Production and Quality Evaluation of Complementary Food produced from yellow maize, Plantain, Soybean, carrot, groundnut and date blends.

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Abstract

Protein-energy malnutrition is perhaps the most significant health issue concerning young children in developing nations. In regions like sub-Saharan Africa, specifically Nigeria, this problem predominantly stems from inadequate feeding practices for infants and providing under nourishing complementary foods that lack essential nutrients. To combat this, enhancing the nutritional content of complementary foods at home through food-to-food fortification has proven effective in alleviating nutritional deficiencies within numerous economically disadvantaged communities. This study evaluated the quality attributes of locally produced complementary food. Maize, soybean, groundnut, plantain, carrot and date fruit were purchased, sorted and processed into flour. The different blend of Maize, Soybean, Groundnut, Carrot, Plantain and Date were mixed in the ratios of 100:0:0:0:0:0(A), 50:25:3:4:15:3(B), 50:30:3:4:10:3 (C), 50:35:3:4:5:3 (D) respectively. The proximate, micronutrients and anti-nutrients properties of the formulated products were determined in line with standard Analytical methods. The results of the proximate analysis of the complementary food blends showed an appreciable increase in protein (7.34-18.30%), ash (0.43-0.86%), fat (2.34-5.39%, %), fibre (4.88-17.66%) and carbohydrate (54.12-63.15%) content. Similarly; the minerals and vitamin A content of the complementary foods also increased (Calcium; 18.44mg/100g – 26.47 mg/100g, iron; 4.67mg/100g – 5.11mg/100g; zinc; 0.89 – 2.12 mg/100g and vitamin A; 102.44 – 181.93 µg/100g) while the anti-nutrient contents were found to be practically minimal (tannin; 0.11-0.12%, phytate; 0.31-0.39% and oxalate; 1.03-1.42%). The formulated complementary food has the potential to reduce protein-energy malnutrition in infants within developing nations by supplying the essential nutrients required for their optimal health and overall well-being.

***Keywords**: Proximate, Micronutrients, Anti nutrients, Infants.*

Introduction

The process of transitioning infants from exclusive breastfeeding to eating solid meals, known as complementary feeding or weaning, is an essential one. High-quality complimentary foods given to children can make them grow and develop to their full potential. When it comes to managing nutritional deficiencies and fostering healthy child development, knowledge of the content and practices surrounding complementary feeding is vital in Nigeria, where infant and young children malnutrition is a major problem. Complementary foods play a vital role when it comes to satisfying infants nutritional needs throughout the weaning period. Proper growth and development depend on the selection and content of these foods. After six months of age, nutrient requirements of infants cannot be met only by breast milk (Victor *et al*., 2020). This indicates the need to provide complementary foods that are both nutritionally sufficient and culturally acceptable. Complementary foods can meet the nutritional needs of children 6-24months by combining nutrient-dense foods in the right proportions (Suprapto *et al*., 2018).

Maize, a common cereal grain, has a lot of carbohydrate and it offers energy for development and growth (Meda *et al*., 2010). A soya bean is rich in high-quality protein, vital fatty acids, and a wide range of minerals (Lee *et al*., 2019). Plantain is high in carbohydrates and also contains vitamins A and C (Osundahunsi *et al*., 2014). Groundnut is rich in protein, healthy fats, and minerals like folate and vitamin E (Jayawardena *et al*., 2017). Both carrots and dates are high in vitamins, minerals, and antioxidants (Al-Farsi *et al*., 2007). Potential nutritional advantages of this varied combination for ≥6months old infants feeding practices can be assessed by analyzing these food mixtures (Sarkar *et al*., 2020).

Adedokun *et a*l. (2018) examined the proximate composition of a variety of complementary foods and reported that the nutritional content varied from recipe to recipe. Most complementary foods were rich in carbohydrates, proteins, and fats, which served as a source of growth-promoting energy and macronutrients. Complementary foods were found to be lacking in many essential vitamins and minerals, including iron, zinc, vitamin A, and vitamin C (Uvere *et al*., 2019). Micronutrient deficiencies are common among infants and young children in Nigeria, and these inadequacies underscore the need for better formulation and variety of complementary foods to address these malnutrition. During the transition to solids, babies' growth and development depend solely on the nutrient density of the foods they are offered. Essential nutrients are made more or less accessible and bioavailable based on the food composition, especially its proximate, micronutrient, and antinutrient concentrations. For this reason, it is crucial to determine the nutrient contents of complementary foods for under 2 children. Complimentary foods including maize, soya, plantain, peanut, carrot, and date fruit are the subject of this investigation on their proximate, micronutrient, and antinutrient compositions. These items were chosen because of their high nutrient content and convenient availability in many different geographic areas.

Infant nutrition is also influenced by cultural norms in Nigerian society that surround complementary feeding. A qualitative investigation of rural communities' long-held beliefs and behaviors about supplemental feeding was undertaken by Olagunju *et al*. (2017). The results showed that cultural variables such as improper feeding techniques, premature introduction of supplementary meals, and a lack of dietary variety were common. Infants may be at a higher risk of developing nutritional deficiencies as a result of these habits.

