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# Evaluation of Nutrient and Organoleptic Properties of Complementary Foods Formulated from Quality-Protein Maize, Orange-Flesh Sweet Potato, Soybean and Date Flour

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**ABSTRACT**
Adequate infant and young child nutrition are essential for optimal growth, cognitive development, and survival. In many low- and middle-income countries, including Nigeria, poor complementary feeding practices and reliance on nutrient-poor cereal-based diets contribute to malnutrition and micronutrient deficiencies. This study formulated and evaluated three complementary food blends (QOSAD 1, QOSAD 2, and QOSAD 3) from Quality Protein Maize (QPM), Orange-Fleshed Sweet Potato (OFSP), soybean, and date flour as affordable and nutrient-dense alternatives. Formulations were optimized using Design Expert software and data were analyzed for proximate composition, micronutrient content, antinutritional factors, amino acid profile, and sensory attributes using Statistical Package for Social Science (SPSS) version 23.0 software 2011 to test the level of significance ($p<0.05$), Turkey Test was used to separate the means where significant differences. The results showed significant synergistic effects among ingredients on energy and iron contents. Energy densities of the formulations exceeded the WHO minimum recommendation of 400 kcal/100 g, with QOSAD 2 recording the highest value (445.23 ± 3.57 kcal/100 g). Protein content ranged from 6.81% to 10.99%, while QOSAD 3 contained the highest iron (56.70 ± 0.10 mg/100 g), zinc (5.30 mg/100 g), and provitamin A carotenoid (1,059.20 µg/100 g) contents. Antinutritional factors were within safe limits. QOSAD 2 exhibited superior protein quality and recorded the highest scores for flavour, texture, and overall acceptability on a 9-point hedonic scale. The findings demonstrate that QOSAD blends are nutrient-dense, safe, and culturally acceptable complementary foods with potential to improve infant nutrition and reduce micronutrient deficiencies in resource-limited settings.

**Keywords:** Complementary foods, Design expert, Quality Protein Maize, Orange Flesh Sweet Potato, Soybean and Date flour.

## INTRODUCTION

Adequate nutrition during infancy and early childhood is essential for optimal growth, cognitive development, and long-term health. However, malnutrition remains a major public health challenge in many developing countries, particularly among infants and young children who are vulnerable to inadequate dietary intake and recurrent infections (Anigo *et al*., 2010; Adigwe *et al*., 2023). According to the World Food Programme (WFP), malnutrition encompasses deficiencies, excesses, or imbalances in nutrient intake and continues to contribute significantly to childhood morbidity and mortality worldwide (WFP, 2024).

In Nigeria, child malnutrition remains a serious concern. Recent reports indicate that millions of children are at risk of acute malnutrition, with a substantial proportion suffering from severe acute malnutrition requiring urgent intervention (UNICEF, 2024). Poor complementary feeding practices are among the major contributors to protein-energy malnutrition, micronutrient deficiencies, growth faltering, and increased susceptibility to infections among infants and young children (WHO, 2023).

Complementary feeding involves the introduction of nutritionally adequate foods alongside breast milk from six months of age to meet the increasing nutritional needs of infants (Kabeer *et al*., 2023). Although breast milk provides optimal nutrition during the first six months of life, it becomes insufficient to meet the growing requirements for energy, protein, vitamins, and minerals thereafter (WHO, 2023). Consequently, the World Health Organization recommends the timely introduction of safe, nutritious, and age-appropriate complementary foods while continuing breastfeeding up to two years and beyond (WHO, 2021).

In many developing countries, complementary foods are predominantly cereal-based and often characterized by low protein quality and inadequate micronutrient content (Faber *et al*., 2014). The high cost of commercial complementary foods further limits access for many households, creating a need for affordable and nutrient-dense alternatives derived from locally available food resources (Becquey *et al*., 2018). Quality Protein Maize (QPM), Orange-Fleshed Sweet Potato (OFSP), soybean, and date fruits possess considerable nutritional potential for complementary food formulation. QPM contains improved levels of lysine and tryptophan compared with conventional maize (Nuss & Tanumihardjo, 2011), while OFSP is rich in β-carotene, an important precursor of vitamin A (Okoronkwo *et al*., 2023). Soybean provides high-quality protein and essential amino acids (Adegbusi *et al*., 2022), whereas date fruits contribute natural sugars, dietary fibre, minerals, and improved sensory acceptability (Hmid *et al*., 2024). Therefore, the utilization of these locally available ingredients in complementary food formulation may provide a cost-effective strategy for improving infant nutrition and reducing the burden of malnutrition in resource-constrained settings.

