipment were obtained from the laboratory of Department of Nutrition and Dietetics, Imo State University, Owerri.

### 2.2 Sample Preparation

#### 2.2.1 Preparation of the Fermented Maize Flour

The fermented maize flour was prepared with slight modifications. The maize grains were sorted, cleaned and soaked in water. It was subjected to 48h fermentation period. The maize grains were allowed to ferment by the microflora inherent in them at temperature of $28\pm2^0$C. The fermented grains were dried at $60^0$C for 12 hours in an air circulating oven, hammer milled and passed through a 0.5 mm mesh size sieve. Afterwhich, it was packaged in an air tight polyethylene bags, store in plastic containers with lids and stored in cool dry place pending usage.

#### 2.2.2 Preparation of the Fermented Lima Beans

The fermented lima beans flour was prepared using the method described by Ariahu *et al.,* (1999). The lima beans sample was cleaned to remove husks, stones, and cobs, damaged and coloured seeds. Afterwhich, the lima beans seeds were washed and soaked in water in a ratio of 1:3 (w/v) and allowed to ferment by the microflora inherent in them for 48h at $28 \pm 2^0$C. The fermented seeds were dried at $60^0$C for 12 hours in an oven to a moisture content of about 10%, dehulled and ground in to flour using attrition mill. The lima beans flour sample were passed through a 0.5 mm mesh size sieve. Afterwhich, they were packaged in an air tight polyethylene bags, store in plastic containers with lids and stored in cool dry place for the next analyses.

Wholesome trifoliate yam tubers were sorted out, cleaned, peeled, sliced with a chipping machine and soaked in tap water for 6 hours. After which it was washed and weighed. The chips were dried to a constant weight in a moisture extraction oven (Gallenkamp 1H-100) set at 60°C, cooled for 12 hours and milled (in a laboratory mill, Thomas Wiley mill model ED-5) into flour and sieved through a 0.5 mm mesh size sieve. The flour sample were packaged in a properly labeled airtight container prior to usage.

#### 2.2.3 Preparation of Date Palm Flour

The date palm fruit was manually deseeded to remove the seeds and cleaned with damp cloth to remove dust. It was oven dried at $60^0$C for 5hours and milled to produce the date palm flour. After which the flour was sieved using 300um sieve to obtain flour of uniform sizes. The flour was then packaged in an air-tight bag for further use.

### 2.3 Recipe Formulation for the Complementary Food Blends

The fermented maize flour were supplemented with different proportions of the fermented lima beans flour, trifoliate flour and date palm flour as shown in Table 1. To obtain a homogenous sample, the different combinations were individually homogenized in a rotary mixer (NSF, ARM-02, Thunderbird, Canada) with mixing speed set at position 2 for 10 minutes and then stored in airtight plastic containers and preserved in a deep freezer until required for analyses.

**Table 1.** Recipe for the Formulation of the Complementary Food

| Sample | Maize Flour (g) | Lima Beans Flour (g) | Trifoliate Yam flour (g) | Date Palm Flour (g) |
|---|---|---|---|---|
| A | 100 | 0 | 0 | 0 |
| B | 80 | 5 | 5 | 10 |
| C | 70 | 10 | 10 | 10 |
| D | 60 | 20 | 10 | 10 |
| E | 50 | 25 | 15 | 10 |

### 2.4 Proximate Analysis

The standard method of the Association of Analytical Chemists (AOAC, 2012) was used for the analysis of the proximate composition of the samples.

