# Formulation and Nutritional Evaluation of a Ready-To-Use Complementary Gruel Food for Infants Using Maize, Soybean, Moringa, Dates, and Yeast

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## ABSTRACT

Food technology is a multidisciplinary field that combines science, technology and engineering in the development of recipes to improve the production, processing of safe and quality food product. This study developed a ready-to-use complementary food using locally available food items (Soya bean, Dates (*dabino*) Yeast powder, Moringa seed and Maize (*corn)*. The study adopted experimental design to generate three samples coded as sample A, B and C. The nutrient, anti nutrient, and organoleptic properties of the samples were determined. The data obtained from the study was subjected to one way analysis of variance (ANOVA). Fisher's least significant difference (LSD) was employed to separate the means and difference accepted at 5% level of probability. The results show that the highest protein content was obtained in sample A which had the highest addition of yeast cells (10g). The carbohydrate in the samples was within the limit for infants for purpose of accurate assessment of nutritional status of 60g/day, 95g/day for 0-6months and 7-12months. The samples were high in calcium, iron, magnesium and potassium but low in Zinc. Based on the findings, recipe of complementary food with these local food items can improve the family food security and infant's nutritional status.

**Key words:** Agriculture, Complementary Gruel, Food Security

## INTRODUCTION

Complementary feeding plays a critical role in meeting the nutritional requirements of infants and young children, particularly during the transition from exclusive breastfeeding to family foods. At approximately six months of age, an infant's energy and nutrient needs begin to exceed the amount provided by breast milk alone, making the introduction of complementary foods essential. At this stage, infants are developmentally prepared to consume semi-solid foods, as they develop the ability to chew and show increased interest in foods other than milk. According to the Codex Alimentarius Commission (CAC, 2008), complementary foods should be nutritionally adequate, safe, and energy-dense in order to effectively complement breast milk for infants and family foods for older children. The primary objective of complementary feeding is to bridge nutrient gaps and prevent micronutrient deficiencies that commonly occur during infancy (Drewett, 2018).

The period of complementary feeding is nutritionally sensitive, as both macro- and micronutrient inadequacies can negatively affect growth, cognitive development, and immune function. Ojinnaka et al. (2013) reported that nutritional requirements are most critical during this stage, as insufficient intake may result in growth faltering and increased susceptibility to infections. Infants also have a high demand for vitamin A from birth, and children aged 1–59 months require adequate intake to support rapid growth and enhance resistance to disease (WHO, 2011; Ashun, 2018). Therefore, complementary foods must be carefully formulated to provide sufficient energy, protein, and essential micronutrients.

The timing of complementary food introduction is equally important. Introducing complementary foods too early (before 12 weeks) or too late (after 26 weeks) has been associated with adverse health outcomes (Kleinman, 2010). Late introduction may lead to feeding difficulties and growth retardation due to delayed development of eating skills (WHO, 2008). When complementary foods are introduced at the appropriate developmental stage generally between four and six months—infants are more likely to meet their nutritional needs and develop proper self-feeding abilities.

Breast milk remains the ideal source of nutrition during the first six months of life; however, from six months onward, it can no longer meet the infant's increasing energy and nutrient requirements. Complementary feeding is therefore recommended for children aged 6–23 months. The energy gap that must be filled by complementary foods increases with age and is estimated at 200 kcal/day for infants aged 6–8 months, 300 kcal/day for those aged 9–11 months, and 550 kcal/day for children aged 12–23 months (Claire, 2018). In addition to energy, complementary foods must supply adequate amounts of protein and essential micronutrients such as iron, zinc, calcium, magnesium, phosphorus, and vitamin B-complex. However, commercially fortified complementary foods are often unaffordable for low-income households, while traditional homemade complementary foods are frequently deficient in key micronutrients, particularly iron, zinc, and calcium.

The World Health Organization (2016) identified poor complementary feeding practices as a major contributor to childhood malnutrition. These practices include inappropriate timing of food introduction, inadequate feeding frequency, poor food consistency, limited dietary diversity, and unsafe hygiene practices. Many commonly used complementary foods are cereal-based and lack sufficient fortification, resulting in low protein quality and poor micronutrient density. Such inadequacies negatively affect the nutritional status, growth, and overall development of infants and young children, especially in resource-limited settings.

