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# Nutritional Evaluation of Formulated Maize-based, Ready-to-Use Complementary Food and Sensory Properties of the Gruel

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**Abstract**

The study investigated nutritional properties and sensory attributes of formulated, ready-to-use maize-based complementary foods. The study adopted experimental research design. Three composite flour samples with the ratios of 8:4:2 1:5, 9:5:1:4 and 10:51:1:4 of maize soybean, yeast, moringa seed and date fruit (sample 1, sample 2 and sample 3) respectively were formulated and subjected to nutrients analysis using standard procedures. Twenty-member panel of judges was employed to determine the organoleptic attributes, using a 9-point hedonic scale. Mean, one-way analyses of variance (ANOVA), Fishers Least Significant Difference (LSD) were used for data analysis. Results show that sample 1had highest ash (36.44±0.52g/100g),fat (15.45±0.27g/100g) and protein (3.52±0.44g/100g) content whereas the highest crude fibre (2.37±0.03g/100g),carbohydrate (44.18±0.03g/100g) and moisture (8.82±0.44g/100g) values were recorded in sample 3. Sample 1 had the highest concentration of all the vitamins analyzed with the exception of pro-vitamin A(beta-carotene) which was highest in sample 3 (0.018±0.0mg/100g). Result on mineral composition indicated that sample 1had the highest ($p<0.05$) zinc (3.37±0.14mg/100g), magnesium (383.05±10.07mg/100g and potassium (643.10±4.84mg/100g) whereas sample 3 recorded the highest ($p<0.05$) calcium (232.05±1.01mg/100g) and iron (10.15±0.15mg/100g) values. Sample one formulation yielded the most acceptable gruel (8.20±0.95[a]).

**Keywords**: Nutritional, Evaluation, Formulation, Nutrient, Maize, Complementary Food, Gruel

## Introduction

Human breast milk, referred to as 'individualized medicine' is ideal to support growth and development of infants and World Health Organization (WHO) recommends that children be breastfed exclusively for the first six months of their life (WHO,2012).It helps in stimulation of the immune system of the infant, maintenance of the microbial modifications in the infant's gastrointestinal system, and stimulation of the epigenetic programming of the infant (Verduci et al;2014). Yaqub & Gul, (2013) however, reported that socio-demographic, environmental, psychosocial and biomedical factors contribute to early cessation of breastfeeding which may pose adverse health outcomes to the infant. This cessation of breastfeeding is necessitated by the nutritional inadequacy of breast-milk alone as the infant advances beyond six months of age.

Complementary foods are foods other than the breast milk or infant formula (liquid, semisolid or solid) introduced to an infant to provide their nutrient requirements (Weinman,2010). Complementary foods are meant to supplement the nutritional needs of babies and children. Around the age of six months, an infant's need for energy and nutrients starts to exceed what is provided by breast milk, and hence, complementary foods are necessary to meet these needs. An infant of this age is also developmentally ready for other foods.

The choice of complementary foods as well as the nutritional composition of such foods is, therefore, important in fighting against childhood malnutrition which has been implicated in infant mortality and morbidity. The quality of complementary foods is important if infants and young children nutrition is to be improved. Also, most families in low- and middle-income countries because of the perennial problem associated with poverty, cannot afford nutritionally-adequate proprietary cereal-based complementary food. Thus, they resort to using traditional foods such as cereals, legumes or tubers employing different processing approaches for complementary feeding (Tizazu et al 2011).

It has been reported that resort to use of traditional foods as ingredients for complementary foods in developing countries has a number of drawbacks, which could also be mitigated. Such drawbacks include nutrient imbalance (high in carbohydrate, low in essential nutrients like protein, healthy fats and fibre) (Tesfaye, et al, 2020); inadequate preparation (Yitayew, et al, 2017, contamination risks (Tesfaye, et al, 2022), allergenic potential, limited bio-availability, lack of diversity (Lartey, et al, 2018), inconvenient and not tailored to individual needs.