#### 2.4.1 Determination of Moisture Content

Five grams (5g) of the sample was weighed into a clean dried aluminum or petri-dish. The sample was oven dried at 105°C for three hours and the petri- dish was b removed, cooled in a desiccator for 30 minutes and finally weighed. The moisture content was calculated and expressed as a percentage of the weight of sample analyzed. It was given by the expression below.

$$\%\ \text{moisture content} = \frac{100}{1} \times \frac{W_2 + W_3}{W_2 - W_1}$$

Where W1 = weight of empty moisture can

$W_2$= weight of empty can + sample before drying

$W_3$= weight of can + sample dried to constant weight

#### 2.4.2 Determination of Ash Content

Five grams (5g) of the sample was measured into a clean dried crucible. The sample was placed in a muffle furnace at 550°C for 2 hours until a white or light gray ash results, it was cooled in a desiccator and weighed. The weight of ash obtained was calculated by difference and expressed as a percentage of the weight of sample analyzed as shown below:

$$\%\ \text{Ash} = \frac{100}{1} \times \frac{W_2 - W_1}{Wt\ of\ sample}$$

Where $W_1$ = weight of empty crucible

$W_2$ = weight of crucible + Ash

#### 2.4.3 Determination of Protein Content

This was done using Kjeldahi method. 0.5g of the sample was mixed with 10ml of conc. $H_2SO_4$ in a digestion flask. A tablet of selenium catalyst was added to the mixture before it was heated under a fume cupboard. The digest was diluted to 100ml in a volumetric flask and sued for the analysis.

10ml of the digest was mixed with equal volume of 45% NaOH solution in a Kjeldahi distillation apparatus. The mixture was distilled into 10ml of 4% buric acid containing 3 drops of mixed indicator (bromocressol green/ methylred). A total of 50ml of distillates was collected and titrated against 0.0024 EDTA from green to a deep red end point. The N2 content and hence the protein was calculated using the formula below:

% Protein $N_2$ x 6.25

$$\%N_2 = \frac{100}{N} \times \frac{N \times 4}{1000} \times \frac{VTT.B}{VA}$$

Where W = weight of sample (0.5 g)

N = Normality of titrant (0.02N $H_2SO_4$)

VT = Total digest volume (100mls)

VA = Volume of digest that will be analyzed (ions)

T = Sample titre value

B = Blank titre value

#### 2.4.4 Determination of Crude Fat Content

The solvent extractive gravimetric method was used. 5g of the sample was wrapped in a porous paper and put in thimble. The thimble was placed in a soxhlet reflux flask and mounted into a weight extraction flask containing 200ml of petroleum ether. The upper end of the reflux flask was connected to a water condenser. The solvent (Petroleum ether) was heated. It boiled, vaporizes and condensed into the reflux flask. Soon the sample in the thimble was covered with the solvent, which extract the oil (fat). The sample remains in contact with the solvent until the reflux flask filled up and siphoned oven, carrying its oil extract down to the boiling flask.

This process was allowed to go on repeatedly for four hours before the defatted sample was removed. The solvent was recovered and the oil extract was in the flask. The flask (containing the oil extract), was dried in the oven at 60°C for 30mins (to remove any residual solvent). It was cooled in desiccators and weighed. By difference the weight of oil (fat) extract was determined and expressed as a percentage of the weight of sample analyzed following the expression below:

$$\%\text{Fat} = \frac{W_2 - W_1}{Wt\ of\ sample} \times \frac{100}{1}$$

**2.4.5 Determination of Crude Fibre Content**

Five grammes (5 g) of the sample was boiled in 150ml of 12.5% $H_2SO_4$ solution for 30minutes under reflux. The boiled sample was washed in several portions of hot water using a two-fold muslin cloth to trap the particles. It was returned to the flask and boiled again in 150mls of 1.25% NaOH for another 30minutes.

After washing in several portion of hot water, the sample was allowed to dry before being transferred quantitatively to a weighed crucible where it was further dried in the oven at 150°C to a constant weight before being burnt to ash in a muffle furnace. By difference, the weight of fiber was obtained and expressed as a percentage of the weight of sample analyzed.

$$\%\text{ Crude fiber} = \frac{100}{1} \times \frac{W_2 - W_3}{Wt\ of\ sample}$$

Where Wt = weight of sample

$W_1$ = weight of crucible + sample after boiling, washing and drying.