In response to these challenges, there is a growing need to develop affordable, nutrient-dense, and ready-to-use complementary foods using locally available ingredients.

This study therefore focused on the formulation and nutritional evaluation of a ready-to-use complementary gruel food using maize, soybean, moringa, dates, and yeast. Maize serves as the primary energy source, while soybean contributes high-quality protein, iron, and essential amino acids necessary for growth. Moringa leaves are rich in minerals and vitamins that support blood health and immune function. Dates provide natural sugars, dietary fiber, and micronutrients that aid digestion, promote healthy weight gain, and support dental and visual development. Yeast, a rich source of B-complex vitamins, supports metabolic processes, growth, and bone development.

Malnutrition during the weaning period remains a significant public health concern, particularly in developing countries. Inadequate nutrient intake resulting from poor dietary choices, inappropriate food preparation, and poverty contributes to growth retardation, increased morbidity, and mortality among infants (UNICEF, 2010). Additional factors such as food taboos, dietary restrictions, and poor sanitation further worsen nutritional outcomes (Igbedioh, 2014).

Therefore, the formulation and nutritional assessment of a locally sourced, ready-to-use complementary gruel food is essential for improving infant feeding practices and reducing the prevalence of malnutrition among infants and young children

## MATERIALS AND METHOD

### Procurement of materials:

Soybean (Glycine Max), Maize (corn), Moringa seed, Dates were purchased from the Relief market in Owerri while the yeast powder was also purchased from Little Wood Pharmaceutical Center also in Owerri Municipal.

### Methods

This study used the experimental research design in carrying out the work which was carried out in the Food Laboratory of the Department of Home Economics and Hospitality management Education of Alvan Ikoku Federal University of Education, Owerri, Imo State.

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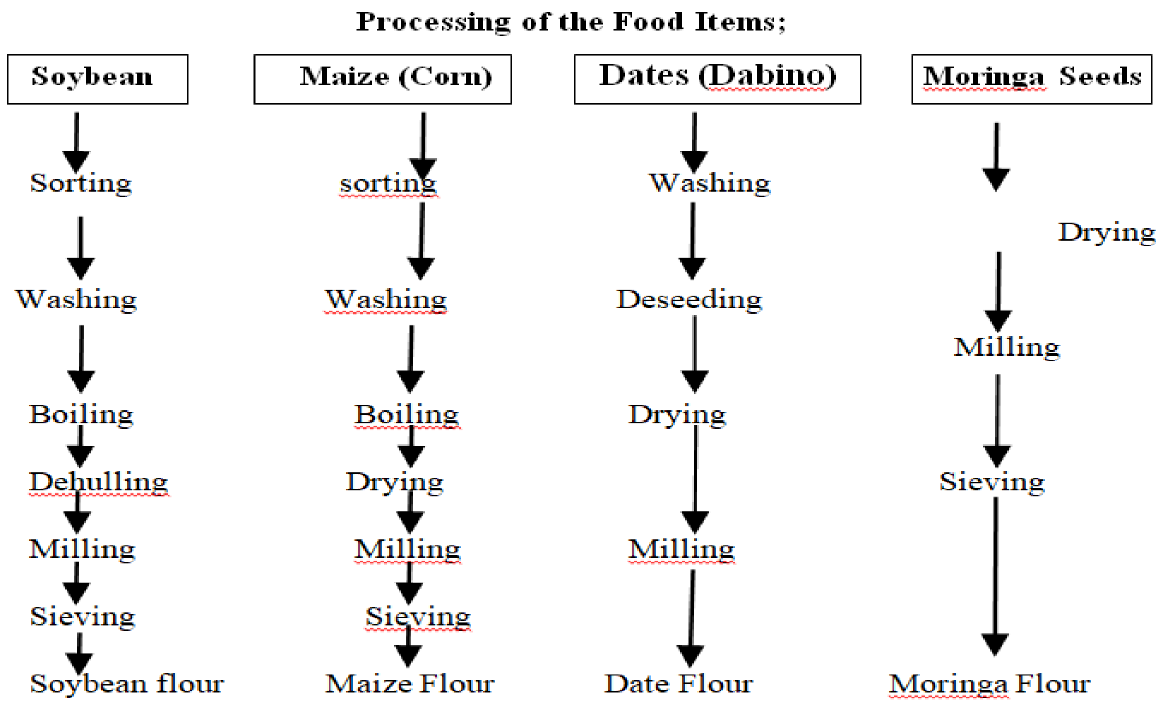