Complementary feeding entails a process which begins when breast milk alone is no longer sufficient to meet with a child's dietary requirements and generally involves foods given to infants between 6 and 24 months of age together with breast milk (Dewey,2009). The choice of complementary foods and improper feeding practices are associated with a high prevalence of malnutrition in children under the age of five years in developing or underdeveloped countries (Park et al;2012). Malnutrition which is often times referred to both under-nutrition and over-nutrition, generally indicates under-nutrition including protein-energy malnutrition and micronutrients deficiency. Globally, severe malnutrition was responsible for greater than 50% childhood mortality of children less than 5 years of age, implying that about 3.5 million children die of malnutrition every year (Park et al;2012).

It has been reported that about 70–80 percent of undernourished children of the world are found in developing countries (Bryce et al, 2008). This could be largely attributed in part, to the nutritional inadequacy of the ingredients used in formulation of traditional complementary foods fed to infants and children. There have been several reports on studies with respect to the use of traditional food ingredients to formulate complementary diets in developing countries including Nigeria with varying levels of nutrients and processing techniques for use in infant nutrition (Lartey et al 2018). In view of these reports, this work focuses on the observed gap which bothers on nutritional quality of the ingredients used in formulation of traditional complementary foods in developing countries such as Nigeria. It is necessary to ascertain the nutritional quality of complementary foods that are fed to children immediately after cessation of exclusive breasting. Such complementary foods obviously contribute to optimal health of children as they advance in life to adulthood, hence the need for this study.

**Objectives of the study**

The main purpose of this study was to investigate nutritional and sensory properties of formulated maize-based, ready–to-use complementary food. Specifically, the study determined the following properties of the ready-to-use complementary:

1. proximate (moisture, ash, fat, protein, crude fibre and carbohydrate).
2. vitamin (beta-carotene[pro-vitamin A],B1,B2,B3,B6,B9,C and E) composition.
3. mineral content (calcium, iron,zinc, magnesium and potassium) composition.
4. sensory pattribute.

**Materials and Methods**

***Design of the study*:** It was an experimental research.

***Materials and Procurement*:** The materials used for the study were maize (base), soybean, yeast, *moringa* seed and date (*dabino*).Soybean (*Glycine max*), maize (*Zea mays*), moringa seed, dates were purchased from the Relief market in Owerri while the yeast powder was purchased from Little Wood Pharmaceutical Company both in Owerri Municipality.

***Processing of the food items*:** Five hundred grams (500 g) each ofsoybean, maize, dates and moringa were separately sorted, washed in portable water. Soyabean was boiled for 3 hours, cooled, dehulled (decorticated) manually by rubbing between the palms. The hulls were separated from the cotyledons by floating in cold water. It was drained and then dried in an oven at 60°C for 24h, cooled and milled in a hammer-mill.It was sieved with a 1-mm mesh-size sieve and stored in an air-tight plastic container, ready for use in formulation.

Maize was boiled for 2h, drained and dried in an oven at 60°C for 24h, cooled and milled in a hammer-mill. Sieving was done with a 1-mm mesh size. The meal was stored in an air-tight container for use in formulation. The same quantity of maize was fermented for 48h,milled,sieved (muslin cloth) and oven-dried as above,to serve as control.

Dates (*dabino*) was de-seeded, dried at 60°C for 24h, milled with a hammer-mill, cooled, sieved with 1-mm mesh size, and stored in an air-tight container for use in formulation.

Moringa seed was air-dried at ambient temperature (28±2°C) for 24h, and milled in a hammer-mill. The flour was sieved with a 1-mm mesh size sieve andstored in an air-tight container for use in formulation.