$W_3$ = weight of crucible + sample (ash)

**2.4.6 Determination of Carbohydrate Content**

The carbohydrate content was calculated as thus;

% Carbohydrate = 100 - % (protein + fat + fibre + ash + moisture content

**2.4.7 Determination of Sodium and Potassium (Using Flame Photometer)**

Sodium and potassium contents was determined using method described by Onwuka (2018). The instrument was switched on and allowed for about 20 min to stabilize. The gas was then turned on, distilled water was aspirated through the siphon in order to zero the instrument and the samples was aspirated and the emission recorded. The concentrations was calculated using sodium and potassium calibration curve for sodium and potassium readings, respectively.

$$\text{Na or K (mg/100g)} = \frac{100}{W} \times \frac{X}{100} \times \frac{Vt}{Va} \times D$$

Where

W = weight of sample used

X = concentration of Na and K obtained from the standard curve

D = dilution factor added

Vt = total of volume extract

Va = volume of extract analyzed

**2.4.8 Determination of Functional Properties of the Flour Samples**

**Determination of Bulk Density (BD)**

This was determined using the procedure described by Onwuka (2005). Ten (10) milliltres capacity graduated measuring cylinder was weighed and gently filled with the sample. The bottom of the cylinder was tapped gently on the laboratory bench several times until there is no further diminution of the sample level after filling to the 10ml mark.

$$\text{Bulk density (g/ml)} = \frac{weight\ of\ sample(g)}{volume\ of\ sample(ml)}$$

**Determination of Water Absorption Capacity**

The procedure described by Onwuka (2005) was followed. One (1) gramme of sample was weighed into a conical graduated centrifuge tube with a warring when mixer. The sample and 10ml distilled water was thoroughly mixed for 30seconds. The sample was allowed to stand for 30minutes at room temperature and then centrifuge at 4000rpm for 15minutes.

$$\text{Gain weight} = \frac{weight\ of\ sample\ after\ centrifuge}{weight\ of\ sample\ before\ centrifuge} \times \frac{100}{1}$$

**Determination of Oil Absorption Capacity**

One (1) gramme of sample was weighed into a conical graduated centrifuge tube with a warring when mixer. The sample and 10ml distilled oil was thoroughly mixed for 30seconds. The sample was allowed to stand for 30minutes at room temperature and then centrifuge at 4000rpm for 15minutes.

Gain weight $= \frac{\textit{weight of sample after centrifuge}}{\textit{weight of sample before centrifuge}} \times \frac{100}{1}$

**2.5 Gelatinization Temperature**

This was determined using the method of Onwuka (2005) for gelling temperature with slight modification. Two grams (2g) of each powder sample was weighed into a beaker (50ml Pyrex beaker) and dispersed to make 20ml suspension using distilled water. A thermometer was clamped into a retort stand with its bulb submerged in the beaker. The beaker was heated using a hot plate while the content is stirred gently using a stirring rod. Attention was paid to the temperature at which the suspension begins to gel. This temperature was recorded. The boiling and stirring operation was continued until the suspension began to boil. This boiling point was also be recorded.

**2.6 Viscosity**

The Brookfield synchro-electric viscometer was used to determine the viscosity of the slurry (i.e reconstituted ogi flour samples). Twenty (20g) of the powder was put in 250ml beaker and 200ml of tap water was added to form a slurry. This slurry was heated at 100$^{o}$C for 15 minutes to gelatinize. The Brookfield synchro-electric viscometer was set first at zero and 60rev per minute. The viscosity of the pap was determined when the spindle revolves 60 times per minute.

**2.7 Hydrolysis of the sample**

One gram (1gram) of the defatted sample was weighed into glass ampoule. A 10ml of 4.2M NaOH was added and oxygen was expelled by passing nitrogen into the ampoule. The glass ampoule was then sealed with Bunsen burner flame and put in an oven preset at 105$^{0}$C ± 5$^{0}$C for 4h. The ampoule was allowed to cool before it was broken open at the tip and the content was filtered to remove the humins. The filtrate was neutralized to pH 7.0 and evaporated to dryness at 40$^{0}$C under vacuum in a rotary evaporator. The residue was dissolved with 5ml of borate buffer (pH 9.0) and stored in plastic specimen bottles, which was kept in the freezer.