## MATERIALS AND METHODS

### Description of Study Area

The study was conducted at Samaru Primary Health Centre, adjacent to Ahmadu Bello University North Gate in Main Campus located in Sabon Gari Local Government Area (LGA), Kaduna State, Nigeria. The health facility provides primary healthcare services, including maternal and child health services and routine immunization.

### Informed Consent

Written informed consent was obtained from the 20 caregivers before participation in the sensory evaluation. The purpose and procedures of the study were explained to the caregivers, and the consent information was provided in both English and Hausa to ensure adequate understanding. Caregiver consent was obtained for the participation of their children.

### Chemical Reagents, Laboratory Equipment and Apparatus

Chemicals and reagents used were of analytical grade and were sourced from reputable companies. The food materials used for this study were Quality Protein Maize (*Zea mays*), soybean (*Glycine max*), orange-fleshed sweet potato (*Ipomoea batatas*), and date fruits (*Phoenix dactylifera*). Soybean and date fruits were purchased from Samaru Market, Zaria, Kaduna State. Quality Protein Maize was obtained from the Institute for Agricultural Research (IAR), Ahmadu Bello University, Zaria, while orange-fleshed sweet potato was sourced from the Decentralized Vine Multiplier (DVM), Ilesha, Osun State, Nigeria. All samples were authenticated at the Department of Botany, Faculty of Life Sciences, Ahmadu Bello University, Zaria, where voucher numbers were assigned.

Some of the chemicals/reagents used in this work are: Sodium hydrogen sulfate, Boric acid, Hydrochloric acid, Sulfuric acid, Methanol, Chloroform, Copper sulfate, Potassium sulfate**,** Diethyl ether, Nitric acid, Perchloric acid, Ammonium molybdate, Ascorbic acid. The laboratory equipment and apparatus used for the study are: Weighing balance, oven, Muffle furnace, Soxhlet extractor, Kjeldahl apparatus (digestion, distillation, and titration units), Furnace, Atomic absorption spectrophotometer (AAS), UV-Visible spectrophotometer, Blender, Sieves, Knife, Desiccator, Chromatography equipment (HPLC/GC), Measuring cylinders, beakers, flasks, pipettes, and burettes, spatulas, stopwatch, freezer, seal bag among others and Design Expert Software.

### Ethical Approval

Ethical approval for this study was obtained from Ahmadu Bello University Committee on Use of Human Subject for Research (Approval Number: ABUCUHSR/2023/015), and permission was obtained from the Department of Health, Sabon Gari LGA, Kaduna State and also from the hospital management.

### Development of Complementary Foods

Complementary foods were formulated from Quality Protein Maize (*Zea mays*), soybean (*Glycine max*), orange-fleshed sweet potato (*Ipomoea batatas*), and date fruit (*Phoenix dactylifera*) flours in accordance with Codex Alimentarius guidelines (Ndife *et al*., 2020; Ubbor *et al*., 2022). Mixture optimization was performed using Design-Expert® software (Version 13.0), which generated seventeen experimental formulations. Based on predicted nutritional quality, particularly energy and iron content, follow by optimization, the three best formulations were selected for further evaluation.

The selected blends were prepared by thoroughly mixing the constituent flours in the optimized proportions to obtain homogeneous samples. Production was carried out in batches under identical processing conditions, after which the batches were combined to ensure uniformity. The formulated complementary foods were packaged in airtight polyethylene bags and stored until analysis.