In addition, socioeconomic issues, food instability, and restricted availability to healthy meals all contribute to the difficulties caregivers already have in delivering sufficient complementary feeding (Olayemi *et al*., 2018). The accessibility, price, and preparation of dietary supplements are all affected by these variables. Improving infant and young child nutrition in Nigeria requires resolving issues with complementary feeding practices. Interventions to increase the quality and variety of complementary foods accessible to Nigerian infants and young children may be devised by better understanding their nutritional contents. The aim of this study was to evaluate the proximate, micronutrient, and anti-nutrient content of complementary foods produced from the blend of maize, soya, plantain, peanut, carrot, and date fruit.

Materials and Methods

Maize, soybean, groundnut, plantain, carrot and date fruit were purchased from Sayedero market Ilaro, Ogun State, extraneous and the bad ones were sorted. The method described by Akinsola *et al*. (2018) with slight modification was used to process maize which was sorted, washed, steeped in tap water for 48hrs and changed after each day. Fermented maize was oven dried at 250°c for 1hr, 4minutes milled using local grinding machine, sieved with muslin cloth of 150 mm and stored in a plastic container.

The method of Henry *et al*. (2010) with slight modification was used for the production of soybean flour. Soybean was sorted, washed, steeped for 8hrs, boiled for 30minutes, dehulled, toasted for 30minutes, oven dried at 60°C for 15 min, milled and sieved to fine flour. Soybean flour was packaged and stored in air tight plastic container at ambient temperature.

The method of Nwokem *et al*. (2019) was used for the production of groundnut paste. Groundnut was sorted, washed, roasted for 27 minutes; skin was peeled after cooling and milled to groundnut paste. Carrot flour was produced using the method described by Roshana & Mahendran (2019) with modifications. Carrot was sorted, washed, sliced into 1mm thickness, blanched for 3minutes, oven dried at 60°C for 2hrs, 23minutes and milled using disc attrition mill.

Plantain was produced using the method described by Onoja *et al*. (2014). Matured plantain was washed, peeled, sliced thinly, oven dried at 250°C for 1h, milled and sieved with muslin cloth of 150 mm.

Date flour was prepared using a modification of the method described by Nwokem *et al*. (2019). Date fruit was washed, crushed using pestle and mortar to remove the seeds, oven dried at 250c for 1hr, 30 minutes. Dried date was then milled into flour using a dry milling machine and stored in an air tight plastic container until usage.

Formulation of complementary foods

Maize, Soybean, Groundnut, Carrot, Plantain and Date flours were blended and coded in the ratios of 100:0:0:0:0:0(A), 50:25:3:4:15:3(B), 50:30:3:4:10:3 (C), 50:35:3:4:5:3 (D) respectively and used to produce porridges. The porridges were evaluated for proximate, micronutrients and anti-nutrients properties using standard methods AOAC (2005).The sample A (100% maize porridge) served as control.

Chemical analyses of the formulations: The proximate, micronutrients and anti-nutrients compositions of the flour blend were determined according to Official Methods of Analysis (AOAC, 2005).

Results

The proximate composition of the flour blend is presented in table 1. The proximate composition ranged from 9.11-14.68%, 2.34-5.39%, 0.43-0.86%, 4.88-17.66%, 7.34-18.30% and 54.12-63.15% in terms of moisture, crude fat, total ash, crude fibre, crude protein and carbohydrate respectively. Sample A had the highest moisture content (14.68%) while sample C had the least (9.11%). Sample D had highest (5.39%) crude fat while sample A had the lowest (2.34%). The crude fibre content was highest (17.66%) in sample A while it was lowest (4.88%) in sample D. Also sample D recorded the highest value (18.30% and 63.15%) in terms of crude protein and carbohydrate respectively while sample A was found to be the lowest in terms of crude protein (7.34%) and carbohydrate (54.12%). Significant differences were observed in all the samples.

Table 1: Proximate Composition of the Samples

Samples	Moisture	Crude fat	Total ash	Crude fibre	Crude protein	Carbohydrate
Sample A	14.68±0.02[d]	2.34±0.01[a]	0.43±0.00[a]	17.66±0.07[d]	7.34±0.04[a]	54.12±0.04[a]
Sample B	12.84±0.04[c]	3.53±0.01[b]	0.68±0.07[b]	12.98±0.01[c]	12.26±0.01[b]	56.68±0.00[b]
Sample C	10.47±0.57[b]	5.18±0.07[c]	0.72±0.07[c]	7.97±0.14[b]	15.00±0.21[c]	61.50±0.01[c]
Sample D	9.11±0.04[a]	5.39±0.00[c]	0.86±0.07[b]	4.88±0.07[a]	18.30±0.21[d]	63.15±0.00[d]

Values reported are means ± standard deviation of duplicate determinations. Means values with different superscript within the columns are significantly different (P<0.05)

100:0:0:0:0:0(A), 50:25:3:4:15:3(B), 50:30:3:4:10:3 (C), 50:35:3:4:5:3 (D)

Table 2 shows the micronutrients composition of the samples. Sample C had the highest composition of vitamin A (181.93 µg/100g) while sample A had the lowest (102.44 µg/100g). Also sample B was found to contain the highest content of calcium (26.47%) iron (5.11%) and zinc (2.12%) compared to other samples. There were no significant differences between samples A and C in terms of iron and samples C and D in terms of zinc respectively.