**2.8 Loading of the Hydrolysate into TSM analyzer**

The amount loaded was 60 microlitres. This was dispended into the cartridge of the analyzer. The period of an analysis will last for 45 min. The analyzer is designed to separate and analyse free acid, neutral and basic amino acids of the hydrolysate.

**2.9 Method of calculating amino acid values**

An integrator attached to the analyzer will calculates the peak area proportional to the concentration of each of the amino acids.

**Sensory Evaluation**

The control and the formulated samples of the complementary flours were separately prepared into gruels. Hundred grams (100g) of each sample was mixed with 120ml of cold water to produce slurry. Then, 80ml of boiling water was added to each of the slurry with continuous stirring to obtain homogenous gruels. Three grams (3g) of granulated sugar was added to each sample of the gruels. The gruels were evaluated in sensory evaluation booths for sensory attributes such as colour, taste, aroma, mouthfeel and overall acceptability by a panel of thirty (30) semi-trained judges comprising of nursing mothers, staff and students of the Department of Nutrition and Dietetics, Imo State University Owerri, Imo State Nigeria. Prior to the sensory test, the gruels was separately coded and served to the assessors in white plastic cups with teaspoons at room temperature (30±2$^{o}$C). Clean water was provided to the judges to rinse their mouth in-between testing of the gruels to avoid residual effect. The assessors were instructed to assess and score each sample of the product based on their degree of likeness and acceptance of the gruels using a nine-point Hedonic scale from 1 to 9, where 1 represents dislike extremely and 9 represents like extremely . Expectoration cups with lids were provided for the judges who did not wish to swallow the samples.

A 9-point hedonic scale ranging from one to nine was used for the assessment of the food samples.

Where; 1 = dislike extremely

2 = dislike very much

3 = dislike moderately

4 = dislike slightly

5 = neither like nor dislike

6 = like slightly

7 = like moderately

8 = like very much

9 = like extremely

## 3. Statistical Analysis

The data generated in this study were subjected to one-way analysis of variance (ANOVA) using Statistical Package for Social Sciences (SPSS, Version 20) software. Significant means were separated using Tukey's Least Significance Difference (LSD) test at $p<0.05$ and the results were expressed as mean ± standard deviation of triplicate determinations.

## 4. Results

### 4.1 Proximate Composition of the Complementary Food Samples

The proximate composition of the complementary food samples made from fermented maize, fermented lima bean, trifoliate yam and date palm flours is presented in Table 2. The moisture content ranged from 6.80% (Sample E) to 9.70% (Sample A), ash content ranged from 2.22% (Sample A) to 4.34% (Sample D), protein content ranged from 6.20% (Sample A) to 8.22% (Sample E), crude fibre ranged from 2.20% (Sample A) to 2.90% (Sample E). Crude fat content ranged from 2.28% (Sample A) to 2.74% (Sample E), carbohydrate content ranged from 74.89% (Sample D) to 77.40% (Sample A). Samples differed significantly ($P<0.05$) from each other.