Fig. flow chart for the production of each flour (Nguyen & Tom 2018)

Table 1: Formulation Ratio for Ready-to-use Complementary Food

The sample bleeds were formulated using the method of Ike et al (2021) with slight modification. The samples were multiple blends of yellow corn, soya beams, yeast powder, Moringa seeds and Dates Seeds

| Samples | **Corn Flour** | **Soybean flour** | **Yeast Flour** | **Moringa Seed Flour** | **Dates Flour** | **Total** |
|---|---|---|---|---|---|---|
| A | 40g | 20g | 10g | 5g | 25g | 100g |
| B | 45g | 25g | 5g | 5g | 20g | 100g |
| C | 50g | 20g | 5g | 5g | 20g | 100g |

**Chemical Analysis of Samples**

Standard analytical procedures were employed to determine the chemical composition of the formulated complementary food samples. Moisture, ash, crude protein, crude fibre, and crude fat contents were determined using methods described by the Association of Official Analytical Chemists (AOAC, 2015). Total carbohydrate content was calculated by difference.

Mineral analysis was carried out in accordance with AOAC (2015). The concentrations of iron (Fe), calcium (Ca), zinc (Zn), magnesium (Mg), and phosphorus (P) were determined using flame atomic absorption spectrophotometry (AAS) following wet digestion of the samples with nitric acid ($HNO_3$) and Perchloric acid ($HClO_4$). An Atomic Absorption Spectrophotometer (Model SP9) was used, and readings were taken at specific wavelengths appropriate for each mineral element.

Vitamins A, $B_1$ (thiamine), $B_2$ (riboflavin), $B_3$ (niacin), $B_6$ (pyridoxine), $B_9$ (folate), C (ascorbic acid), and E (tocopherol) were analyzed using the method described by Usman and Musa (2021). Absorbance readings were obtained using the Atomic Absorption Spectrophotometer (AAS Model SP9) at designated wavelengths for each vitamin, with chloroform used as the blank. Anti-nutritional factors, including calcium oxalate, phytate, tannins, trypsin inhibitor, and saponins, were determined using standard AOAC (2015) procedures.

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**Sensory Evaluation**

Sensory evaluation of the complementary food samples was conducted using a twenty-member semi-trained panel to assess organoleptic attributes such as texture, appearance (colour), aroma, mouth feel, and overall acceptability. The panelists comprised staff and students from the Department of Home Economics and Hospitality Management Education, Alvan Ikoku Federal University of Education, Owerri, Imo State.

The samples were freshly prepared into gruel and served warm to the panelists. To prevent taste interference between samples, potable water was provided for mouth rinsing after each evaluation. A nine-point hedonic scale, as described by Ihekoronye and Ngoddy (1985), was used for sensory assessment. The scale ranged from like extremely (9) **to** dislike extremely **(1)**, with intermediate points representing varying degrees of liking or disliking.

**Statistical Analysis**

Data obtained from chemical, anti-nutritional, and sensory analyses were subjected to one-way analysis of variance (ANOVA). Mean differences were separated using Fisher's Least Significant Difference (LSD) test, and statistical significance was accepted at $\mathbf{P < 0.05}$.