**Table 1: Composition of the Optimized Complementary Foods (% w/w)**

| Name | QPM | OFSP | Soybean | Date |
|---|---|---|---|---|
| QOSAD 1 | 52.70 | 20.00 | 22.30 | 5.0 |
| QOSAD 2 | 48.90 | 19.20 | 26.90 | 5.0 |
| QOSAD 3 | 49.80 | 18.00 | 27.20 | 5.0 |

QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

### Processing of Raw Materials

Orange-fleshed sweet potato (OFSP), soybean, quality protein maize (QPM), and date fruits were processed into flour using standard methods. OFSP roots were peeled, washed, sliced, oven-dried at 50°C, milled, sieved, and packaged in airtight storage bags (Adigwe *et al.,* 2023). Soybeans were cleaned, soaked, dehulled, dried at 70°C, milled, sieved and packaged in airtight storage bags (van den Berg *et al*., 2022). QPM grains were cleaned, soaked overnight, oven-dried at 60°C, milled, sieved and packaged in airtight storage bags (Nuss and Tanumihardjo 2011). Date fruits were cleaned, treated with 1% ascorbic acid to prevent enzymatic browning, oven dried at 50°C, milled, sieved and packaged in airtight storage bags before storage (Al-Shahib & Marshall, 2003).

### Proximate Composition

Proximate composition, including moisture, crude protein, crude fat, crude fibre, ash, and carbohydrate contents, was determined using standard AOAC methods (AOAC, 2019). Carbohydrate content was calculated by difference, while energy value was estimated using Atwater conversion factors. Protein caloric contribution was also calculated following standard procedures (Adigwe *et al*., 2023).

### Mineral Analysis

Mineral contents (Ca, Mg, Fe, Zn, K, and Na) were determined according to AOAC (2019) procedures. Samples were dry-ashed at 550°C using crucible for 2 hours, digested with hydrochloric acid, filtered, and analyzed using Atomic Absorption Spectrophotometry (AAS). Sodium was determined using a flame photometer.

**Vitamin Analysis**

Pro-vitamin A (β-carotene) was determined spectrophotometrically using the Carr and Price method as modified by (Onwuka 2018). Vitamin D was analyzed using High-Performance Liquid Chromatography (HPLC) following AOAC (2011) procedures. Water-soluble vitamins (Vitamin C and Vitamin $B_{12}$) were determined using HPLC after solvent extraction and filtration of sample extracts ((Temova Rakuša *et al*., 2021).

**Amino Acid Profile and Amino Acid Score**

The amino acid composition of the formulated complementary foods was determined using HPLC after acid hydrolysis of samples (Darragh and Moughan, 2005). Amino acid scores were calculated according to the WHO/ FAO/UNU (2007) reference pattern for children aged 6 months to 3 years. The limiting amino acid was identified as the essential amino acid with the lowest score (Schaafsma, 2012).

**Determination of Antinutritional Factors**

Antinutritional factors, including saponins, oxalates, phytates, tannins, and trypsin inhibitor activity, were determined using standard analytical procedures described by (AOAC, 2019; Babarinde and Fabunmi, 2019). All analyses were conducted in triplicate and results expressed on a dry weight basis.

**Sensory Evaluation**

Sensory evaluation was conducted using 20 caregivers and 20 children attending immunization services at Samaru Primary Health Centre. Porridges were prepared from the formulated flour blends and evaluated for colour, flavour, taste, texture, and overall acceptability using a 9-point Hedonic scale ranging from 1 (dislike extremely) to 9 (like extremely) (Theophilus *et al*., 2019).

**Statistical Analysis**

All analyses were performed in triplicate and results expressed as mean ± standard deviation. Data were subjected to one-way Analysis of Variance (ANOVA) using SPSS version 23.0. Significant differences among means were separated using Tukey's Honestly Significant Difference (HSD) test at a significance level of $p < 0.05$

NB. Regression model was done by the Design expert software.

## RESULTS AND DISCUSSION

**Regression Coefficients for Energy and Iron Content**

The mixture design model demonstrated that individual ingredients and their interactions significantly influenced the energy and iron contents of the formulated complementary foods. Date flour exerted the greatest positive effect on energy content (+9698.49 kcal), while Quality Protein Maize (QPM) and soybean also contributed positively. In contrast, Orange-Fleshed Sweet Potato (OFSP) alone reduced energy content (Nkhata *et al*., 2022). The three-way interaction between QPM, OFSP, and date flour (ABD) showed the highest positive effect on energy (+34,758.27 kcal), indicating a strong synergistic relationship among these ingredients.