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

| Sample | Moisture | Ash | Parameters (%) Protein | Fibre | Fat | Carbohydrate |
|---|---|---|---|---|---|---|
| A | $9.70^{a}\pm0.03$ | $2.22^{e}\pm0.03$ | $6.20^{d}\pm0.02$ | $2.20^{d}\pm0.00$ | $2.28^{d}\pm0.01$ | $77.40^{a}\pm0.08$ |
| B | $8.50^{b}\pm0.02$ | $2.60^{d}\pm0.01$ | $6.80^{c}\pm0.02$ | $2.38^{c}\pm0.02$ | $2.44^{c}\pm0.02$ | $77.28^{b}\pm0.05$ |
| C | $7.80^{c}\pm0.02$ | $3.20^{c}\pm0.02$ | $7.22^{b}\pm0.02$ | $2.60^{b}\pm0.03$ | $2.58^{b}\pm0.02$ | $76.60^{c}\pm0.10$ |
| D | $7.30^{d}\pm0.01$ | $4.34^{a}\pm0.04$ | $8.03^{a}\pm0.04$ | $2.82^{a}\pm0.02$ | $2.62^{ab}\pm0.03$ | $74.89^{e}\pm0.18$ |
| E | $6.80^{e}\pm0.02$ | $3.80^{b}\pm0.02$ | $8.22^{a}\pm0.00$ | $2.90^{a}\pm0.03$ | $2.74^{a}\pm0.02$ | $75.54^{d}\pm0.10$ |

Values are means ± SD. Values on the same column with different superscripts are significantly different.

<u>Keys</u>

**A =** Complementary food from 100% fermented maize flour (Control)

**B =** Complementary food from 80% fermented maize + 5% fermented lima beans + 5% trifoliate yam + 10% date palm flours

**C =** Complementary food from 70% fermented maize + 10% fermented lima beans + 10% trifoliate yam + 10% date palm flours

**D =** Complementary food from 60% fermented maize + 20% fermented lima beans + 10% trifoliate yam + 10% date palm flours

**E =** Complementary food from 50% fermented maize + 25% fermented lima beans + 15% trifoliate yam + 10% date palm flours

### 4.2 Functional Properties of the Complementary Food Samples

The functional properties of the complementary food samples is presented in Table 3. Result obtained from the functional properties analysis of the complementary food samples shows that bulk density of the samples ranged from 0.40g/ml (sample E) to 0.64g/ml (sample A), oil absorption capacity ranged from 2.35g/ml (A) to 2.92g/ml (E), swelling index ranged from 1.66g/g (sample E) to 1.96g/g (sample A), gelatinization temperature ranged $72^{0}$C (sample D and E) to $84^{0}$C (sample A) and viscosity ranged from 1058cp (sample E) to 1570cp (sample A) respectively. Samples differed significantly ($p< 0.05$) from each other.

**Table 3.** Functional properties of the complementary food samples.

| Sample | Bulk Density (g/ml) | Oil Asorption Capacity (g/ml) | Parameters Swelling Index (g/g) | Gelatinization Temperature (°C) | Viscosity (cp) |
|---|---|---|---|---|---|
| A | $0.64^{a}\pm0.03$ | $2.35^{c}\pm0.04$ | $1.96^{a}\pm0.02$ | $84^{a}\pm0.10$ | $1570^{a}\pm 1.35$ |
| B | $0.51^{b}\pm0.01$ | $2.66^{b}\pm0.02$ | $1.80^{b}\pm0.02$ | $83^{b}\pm0.15$ | $1438^{b}\pm 1.02$ |
| C | $0.47^{bc}\pm0.01$ | $2.71^{b}\pm0.01$ | $1.76^{bc}\pm0.01$ | $82^{c}\pm0.12$ | $1277^{c}\pm 2.03$ |
| D | $0.41^{c}\pm0.04$ | $2.88^{a}\pm0.04$ | $1.70^{bc}\pm0.00$ | $72^{d}\pm0.14$ | $1134^{d}\pm 0.88$ |
| E | $0.40^{c}\pm0.02$ | $2.92^{a}\pm0.02$ | $1.66^{c}\pm0.03$ | $72^{d}\pm0.11$ | $1058^{e}\pm 0.90$ |

Values are means ± SD. Values on the same column with different superscripts are significantly ($p< 0.05$) different.