**Result**

Table 2: Proximate Composition of the Samples

| **Samples** | **Moisture** | **Ash** | **Fat** | **Protein** | **CF** | **CHO** |
|---|---|---|---|---|---|---|
| **A** | $8.25 \pm 0.02^{c}$ | $36.44 \pm 0.52^{a}$ | $15.45 \pm 0.27^{a}$ | $3.52 \pm 0.44^{a}$ | $2.14 \pm 0.08^{b}$ | $34.20 \pm 1.16^{c}$ |
| **B** | $8.58 \pm 0.03^{b}$ | $32.06 \pm 1.61^{b}$ | $14.66 \pm 0.32^{b}$ | $3.15 \pm 0.11^{a}$ | $2.30 \pm 0.03^{a}$ | $39.25 \pm 1.69^{b}$ |
| **C** | $8.82 \pm 0.11^{a}$ | $28.97 \pm 0.71^{c}$ | $13.39 \pm 0.32^{c}$ | $2.28 \pm 0.13^{b}$ | $2.37 \pm 0.03^{a}$ | $44.18 \pm 0.41^{a}$ |
| $LSD_{(0.05)}$ | **0.14** | **2.11** | **0.61** | **0.54** | **0.11** | **2.42** |

KEY= CF= Crude fibre

CHO = Carbohydrate

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

Table 3: Composition of some Vitamins in the Food Samples

| **SAMPLES** | **A(UI/kg)** | **B1(mg/kg)** | **B2(mg/kg)** | **B3(mg/kg)** | **B6(mg/kg)** | **B9(mg/kg)** | **C(mg/kg)** | **E(mg/kg)** |
|---|---|---|---|---|---|---|---|---|
| **A** | $24.78 \pm 0.58^{c}$ | $0.67 \pm 0.03^{a}$ | $0.82 \pm 0.02^{a}$ | $3.34 \pm 0.09^{a}$ | $0.58 \pm 0.03^{a}$ | $0.98 \pm 0.02^{a}$ | $2.27 \pm 0.03^{a}$ | $0.44 \pm 0.03^{a}$ |
| **B** | $27.69 \pm 0.19^{b}$ | $0.66 \pm 0.02^{a}$ | $0.73 \pm 0.02^{b}$ | $3.23 \pm 0.01^{ab}$ | $0.54 \pm 0.01^{a}$ | $0.90 \pm 0.03^{b}$ | $2.16 \pm 0.05^{b}$ | $0.36 \pm 0.02^{a}$ |
| **C** | $29.84 \pm 0.24^{a}$ | $0.64 \pm 0.03^{a}$ | $0.67 \pm 0.02^{c}$ | $3.18 \pm 0.04^{b}$ | $0.48 \pm 0.05^{b}$ | $0.86 \pm 0.01^{c}$ | $2.05 \pm 0.03^{c}$ | $0.41 \pm 0.25^{a}$ |
| $LSD_{(0.05)}$ | **0.76** | **0.05** | **0.04** | **0.12** | **0.06** | **0.04** | **0.07** | **0.29** |

**KEY: A= Vitamin A, $B_1$ = Vitamin $B_1$, $B_2$ = Vitamin $B_2$, $B_3$ = Vitamin $B_3$, $B_6$ =Vitamin $B_6$, $B_9$ =Vitamin $B_9$, Vitamin C, Vitamin E**

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

Table 3: Composition of some Minerals in the Food Samples

| Samples | Ca(Mg/100g) | Fe(Mg/100g) | Zn(Mg/100) | Mg(Mg/100) | K(Mg/100g) |
|---|---|---|---|---|---|
| **A** | $210.94 \pm 1.41^{c}$ | $7.97 \pm 0.04^{c}$ | $3.47 \pm 0.14^{a}$ | $383.05 \pm 10.07^{a}$ | $643.10 \pm 4.84^{a}$ |
| **B** | $222.43 \pm 0.70^{b}$ | $9.08 \pm 0.08^{b}$ | $3.32 \pm 0.02^{a}$ | $351.06 \pm 12.58^{b}$ | $614.64 \pm 6.15^{b}$ |
| **C** | $232.05 \pm 1.01^{a}$ | $10.15 \pm 0.15^{a}$ | $3.32 \pm 0.17^{a}$ | $317.21 \pm 4.12^{c}$ | $579.03 \pm 18.24^{c}$ |
| $LSD_{(0.05)}$ | **2.16** | **0.2** | **0.27** | **19.18** | **22.9** |