***Formulation Ratios for Ready-To-Use Complementary Food*:** Three samples of the ready-to-use complementary food were formulated based on the ratios as follows: each formulated sample was put in the Sun-show petrol engine machine and milled for 5min for homogeneity. Each sample was packaged in a zip- lock and used for chemical and sensory evaluation.

| Samples | Maize Flour | Soybean flour | Yeast Flour | *Moringa* Seed Flour | Dates Flour | Total |
|---|---|---|---|---|---|---|
| $CSYMD_1$ | 40g | 20g | 10g | 5g | 25g | 100g |
| $CSYMD_2$ | 45g | 25g | 5g | 5g | 20g | 100g |
| $CSYMD_3$ | 50g | 20g | 5g | 5g | 20g | 100g |
| Control | 100g | Nil | Nil | Nil | Nil | 100g |

Key: $CSYMD_1$: 40g:20g:10g:5g:25g: Maize flour: Soybean flour: Yeast Flour: Moringa seed: dates
$CSYMD_2$: 45g:25g:5g:5g;20g: Maize flour: Soybean flour: Yeast Flour: Moringa seed: dates
$CSYMD_3$:50g:20g:5g:5g:20g : Maize flour: Soybean flour: Yeast Flour: Moringa seed: date

***Proximate Analysis of samples*:** The proximate composition of the formulated complementary food samples and the control (fermented yellow maize) were determined by standard methods (AOAC, 2010). Moisture content was determined by the drying method using hot-air oven circulation (method #925.09). Ash content of a known weight sample was determined through incineration (550° C) using a muffle furnace (method #923.03). Crude protein was determined by micro-Kjeldahl (method #979.09) and calculated by multiplying the corresponding total nitrogen content by a factor of 6.25. The crude fat content of the sample was determined by a Soxhlet extractor (method #930.09). Crude fiber content was determined by the following method #962.09.

Available carbohydrate was calculated by difference, in essence, % Carbohydrate = 100 – (% protein + % fat + % Ash + % Crude fibre).

***Micro-nutrient Analysis*:** Vitamins and Minerals were determined using standard methods:

***Vitamins*:** Pro-Vitamin A (beta-carotene) was determined by spectrophotomertic method (AOAC, 2010).

The results were converted to vitamin A values using the conversion factor of 6 µg β-carotene: 1 µg RE according to (WHO/FAO, 2004). B1(thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxine), B9 (folic acid), C (ascorbic acid) and E (tocopherol) were each determined by ultra-high performance liquid chromatography (UPHLC) after the necessary pre-treatments (Nelson *et al*, 2006).

***Minerals*:** The method described by Onwuka (2005) was used in the determination of mineral content of sample. The digest was for the determination of calcium and potassium by the flame photometry method, while iron, zinc and magnesium were determined using the atomic absorption spectrophotometer method.

***Preparation of the complementary gruel*:** Four samples of complementary gruel were prepared as follows:

**Recipe of the gruels**

| **Ingredients** | **Quantity** |
|---|---|
| Formulated sample | 100g |
| Water | 300ml |

**Preparation procedure**

1. Put each sample into a bowl.
2. Mix the flour with cold water (300ml) to obtain a slurry.
3. Pour/boiling water gradually it into the bowl, to gelatinize.

*Sensory Evaluation*

**Panel of judges:** The panel of 20 judges was selected from staff and students of Department of Home Economics and Hospitality Management of Alvan Ikoku Federal University of Education, Owerri. The selection of judges was based on their sensory acuity. They were trained on the procedures of tasting the gruel and scoring samples appropriately.

***Instrument for data collection*:** instrument used was a scoring sheet based on 9-point hedonic scale of like extremely (9 points), like very much (8), like moderately (7 points), like slightly (6 points), neither like nor dislike (5 points), dislike slightly (4 points), dislike moderately (3 points), dislike very much (2 points), and dislike extremely (1 point), (Ihekoronye & Ngoddy, 1985).

***Data collection procedure*:** The prepared gruels were coded as samples 1, 2, 3, and the control. Samples were randomly served to the panelists. They were to taste, score each sample, and rinse their mouths before proceeding to the next sample. The tasting was carried out in a well-ventilated and lighted place (Home Economics Food Laboratory). The sensory attributes tested and scored were texture, appearance, (colour), aroma, mouth feel and general acceptability.

***Data analysis technique*:** Data generated from proximate, sensory evaluation, vitamin and mineral determinations were all analyzed using mean, one-way analysis of variance (ANOVA) and Fisher's least significant difference (LSD) at 0.05 level of significance ($P < 0.05$ ).