For iron content, OFSP had the strongest positive individual effect (+2928.81 mg), whereas date flour exhibited a negative effect. Significant positive interactions were observed for OFSP–date flour (BD), soybean–date flour (CD), and QPM–soybean (AC), suggesting that combining these ingredients improved iron availability. These findings demonstrate the potential of ingredient optimization in developing nutrient-dense complementary foods suitable for infant feeding (Abebe *et al*., 2020).

**Table 2: Regression Coefficients for Energy and Iron Content**

| Component / Interaction | Effect on Energy (kcal) | Effect on Iron (mg) |
|---|---|---|
| QPM (A) | +343.39 | +56.68 |
| OFSP (B) | −3507.36 | +2928.81 |
| Soybean (C) | +739.46 | −270.18 |
| Date Flour (D) | +9698.49 | −4950.20 |
| AB (QPM–OFSP) | +8415.87 | +402.33 |
| AC (QPM–Soybean) | −367.48 | +5526.16 |
| AD (QPM–Date) | −10168.24 | −6385.74 |
| BC (OFSP–Soybean) | +8863.51 | −2825.19 |
| BD (OFSP–Date) | −26927.47 | +17050.51 |
| CD (Soybean–Date) | −15978.05 | +11498.35 |
| ABC | −23255.06 | +15294.10 |
| ABD | +34758.27 | −24207.43 |
| ACD | +5826.77 | −4160.68 |
| BCD | −4799.84 | +3679.17 |

**Proximate Composition**

The proximate composition of the formulated complementary foods is presented in Table 3. The crude fibre content of the complementary foods ranged from 1.06% to 1.15%, with QOSAD 1 recording the highest value (1.15 ± 0.05%), while QOSAD 2 had the lowest (1.06 ± 0.02%). Moisture content ranged from 6.50% to7.31%, which is below the recommended maximum level for complementary foods and suggests good storage stability. Similar low moisture values have been associated with prolonged shelf life and reduced microbial deterioration (Gichau *et al*., 2020). The ash content ranged from 0.84% to 1.88%, with QOSAD 1 recording the highest value (1.88 ± 0.02%) and QOSAD 2 the lowest (0.84 ± 0.16%).

Protein content ranged from 6.81% to 10.99%, with QOSAD 1 containing the highest value. The relatively high protein content may be attributed to the inclusion of soybean and QPM, both recognized as excellent sources of quality protein. The values obtained compare favorably with those reported for many cereal-based complementary foods commonly consumed in developing countries (Nuss and Tanumihardjo, 2011).

Crude fat content varied between 12.18% and 15.58%, providing an important source of dietary energy for infants and young children. Total carbohydrate content ranged from 65.40% to 72.04%, while energy density ranged from 425.01 to 445.23 kcal/100 g. All formulations exceeded the minimum energy density recommended by WHO for complementary foods, indicating their suitability for supporting infant growth and development (WHO, 2023).

**Table 3: Proximate Composition of the Complementary Foods**

| Proximate Composition (100%) | QOSAD 1 | QOSAD 2 | QOSAD 3 |
|---|---|---|---|
| Crude Fiber | 1.15±0.05$^{b}$ | 1.06±0.02$^{a}$ | 1.09±0.02$^{a}$ |
| Moisture | 7.31±0.01$^{c}$ | 6.50±0.01$^{a}$ | 6.84±0.00$^{b}$ |
| Ash | 1.88±0.02$^{c}$ | 0.84±0.16$^{a}$ | 1.04±0.01$^{b}$ |
| Crude fat | 13.28±0.01$^{b}$ | 15.58±0.01$^{c}$ | 12.18±0.01$^{a}$ |
| Crude protein | 10.99±0.05$^{c}$ | 10.04±0.04$^{b}$ | 6.81±0.09$^{a}$ |
| Total CHO | 65.40±0.40$^{a}$ | 66.21±0.65$^{b}$ | 72.04±0.00$^{c}$ |
| Energy (Kcal) | 425.01±1.97$^{a}$ | 445.23±3.57$^{b}$ | 425.02±0.27$^{a}$ |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).
QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

**Mineral Composition**

The mineral composition of the formulated foods as presented in Table 4 revealed significant differences among the samples ($p < 0.05$). Iron content ranged from 42.89 to 56.70 mg/100 g, with QOSAD 3 recording the highest value. The iron content of the formulated foods could contribute substantially to meeting the daily iron requirements of infants and may help reduce the risk of iron deficiency anaemia when consumed in appropriate amount. However, iron intake should not exceed recommended levels, as excessive intake may cause adverse health effects (NIH, 2025).