**KEY: CA = Calcium, Fe = Ion, Zn = Zinc, Mg = Magnesium, K= Potassium**

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

Table 5. Result of sensory evaluation

| Samples | Texture | Appearance | Taste | Mouthfeel | Aroma | Gen.Acceptability |
|---|---|---|---|---|---|---|
| **A** | $8.15 \pm 0.88^{a}$ | $8.05 \pm 0.76^{a}$ | $8.15 \pm 0.8^{a}$ | $7.45 \pm 1.15^{a}$ | $7.65 \pm 1.4^{a}$ | $8.20 \pm 0.95^{a}$ |
| **B** | $7.15 \pm 1.18^{b}$ | $8.00 \pm 0.79^{a}$ | $7.50 \pm 1.43^{a}$ | $6.95 \pm 1.54^{a}$ | $7.15 \pm 1.58^{a}$ | $7.65 \pm 1.42^{a}$ |
| **C** | $7.70 \pm 1.17^{ab}$ | $7.75 \pm 0.85^{a}$ | $7.75 \pm 1.33^{a}$ | $7.50 \pm 1.19^{a}$ | $7.70 \pm 1.45^{a}$ | $7.55 \pm 1.36^{a}$ |
| $LSD_{(0.05)}$ | **0.89** | **0.66** | **1.01** | **1.06** | **1.23** | **1.03** |

## DISCUSSION OF RESULTS

The proximate composition of the formulated complementary food samples, as presented in Table 2, shows that the moisture content ranged from 8.25 ± 0.02% to 8.82 ± 0.11%, which is below the critical limit of 12%. This low moisture content is desirable, as Murano (2003) reported that flour products with moisture levels above 12% are highly susceptible to microbial spoilage due to increased water activity. Although the moisture values fell within the same whole-number range, the differences among samples were statistically significant, indicating variations in the degree of dryness of the raw materials used. This underscores the importance of proper drying and handling of ingredients during formulation to enhance shelf stability.

The protein contents of the samples were higher than values reported by Makinde (2013) and Lawrence (2015), where maize alone was used in formulation. The increased protein levels observed in this study can be attributed to the inclusion of soybean and yeast, both of which are known for their high protein content. The protein levels obtained are adequate to support the protein requirements for infants, particularly in the prevention of protein-energy malnutrition, as recommended by FAO/WHO/UN, with values of 1.25 g/kg/day, 1.40 g/kg/day, and 1.65 g/kg/day for weaning children aged 3–5 months, 5–9 months, and 9–12 months, respectively. Sample A recorded the highest protein content, likely due to the higher inclusion level of yeast (10 g), while Sample B contained more protein than Sample C, possibly due to its higher proportion of soybean.

The fat content of the samples was comparable to values reported by Neils (1994). Faquire and Mohammed (2015) reported that soybean is naturally high in fat, which supports the finding that Sample B, with the highest soybean inclusion, also recorded the highest fat content. Shuba et al. (2012) reported similar fat values and noted that soybean fats are predominantly unsaturated. Ademora (2004) further emphasized that soybean is a rich

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source of dietary fats, providing appreciable amounts of saturated, monounsaturated, and polyunsaturated fatty acids, including omega-3 and omega-6 fatty acids, which are essential for infant growth and brain development.

Ash content, which reflects the total mineral content of food, showed that Samples A and B were statistically similar, while Sample C had a significantly lower value. Since Samples A and C contained equal amounts of soybean and moringa, and Samples B and C had similar quantities of date fruit and yeast, it is likely that soybean and date fruit contributed significantly to the higher ash content observed. The reduction in ash content with increased maize proportion suggests that maize contributed less to total mineral content. Crude fibre content increased with the proportion of maize in the formulation. Fibre is important for enhancing satiety and supporting digestive health. Samples B and C had similar fibre values, while Sample A had significantly lower fibre content, reflecting differences in ingredient composition.