**Results**

**Table 1: Proximate Compositions (g/100g) and Enenrgy values of the Formulated Flours**

| Samples | Moisture | Ash | Fat | Protein | CF | CHO | Energy(kcal /100g) |
|---|---|---|---|---|---|---|---|
| $CSYMD_1$ | $8.25±0.02^c$ | $3.64±0.05^a$ | $15.45±0.27^a$ | $3.52±0.44^a$ | $2.14±0.08^c$ | $34.20±1.16^c$ | $289.93±2.67^a$ |
| $CSYMD_2$ | $8.58±0.03^b$ | $3.21±0.16^b$ | $14.66±0.32^b$ | $3.15±0.11^a$ | $2.30±0.03^b$ | $39.25±1.69^b$ | $301.54±3.1^a$ |
| $CSYMD_3$ | $8.82±0.11^a$ | $2.90±0.07^c$ | $13.39±0.32^c$ | 2.28±0.13c | $2.37±0.03^b$ | $44.18±0.41^a$ | $306.35±3.8^a$ |
| Control | $7.8±0.04^d$ | $1.96±0.02^d$ | $4.58±0.15^d$ | $2.98±0.13^b$ | $3.70±0.06^a$ | $29.75±0.56^d$ | $172.14±^b$ |
| $LSD_{(0.05)}$ | 0.14 | 2.11 | 0.61 | 0.54 | 0.11 | 2.42 | 10.25 |

KEY= CF= Crude fibre;Control: I00% fermented yellow maize

CHO = Carbohydrate

Each value is the mean of triplicate determinations. $^{abc}$Mean values with different superscripts in the same row are statistically significant.

Table 1 shows that the moisture values of the samples were low, which ranged from 8.25g/100g in sample 1 ($CSYMD_1$) to 8.82g/100g in sample 3 ($CSYMD_3$) . Sample 1 had the highest ash and fat values (3.64g/100g and

15.45g/100g respectively) when compared with the other samples. The protein contents of samples 1 and 2 ($CSYMD_2$), and crude fibre contents of sample 2 and sample 3 were statistically similar; sample 3 had statistically higher carbohydrates value (44.18g/100g), followed by sample 2 (39.25g/100g). The energy values of the complementary food samples ranged from 289.93 to 306.35kcal/100g, with sample 3 being the highest.

**Table 2: Vitamin Composition of the Formulated Flours (mg/100g)**

| SAMPLES | Betacarotene | B1 | B2 | B3 | B6 | B9 | C | E |
|---|---|---|---|---|---|---|---|---|
| $CSYMD_1$ | $0.015 \pm 0.0^{c}$ | 0.67±0.03 | 0.82±0.02 | $3.34 \pm 0.09^{a}$ | 0.58±0.03 | 0.98±0.02 | 2.27±0.03 | 0.44±0.03 |
| $CSYMD_2$ | $0.017 \pm 0.0^{b}$ | 0.66±0.02 | 0.73±0.02 | $3.23 \pm 0.01^{ab}$ | 0.54±0.01 | 0.90±0.03 | 2.16±0.05 | 0.36±0.02 |
| $CSYMD_3$ | $0.018 \pm 0.0^{a}$ | 0.64±0.03 | 0.67±0.02 | $3.18 \pm 0.04^{b}$ | 0.48±0.05 | 0.86±0.01 | 2.05±0.03 | 0.41±0.25 |
| $LSD_{(0.05)}$ | **0.76** | **0.05** | **0.04** | **0.12** | **0.06** | **0.04** | **0.07** | **0.29** |

KEY: B1= thiamine, B2=riboflavin;B3= niacin;B6=pyridoxine; B9=folic acid;C=ascorbic acid;E=tocopherolEach value is the mean of triplicate determinations. Mean values with different superscripts in the same row are statistically significant.