**Keys**

**A =** Complementary food from 100% fermented maize flour (Control)

**B =** Complementary food from 80% fermented maize + 5% fermented lima beans + 5% trifoliate yam + 10% date palm flours

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**D =** Complementary food from 60% fermented maize + 20% fermented lima beans + 10% trifoliate yam + 10% date palm flours

**E =** Complementary food from 50% fermented maize + 25% fermented lima beans + 15% trifoliate yam + 10% date palm flours

### 4.3 Sensory Scores of the Complementary Food Gruel Samples

The sensory characteristics of the complementary food gruel produced from varying blends of fermented maize, fermented lima bean, trifoliate yam and date palm flours is presented in Table 4. The appearance of the gruel samples showed mean scores of 7.30, 7.50, 6.50, 6.80 and 6.10 for samples A, B, C, D and E respectively.

The taste of sample B was superior to those of the other samples recording the best score of 7.20 which didn't differ significantly ($p<0.05$) from that of samples A and C while sample E was least accepted in terms of taste recording the lowest score of 5.80. Based on sensory evaluation, aroma range between 6.50 to 7.80. Sample B had the highest score of 7.80 while sample A had the lowest score of 6.50, this showed that sample B was most preferred in terms of aroma.

The mouthfeel of the product refers to the smoothness and feel of the product. The mean score of mouthfeel attribute of the products range between 5.50 for sample E to 7.80 for sample A. In terms of general acceptability mean score showed 7.40, 7.50, 7.20, 7.00 and 5.60 for samples A, B, C, D and E respectively.

**Table 4.** Sensory scores of the complementary food gruel samples

| Sample | Appearance | Taste | Parameters<br>Aroma | Mouthfeel | Overall Acceptability |
|---|---|---|---|---|---|
| A | $7.30^{a}\pm0.18$ | $7.00^{a}\pm0.10$ | $6.50^{c}\pm0.20$ | $7.80^{a}\pm0.20$ | $7.40^{a}\pm0.18$ |
| B | $7.50^{a}\pm0.20$ | $7.20^{a}\pm0.15$ | $7.80^{a}\pm0.14$ | $7.70^{a}\pm0.18$ | $7.50^{ab}\pm0.15$ |
| C | $6.50^{b}\pm1.04$ | $7.10^{a}\pm0.20$ | $7.60^{ab}\pm0.20$ | $7.60^{ab}\pm0.12$ | $7.20^{bc}\pm0.20$ |
| D | $6.80^{b}\pm0.15$ | $6.60^{b}+0.22$ | $7.50^{b}\pm0.15$ | $7.40^{b}+0.15$ | $7.00^{c}\pm0.12$ |
| E | $6.10^{c}\pm0.10$ | $5.80^{c}\pm0.11$ | $7.00^{c}\pm0.14$ | $5.50^{c}\pm0.10$ | $5.60^{d}\pm0.08$ |

Values are means ± SD. Values on the same column with different superscripts are significantly different.

**Keys**

**A =** Complementary food from 100% fermented maize flour (Control)

**B =** Complementary food from 80% fermented maize + 5% fermented lima beans + 5% trifoliate yam + 10% date palm flours

**C =** Complementary food from 70% fermented maize + 10% fermented lima beans + 10% trifoliate yam + 10% date palm flours

**D =** Complementary food from 60% fermented maize + 20% fermented lima beans + 10% trifoliate yam + 10% date palm flours

**E =** Complementary food from 50% fermented maize + 25% fermented lima beans + 15% trifoliate yam + 10% date palm flours

## 5. Discussion

The moisture content (10.03-12.59%) of complementary foods made from fermented maize, soybean, and carrot flours reported by [13] was higher than the values found in this investigation. The supplemental food items had significantly different moisture contents ($p<0.05$). The samples' moisture content was within the recommended daily allowance (RDA) range of 5-10% for supplemental foods, and it was comparatively low (<10%) [5]. This will undoubtedly improve shell life and reduce microbial activity. It has been demonstrated that a high moisture content in food promotes microbial development [6]. The reduced moisture level found in this study suggests that the products will have greater shelf stability and can be kept at room temperature without compromising their quality characteristics. It has been stated that food does not deteriorate when its moisture level is less than 10%. [10]