Carbohydrate content varied significantly among the samples and increased with higher maize inclusion. Carbohydrates serve as the primary energy source for infants, and the values obtained were within the recommended intake levels for infants and young children, reported as approximately 60 g/day for 0–6 months and 95 g/day for 7–12 months (Satrsh Ckelchen, 2019). Adequate carbohydrate intake is essential for preventing protein-energy malnutrition by sparing protein for growth and tissue repair. The carbohydrate values obtained were comparable to those reported by Neils (1994) and Makinde (2003). Slightly higher values observed in earlier studies may be attributed to lower levels of soybean substitution in their formulations.

Mineral analysis revealed that the samples were rich in calcium, iron, magnesium, and potassium, but relatively low in zinc when compared to values reported by Roth and Townsend (2003) and Rolfe et al. (2009). All minerals showed significant differences among samples, except zinc. Calcium and iron levels increased with increasing maize content, while magnesium and potassium decreased as maize proportion increased. These minerals are particularly important for infants, as they support growth, tissue development, blood formation, and proper functioning of muscles and nerves. The relatively high calcium content indicates that the formulated gruels can support bone and tooth development, muscle contraction, and blood pressure regulation. Similarly, the high iron content supports red blood cell formation and cognitive development in children.

Although zinc levels were relatively low, they were within acceptable limits when compared with commercially available infant formulas. Zinc plays a critical role in cell growth, immune function, and metabolism, and its presence further supports the suitability of these formulations as complementary foods. The relatively high magnesium content suggests enhanced metabolic activity and efficient protein synthesis, while the high potassium levels indicate that the formulations may aid in fluid balance and proper nerve and muscle function.

Vitamin analysis showed that vitamin A content increased with higher maize substitution, suggesting that yellow maize was the primary source of vitamin A in the formulations. Vitamin A is essential for vision, immune function, and overall growth, making it a valuable component of complementary foods.

In contrast, the concentrations of other vitamins decreased as maize proportion increased, indicating that soybean contributed more significantly to the vitamin content of the formulations.

Vitamin $B_1$ (thiamine), $B_2$ (riboflavin), $B_3$ (niacin), $B_6$ (pyridoxine), and $B_9$ (folic acid) play vital roles in energy metabolism, nervous system function, red blood cell formation, and DNA synthesis. These water-soluble vitamins are essential for infant health and development.

The vitamin C content of the samples ranged from **2.05 ± 0.03 to 2.27 ± 0.03 mg**, which was higher than values reported by Makinde (2013), Mohammed (2015), and Mosan and Emay (1997), but lower than those reported by Lawrence (2015). The values were comparable to findings by Neils (1999), Edeogu (2019), and Omale et al. (2008). Overall, the vitamin content of the formulations meets the recommended daily intake levels as outlined by FAO/WHO/UN (2013).

Vitamin E content was within the range reported by Mosan and Emay (1997). Vitamin E functions as an antioxidant and supports calcium absorption and bone health, further enhancing the nutritional quality of the formulated complementary gruel foods.

# CONCLUSION

This study developed a ready-to-use complementary gruel using locally available ingredients; soybean, dates (dabino), yeast powder, moringa seed, and maize. The results show that supplementing maize with these ingredients significantly improves the nutritional quality of complementary food, as reflected in higher protein (28.97 ± 0.71%), low moisture (8.25 ± 0.02%), and increased vitamin content (29.84 ± 0.24%). The formulation is simple, affordable, and highly acceptable in sensory evaluation, with samples A and B being the most preferred. Therefore, this product can serve as a nutritious and cost-effective complementary food for infants and young children.

# RECOMMENDATIONS

Based on the findings of this study, the following recommendations are made:

1. Parents, especially mothers, should prepare complementary gruel foods using yellow maize, soybean, dates (dabino), moringa seed, and yeast powder to enhance the nutritional status of infants and young children**.**

2. Healthcare facilities should create awareness and provide guidance on the preparation and benefits of nutritious complementary gruel foods formulated from yellow maize, soybean, dates (dabino), moringa seed, and yeast powder**.**

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