Table 2 shows that sample 3 ($CSYMD_3$) had the highest (statistically) value (0.018mg/100g) in beta-carotene (pro-vitamin A), followed by sample 2($CSYMD_2$) However, sample 1($CSYMD_1$) had the highest vitamins B1,B2,B3,B6,B9,C and E values (0.67mg/100g, 0.82mg/100g, 3.34mg/100g, 0.58mg/100g, 0.98mg/100g, 2.27mg/100g and 0.44mg/100g respectively) when compared with the other samples.

**Table 3: Mineral Composition of the Formulated Flours (mg/100g)**

| Samples | Calcium | Iron | Zinc | Magnesium | Potassium |
|---|---|---|---|---|---|
| $CSYMD_1$ | $210.94 \pm 1.41^{c}$ | $7.97 \pm 0.04^{c}$ | $3.47 \pm 0.14^{a}$ | $383.05 \pm 10.07^{a}$ | $643.10 \pm 4.84^{a}$ |
| $CSYMD_2$ | $222.43 \pm 0.70^{b}$ | $9.08 \pm 0.08^{b}$ | $3.32 \pm 0.02^{a}$ | $351.06 \pm 12.58^{b}$ | $614.64 \pm 6.15^{b}$ |
| $CSYMD_3$ | $232.05 \pm 1.01^{a}$ | $10.15 \pm 0.15^{a}$ | $3.32 \pm 0.17^{a}$ | $317.21 \pm 4.12^{c}$ | $579.03 \pm 18.24^{c}$ |
| $LSD_{(0.05)}$ | **2.16** | **0.2** | **0.27** | **19.18** | **22.9** |

Each value is the mean of triplicate determinations. Mean values with different superscripts in the same row are statistically significant.

Table 3 reveals that sample 3 ($CSYMD_3$) had the highest calcium and iron values (232.05mg/100g and 10.15mg/100g respectively) when compared with the other samples. Interestingly, all the 3 samples had statistically similar values in zinc. However, sample 1($CSYMD_1$) recorded the highest magnesium and potassium values (383.05mg/100g and 643.10mg/100g respectively) in comparison with the other samples.

**Table 4: Sensory Properties Gruel**

| Samples | Texture | Appearance | Taste | Mouth feel | Aroma | O. Acceptability |
|---|---|---|---|---|---|---|
| $CSYMD_1$ | 8.15±0.88[a] | 8.05±0.76[a] | 8.15±0.88[a] | 7.45±1.15[a] | 7.65±1.46[a] | 8.20±0.95[a] |
| $CSYMD_2$ | 7.15±1.18[b] | 8.00±0.79[a] | 7.50±1.43[a] | 6.95±1.54[a] | 7.15±1.58[a] | 7.65±1.42[a] |
| $CSYMD_3$ | 7.70±1.17[ab] | 7.75±0.85[a] | 7.75±1.33[a] | 7.50±1.19[a] | 7.70±1.45[a] | 7.55±1.36[a] |
| Control | 7.20±1.09[b] | 8.10±0.68[a] | 7.01±1.04[a] | 7.34±1.09[a] | 6.93±1.52[a] | 7.01±0.97[a] |
| $LSD_{(0.05)}$ | **0.89** | **0.66** | **1.01** | **1.06** | **1.23** | **1.03** |

Table 4 reveals that sample 1 ($CSYMD_1$) had the statistically highest score (8.15) in texture, followed by sample 3 ($CSYMD_3$) which had 7.70.However, it is interesting that all the 3 samples had statistically similar values in the other sensory attributes (appearance, taste, mouth feel and aroma). They all are also statistically similar in overall acceptability.

**Discussion**

The result on proximate composition of the samples shows that moisture contents were between 8.25% and 8.82% which were below 12%. Mekuria, et al (2021) reported a higher moisture range of 6.04 to 13.36 g/100 g (13.36 g/100 g),due to the high moisture content of 13.36g/100g. Flours above 12% moisture content, flours will be highly susceptible to microbial spoilage arising from water activity [$a_w$]. The highest value of protein as observed in sample 1($CSYMD_1$) could be attributed to the combined effects of soy bean and yeast flour; however, this value is much lower than 16.6-16.98% reported by Gebrezgi,(2019), who worked on a composite complementary food using maize, soybean and moringa leaf. Soybean added in the formulation is capable of supplying the protein need in calorie (for protein-energy malnutrition) as recommended by Food and Agricultural Organization/World Health Organization/United Nations, (2013).