Calcium concentrations ranged from 54.14 to 77.02 mg/100 g, while zinc values ranged from 4.46 to 5.30 mg/100 g. Adequate levels of calcium and zinc are essential for skeletal growth, immune competence, and cognitive development. Potassium, magnesium, phosphorus, and sodium were also present in appreciable quantities, indicating that the formulations can contribute significantly to meeting infant micronutrient requirements (WHO, 2023).

**Table 4: Minerals Composition of the Complementary Foods**

| Mineral (mg/100g) | QOSAD 1 | QOSAD 2 | QOSAD 3 |
|---|---|---|---|
| Iron (Fe) | 55.40±0.53$^{b}$ | 42.89±0.22$^{a}$ | 56.70±0.10$^{c}$ |
| Calcium (Ca) | 77.02±0.99$^{c}$ | 54.14±0.06$^{a}$ | 64.07±2.23$^{b}$ |
| Sodium (Na) | 57.97±0.02$^{b}$ | 54.28±0.16$^{a}$ | 61.97±0.01$^{b}$ |
| Magnesium (Mg) | 31.32±0.61$^{a}$ | 50.49±1.56$^{c}$ | 36.21±1.29$^{b}$ |
| Potassium (K) | 63.43±26.33$^{b}$ | 189.47±0.40$^{c}$ | 34.47±17.25$^{a}$ |
| Zinc (Zn) | 4.46±0.13$^{a}$ | 4.93±0.12$^{b}$ | 5.30±0.02$^{c}$ |
| Phosphorus (P) | 86.19±3.55$^{c}$ | 81.23±1.47$^{b}$ | 75.02±001$^{a}$ |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).
QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

**Vitamins Composition**

Table 5 showed Vitamin analysis that all formulations contained substantial amounts of provitamin A, vitamin B12, vitamin C, and vitamin D. Provitamin A content ranged from 613.20 to 1,059.20 µg/100 g, with QOSAD 3 exhibiting the highest concentration. The high provitamin A content is attributable to the inclusion of OFSP, a recognized source of β-carotene. Vitamin A plays a critical role in vision, immune function, and growth and is particularly important in regions where vitamin A deficiency remains prevalent (Okoronkwo *et al*., 2023).

Vitamin C ranged from 38.13 to 48.93 mg/100 g and may enhance non-heme iron absorption, thereby improving iron bioavailability. The observed levels of vitamins B12 and D further increase the nutritional value of the formulations and support metabolic and skeletal development.

**Table 5: Vitamins Composition of the Complementary Foods**

| Vitamins | QOSAD 1 | QOSAD 2 | QOSAD 3 |
|---|---|---|---|
| Pro Vitamin A (µg/100g) | 613.20±0.03$^{a}$ | 986.51±1.50$^{b}$ | 1,059.20±0.04$^{c}$ |
| Vitamin $B_{12}$ (µg/100g) | 10.94±0.03$^{c}$ | 8.80±0.02$^{b}$ | 5.63±0.04$^{a}$ |
| Vitamin C (mg/100g) | 48.93±0.04$^{c}$ | 44.90±0.03$^{b}$ | 38.13±0.03$^{a}$ |
| Vitamin D (µg/100g) | 11.60±0.03$^{c}$ | 10.44±0.03$^{b}$ | 9.52±0.02$^{a}$ |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).

QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

**Amino Acid Profile and Amino Acid Score**

Table 6 showed the amino acid profiles of the complementary foods with substantial amounts of both essential and non-essential amino acids. QOSAD 2 consistently recorded the highest concentrations of essential amino acids, including histidine (3.73 g/100 g), leucine (13.48 g/100 g), lysine (9.23 g/100 g), threonine (10.63 g/100 g), and tryptophan (13.30 g/100 g).

Comparison with the WHO/ FAO/UNU (2007) reference pattern indicated that most essential amino acids exceeded recommended requirements. Amino acid scores were above 100% for nearly all essential amino acids, demonstrating excellent protein quality. Tryptophan exhibited exceptionally high scores, while valine was identified as the limiting amino acid across all formulations. Nevertheless, the overall amino acid balance indicates that the formulated foods can support optimal growth and tissue development in infants and young children.