When fermented lima bean and trifoliate yam flours were added to the blends in place of fermented maize flour, the ash level of the supplementary food samples rose noticeably ($p<0.05$). The high mineral content of fermented lima bean and trifoliate yam flours may be the cause of the rise in ash content seen in samples that were substituted with fermented maize flour and fermented lima bean and trifoliate yam flours at various graded levels. An indicator of the mineral components of a food item could be its ash concentration (Ishiwu and Onyeji, 2004). The study's ash content (2.22% to 4.34%) was comparable to the range of 1.98% to 4.33% reported by [12] for complementary foods made from sorghum, African yam bean, and crayfish flours, but it was higher than the 1.68% to 3.40% level reported in maize-soy complementary foods by [11] and lower than the ash content (4.25% to 5.81%) of complementary foods made from sorghum and African yam bean flour blends. Minerals are essential for numerous bodily functions. They are essential for the operation of the nervous system, other cellular functions, water balance, and structural (skeletal, for example) systems. High concentrations of different mineral elements are anticipated to be present in samples with high percentages of ash content, which should accelerate metabolic processes and enhance growth and development. [13]

As more fermented lima bean and trifoliate yam flours were substituted for fermented maize flour in the formulations, the samples' protein level rose. All of the supplemental food products that were created had higher protein levels than the control, which was 100% fermented maize flour. The high levels of fermented lima bean flour in the blends may have contributed to the observed increase in protein, which is consistent with the finding that lima beans are a good source of protein [9]. Reducing protein-energy malnutrition brought on by the high cost of animal protein and commonly consumed legumes would be greatly aided by the high protein contents of complementary foods enhanced with high amounts of lima bean flour. Growth and tissue replacement depend on protein [14].

The crude fibre concentration (0.31-1.82%) of complementary foods made from fermented maize, soybean, and carrot flours reported by [8] was lower than the values found in this investigation. As the amounts of substitution with fermented lima beans and trifoliate yam increased, it was found that the crude fibre content of the supplemental food samples increased as well. This is consistent with the finding that these foods are high in dietary fibre [15]. The fibre levels found in this study fell within the FAO/WHO-recommended range of no more than 5% for kids. Complementary foods with low fibre content are less bulky and promote better digestion and nutrient absorption, including for proteins and minerals.

Compared to all of the formulated samples, the fat level of the control (100% fermented maize flour) was considerably ($p<0.05$) lower. Compared to the control sample, the designed complementary food samples had a comparatively greater fat content. Food products' sensory qualities have been shown to be influenced by fat, however a high fat content can make food more likely to go bad and so lower its shelf life [16].

All of the designed complementary food items had significantly ($p<0.05$) lower carbohydrate levels than the control. The large amount of fermented maize flour utilised may have contributed to the control sample's increased carbohydrate content. Since children need energy to perform their demanding activities as they develop, the carbohydrate levels in all formulations provide nutritional benefits. The carbohydrate content (69.20-74.50%) of supplemental foods made from blends of soybean, plantain, and malted millet flour was lower than the values found in this study [6]. The body uses carbohydrates as its primary energy source. It is the primary source of energy for the brain and the only supply of glucose for red blood cells. If there is a shortage, the body may consume body fat and proteins to make the energy it needs, which could deplete bodily tissues [17]. Despite the lack of a set recommended dietary allowance (RDA) for the consumption of carbohydrates.

Bulk densities of 0.76 to 0.83 have been found for fermented maize and full-fat soy flour blends used to produce "agidi." As the amount of fermented maize flour substituted with lima bean and trifoliate flours increased, it was found that the bulk density of the complementary food decreased significantly ($p<0.05$). The ratio of flour weight to volume, expressed in grammes per millilitre, is known as bulk density. It is a measurement of flour weight and a crucial factor in determining whether flour is suitable for the packaging and transportation of particulate matter. When deciding on packaging requirements, raw material handling, and wet processing applications in the food business, bulk density—which is often influenced by particle size and flour or flour mix density—is crucial [18]. According to reports, foods' bulk density rises as their starch level does. The reduced starch content in the prepared samples may be the cause of their lower bulk density.