The fat contents (13.39-15.45g/100g) obtained in the study were higher than the values (10.5-10.7% reported by Gebrezgi,(2019) in the complementary food, . This higher value was due the greater proportion of soy bean with higher fat content (34%),Gebrezgi,(2019), coupled with less proportion of maize in the formulation (sample 1,($CSYMD_1$).On the contrary, Mekuria,Kinyuru, Mokua & Tenagashaw,(2021) reported a much lower (19:53g/100g) fat content of soybean.

The statistically higher ash content of sample 1 ($CSYMD_1$) (3.64g/100g) could be ascribed more to the high ash content (6-12%) of dried yeast used which was in greater proportion than the other formulations. Gebrezgi,(2019) reported a similar result in ash (3.5-4.0%), though he did not add date to the formulation.

Crude fiber result (2.14-2.37g/100g) of this work is much lower (2.96-6.75%) reported by Gebrezgi,(2019). This is good in view of the developing intestine of infants who cannot digest fiber at this stage.

The highest carbohydrate value (44.18g/100g) in sample 3 was expected as it contained the greatest proportion of maize in the formulation.This value is low when compared with 57.3-66.1g/100g reported by Gebrezgi,(2019). This variation could be due disparities in the formulations.

The energy values (289.93-306.35kcal/100g) obtained in the formulated complementary foods were lower (399.8-429.5kcal/100g) values reported by Gebrezgi,(2019). However,the implication is that it will require about 200g of the complementary food per day to meet the Recommended Dietary Allowance (RDA) (625kcal/day) for the 6-8 months infant;227g of it per day to meet the RDA (710 kcal/day for the 9-12 months infant, while it will require 294g of it to meet the RDA (920kcal/day) (for boys) 1-2 years and 269g to meet the RDA(840kcal/day) for girls.

The result suggests that beta carotene (pro-vitamin A) content, though very low(0.018mg/100g) increased with higher proportion of maize substitution as observed in Sample 3. All the other vitamins decreased as maize quantity in the formulation increased. This implies that the soybean is richer than maize in those vitamins. Sample 1 had the highest values in all the other vitamins, namely vitamins B1,B2,B3,B6,B9, C and E. This is attributed to the yeast and dates which had the greatest proportions in the sample. These vitamins are essential for the growth and development of infants and children.

Sample 3 (CSYMD$_3$) had the highest (232.05mg/100g) value of calcium and iron (10.15±0.15mg100g$^{-1}$); this implies that the formulation had best proportion with respect to calcium and iron, possibly contributed by the ingredients used. Sample 1(CSYMD$_{1)}$ which had highest (383.05mg/100g) value of magnesium, zinc (3.47 mg/100g) and potassium (643.10 mg/100g), implies that the proportion had the best in terms of magnesium, zinc and potassium different for the minerals determined in the study except for zinc. It is worthy of note that mineral elements are not affected by any processing unit operation.

The result in Table 5 on the sensory attributes of the samples shows that though the complementary foods were not statistically different with respect to the sensory attributes analyzed, the most preferred was sample 1 (CSYMD$_1$) had the highest score (8.20**)** in all the overall acceptability.

## Conclusion

This work revealed that poor nutritional quality of complementary food can be improved through compositing of local, rich, available and affordable foods (maize, soybean ,moringa seed ,date fruit (*Dabino*) and yeast powder). The most preferred sample was the one with the greatest proportion of yeast and date, Therefore, the combination of these local food ingredients in the production of complementary (gruel) food of high nutritional value can be used to remarkably enhance the nutritional status of infants.

## Recommendations

1. This work strongly recommends the use of these foods in the production of
2. complementary food for infants since they are locally available and relatively affordable to households.

3. The formulation of the complementary foods should be done using the appropriate proportions of the ingredients to achieve a nutrient-rich and acceptable complementary food.

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