**Table 6: Amino Acids Composition of the Complementary Foods**

| Amino Acids (g/100) | QOSAD 1 | QOSAD 2 | QOSAD 3 | FAO/WHO/UNU (2007) |
|---|---|---|---|---|
| **Essential** | | | | |
| Histidine | 2.33±0.02$^{a}$ | 3.73±0.02$^{c}$ | 3.23±0.02$^{b}$ | 1.90 |
| Isoleucine | 3.28±0.02$^{a}$ | 6.53±0.02$^{c}$ | 5.98±1.02$^{b}$ | 2.80 |
| Leucine | 6.40±0.02$^{a}$ | 13.48±0.02$^{c}$ | 12.10±0.05$^{b}$ | 6.60 |
| Lysine | 7.01±0.02$^{a}$ | 9.23±0.03$^{c}$ | 8.67±0.02$^{b}$ | 5.80 |
| Methionine + Cysteine | 2.70±0.02$^{a}$ | 7.85±0.03$^{c}$ | 6.33±0.02$^{b}$ | 2.20 |
| Phenylalanine + Tyrosine | 3.23±0.02$^{a}$ | 6.38±0.01$^{c}$ | 5.75±0.02$^{b}$ | 2.80 |
| Threonine | 2.35±0.02$^{a}$ | 10.63±0.02$^{c}$ | 9.33±0.02$^{b}$ | 3.40 |
| Tryptophan | 6.42±0.02$^{a}$ | 13.30±0.02$^{c}$ | 11.85±0.03$^{b}$ | 1.25 |
| Valine | 2.00±0.01$^{a}$ | 4.53±0.04$^{c}$ | 4.13±0.01$^{b}$ | 5.50 |
| **Non-Essential** | | | | |
| Alanine | 3.70±0.02$^{a}$ | 7.03±0.02$^{c}$ | 6.25±0.03$^{b}$ | |
| Cysteine | 1.43±0.02$^{a}$ | 2.38±2.03$^{c}$ | 2.13±0.11$^{b}$ | |
| Glutamic acid | 9.17±0.06$^{a}$ | 16.01±0.04$^{c}$ | 13.93±0.02$^{b}$ | |
| Glycine | 3.16±0.02$^{a}$ | 9.05±0.02$^{c}$ | 7.90±0.02$^{b}$ | |
| Proline | 3.55±0.02$^{a}$ | 12.85±0.02$^{c}$ | 7.15±0.04$^{b}$ | |
| Serine | 8.10±0.02$^{a}$ | 15.83±0.02$^{c}$ | 13.43±2.11$^{b}$ | |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).
QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

**Amino Acid Scores**

The amino acid scores of the formulated complementary foods as presented in table 7 shows that most essential amino acids exceeded the FAO/WHO/UNU (2007) reference requirements for infants and young children, indicating good protein quality. QOSAD 2 recorded the highest scores for most essential amino acids, followed by QOSAD 3

**Table 7: Amino Acids Score (AAS) of the Complementary Foods**

| Amino Acids (%) | QOSAD 1 | QOSAD 2 | QOSAD 3 |
|---|---|---|---|
| Histidine | 122.63 | 196.32 | 170.00 |
| Isoleucine | 117.14 | 233.21 | 213.57 |
| Leucine | 96.97 | 204.24 | 183.33 |
| Lysine | 120.86 | 159.14 | 149.48 |
| Methionine + Cysteine | 122.72 | 356.82 | 287.72 |
| Phenylalanine + Tyrosine | 115.36 | 227.86 | 205.36 |
| Threonine | 67.14 | 312.65 | 274.41 |
| Tryptophan | 513.6 | 1,064 | 948.00 |
| Valine | 36.36 | 82.36 | 75.09 |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).
QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).

QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

**Anti-Nutrient Composition**

Anti-nutritional factors were as presented in Table 8, the anti-nutrient contents of the complementary foods were generally low, with saponin ranging from 4.53–7.15 mg/100 g, oxalate from 0.08–0.15 mg/100 g, phytate from 0.10–0.15 mg/100 g, tannin from 1.70–1.94 mg/100 g and trypsin inhibitor from 0.69–0.92 mg/100 g. The oxalate and phytate levels were markedly lower than those reported by (Adeosun *et al*. 2026) in maize–soybean–date composite cereals, which were 61–67 and 39–41 mg/100 g, respectively, after conversion from mg/g. This difference may be attributed to variations in ingredient proportions and processing conditions. The low phytate, oxalate and trypsin inhibitor contents observed are nutritionally desirable because these compounds can interfere with mineral availability and protein digestion. The relatively low values may also indicate effective reduction of antinutritional factors during processing. This agrees with (Ochelle and Sogunle 2026), who reported that processing and enrichment of maize-based foods with soybean resulted in reduced antinutritional factors. Overall, the QOSAD formulations exhibited a low antinutritional profile, which is favourable for their use as complementary foods.

**Table 8: Anti-Nutrient Composition of the Complementary Foods**

| Sample (mg/100g) | QOSAD 1 | QOSAD 2 | QOSAD 3 |
|---|---|---|---|
| Saponins | 4.53±0.05$^{a}$ | 5.31±0.05$^{b}$ | 7.15±0.07$^{c}$ |
| Oxalate | 0.10±0.01$^{a}$ | 0.08±0.00$^{a}$ | 0.15±0.01$^{b}$ |
| Phytate | 0.10±0.0$^{a}$ | 0.15±0.01$^{b}$ | 0.12±0.01$^{b}$ |
| Tannins | 1.70±0.00$^{a}$ | 1.94±0.01$^{b}$ | 1.73±0.02$^{a}$ |
| Trypsin | 0.92±0.05$^{b}$ | 0.75±0.04$^{b}$ | 0.69±0.04$^{a}$ |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).
QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

**Sensory Evaluation**

Table 9 showed the sensory evaluation which demonstrated good acceptability of all formulations. QOSAD 2 achieved the highest scores for colour (8.53), flavour (8.80), texture (8.69), and overall acceptability (8.73), indicating a strong consumer preference. QOSAD 1 received the highest score for taste (8.67). The high acceptability observed may be due to the natural sweetness contributed by date flour and the desirable texture resulting from the optimized ingredient combinations. Consumer acceptability is a critical determinant of successful adoption of complementary foods, particularly in resource-limited settings (Abuengmoh *et al.*, 2024).

**Table 9: Sensory Evaluation of the Complementary Foods**

| Sensory Attribute | QOSAD 1 | QOSAD 2 | QOSAD 3 |
|---|---|---|---|
| Colour | 7.30±1.15$^{a}$ | 8.53±0.78$^{b}$ | 7.63±1.16$^{a}$ |
| Flavor | 7.33±1.24$^{a}$ | 8.80±0.66$^{b}$ | 7.47±1.61$^{a}$ |
| Taste | 8.67±0.76$^{c}$ | 7.70±1.34$^{b}$ | 7.27±1.41$^{a}$ |
| Texture | 7.73±1.17$^{a}$ | 8.69±0.80$^{b}$ | 7.43±1.33$^{a}$ |
| Acceptability | 8.33±1.24$^{b}$ | 8.73±0.58$^{b}$ | 7.57±1.45$^{a}$ |

Values are presented as means ± S.D (n = 3).
Mean values with different superscript (a, b, c) along the row are significantly different ($p<0.05$).
QOSAD 1 = QPM (52.70%), OFSP (20.00%), Soybean (22.30%) and Date (5.0%).
QOSAD 2 = QPM (48.90%), OFSP (19.20%), Soybean (26.90%) and Date (5.0%).
QOSAD 3 = QPM (49.80%), OFSP (18.00%), Soybean (27.20%) and Date (5.0%).

## CONCLUSION

This study demonstrated that quality protein maize, orange-fleshed sweet potato, soybean, and date flour can be combined to produce nutritionally adequate complementary foods. The formulations provided sufficient energy, protein, essential amino acids, vitamins, and minerals, with antinutrient levels remaining within safe limits.

Among the formulations, QOSAD 2 showed the best overall nutritional quality and sensory acceptability. The high iron, zinc, and provitamin A contents further indicate its potential to address common micronutrient deficiencies among infants and young children.

Therefore, the developed complementary foods, particularly QOSAD 2, offer an affordable, acceptable, and sustainable option for improving infant and young child nutrition and may contribute to reducing malnutrition in resource-limited settings.

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