Regarding its packing, protein material's high bulk density is also crucial. The examples of enriched complementary flours have a low bulk density, which makes them appropriate for creating complementary foods with a high nutrient density. Additionally, a reduced loose bulk density means that fewer food samples would need to be packed in a given container, guaranteeing cost-effective packing. Nutritionally speaking, low loose bulk density makes food products easier to digest, especially for young infants whose digestive systems are still developing. Because high bulk density restricts the caloric and nutritional intake per feed per child and infants occasionally cannot consume enough to meet their energy and nutrient requirements, the lower bulk density displayed by the formulated samples (samples B, C, D, and E) would be advantageous in the preparation of infant gruels [19]. The bulk density value (both packed and loose) is consistent with the 0.54-0.71 g/ml value of a weaning diet made from oilseeds, sorghum, and Nutrend that was reported by [3]. These values, however, are greater than those for the nutritional quality of tempeh flour reported by [20], which was 0.50 to 0.54 g/ml.

The unfortified sample (control) was shown to have a considerably ($p<0.05$) lower oil absorption capacity than the fortified samples (samples B, C, D, and E). This may be related to the protein's heat dissociation and denaturation, which should reveal the non-polar residue inside the protein molecule. Physical trapping of the lipid by the protein is the cause of oil retention. Food with oil has a nice taste and a soft texture. As a result, food products that absorb oil have better mouthfeel and taste retention. Doughnuts, pancakes, soups, meat extenders and substitutes, and ground meat compositions all benefit from a high oil absorption capacity [21]. It has been noted that flour derived from seeds and legumes with an oil absorption capacity of greater than 6.00% works well when used to make meat extenders, baked goods, and weaning products.

The current study's findings are consistent with those of [22], who found that adding more soy flour to soy-plantain composite flour decreased its swelling capability. The amount of associative forces present in flour granules is indicated by their swelling power. The starch-based flour's water absorption index during heating can also be linked to its swelling capability. Low swelling capacity was caused by the weak strength of the starch granules seen in the fortified supplemental food samples.

The varying ratios of amylose to amylopectin for the various flour samples may be the cause of the variations in viscosities seen in this investigation. The internal friction that occurs within a liquid is known as viscosity. Viscosity is also related to protein functionality and content. The viscosity of formulations containing date palm flour, trifoliate yam, and lima bean flour was shown to be reduced in this investigation; this suggests that the protein in lima beans contributed to the viscosity. The amylose content of the fortified samples (samples B, C, D, and E) may be the cause of their poor viscosity. This information is useful because it allows scientists to determine the flour concentration and cooking time required for different types of porridge.

## 6. Conclusion

According to the study, using fermented lima bean flour, trifoliate yam flour, and date palm flour in place of maize-based complementary foods enhanced the products' protein, fat, and fibre content as well as their functional qualities. This finding opens up new applications for the flours. During the complementary feeding time, nursing moms could feed their newborns and young children the complementary foods developed in this study. The anti-nutrient content of the trifoliate yam, lima beans, and maize was brought down to safe levels by the use of processing techniques like fermentation, soaking, and drying.

All of the complementary food gruels that were analysed received noteworthy ratings for appearance, mouthfeel, aroma, taste, and general acceptability, according to the sensory scores of the gruel made from the complementary food composite flour blends. Samples B and C compared favourably with the control sample (sample A). The study generally demonstrated that locally accessible raw ingredients, such as maize, lima beans, trifoliate yam, and date palm fruit, may be used to generate high-quality supplementary foods that are both nutrient-dense and consumer-acceptable.

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