Table 2: Micronutrients Composition of the Samples

Samples	Vitamin A µg/100g	Calcium mg/100g	Iron mg/100g	Zinc mg/100g
Sample A	102.44±0.02[a]	20.45±0.01[b]	4.67±0.05[a]	0.89±0.00[a]
Sample B	121.16±0.08[c]	26.47±0.02[d]	5.11±0.01[b]	2.12±0.03[c]
Sample C	181.93±0.04[d]	18.44±0.01[a]	4.96±0.06[a]	1.11±0.03[b]
Sample D	120.81±0.01[b]	22.92±0.15[c]	5.09±0.04[b]	1.11±0.01[b]

Values reported are means ± standard deviation of duplicate determinations. Means values with different superscript within the columns are significantly different (P<0.05)

100:0:0:0:0:0(A), 50:25:3:4:15:3(B), 50:30:3:4:10:3 (C), 50:35:3:4:5:3 (D)

Table 3 shows the anti-nutrients composition of the samples. Sample D had the highest composition of tannin (0.12mg/100g)) and phytate (0.39mg/100g) while sample C had the least (0.10mg/100g and 0.31mg/100g). Also sample D was found to be highest in oxalate (1.42g/100g) while sample A had the least oxalate (1.03g/100g) composition respectively. Also, no significant differences were found in the anti-nutrients composition of samples A and B in terms of tannin, and samples A and D in terms of oxalate respectively.

Table 3: Anti-Nutrients Composition of the Samples (mg/100g)

sampes	Tannin	Phytate	Oxalate
A	0.11 ± 0.01^{b}	0.38 ± 0.00^{b}	1.03 ± 0.04^{c}
B	0.11 ± 0.00^{b}	0.33 ± 0.02^{c}	1.42 ± 0.04^{a}
C	0.10 ± 0.02^{c}	0.31 ± 0.02^{d}	1.22 ± 0.01^{b}
D	0.12 ± 0.01^{a}	0.39 ± 0.05^{a}	1.12 ± 0.15^{c}

Values reported are means ± standard deviation of duplicate determinations. Means values with different superscript within the columns are significantly different ($P<0.05$).

Discussion

The level of moisture in the samples decreased as the proportion of soya beans substitution increased. This decrease could be traceable to the naturally low moisture content of soya beans. According to Akanbi *et al.* (2010), moisture content serves as an indicator of how long a product can be stored without spoiling. Higher moisture content can promote the growth of microorganisms, which in turn leads to the deterioration of food items. Furthermore, FAO (1992) recommends a moisture content range of 12% to 14% for flour or powdered foods in order to maintain their quality and safety. As a result, the produced complementary food demonstrated favorable shelf stability.

The complementary food displayed noticeable fat content, a vital nutritional component due to its high energy value. This high fat content could emanate as a result of incorporation of soybeans in the mixture, as soybeans are known for their richness in essential monounsaturated and polyunsaturated fats (United Soybean Board, 2015). Additionally, the inclusion of groundnut in the blend might have contributed to the increased fat content in the samples. The fat content in the samples is similar to the fat content in complementary food samples produced in a study by Bolarinwa *et al.* (2016).

The mineral content, as indicated by the ash content, varied among the food samples. Sample D exhibited the highest ash content (0.86%), which could be ascribed to the elevated proportion of soybeans in the flour blend. Soybeans are known to contain a significant amount of ash compared to maize and plantain (Ariahu *et al.* 1999). Significant distinctions in ash content were also evident across all the samples.

Regarding fiber content, sample A had the highest fiber content, while sample D had the lowest. The fiber content increased with higher substitution of plantain, reflecting the greater fiber content inherent in plantain. Bassey *et al.* (2022) reiterated in his findings, the commendable fiber content of plantain and its suitability for use in complementary food formulation. This aligns with the recommendation that crude fiber in complementary food should not exceed 5% (CODEXCAC/GL, 1991), a criterion that sample D (4.88%) met.

Protein content in the samples ranged from 7.34% to 18.30%, slightly surpassing the range (11.17-14.21%) reported by Onoja *et al.* (2014) in a similar study. Sample D had the highest protein content (18.30%), likely due to the substantial amount of soybean flour in the mixture. Protein content in the samples increased with greater inclusion of soybean flour, except for sample A which consisted solely of maize. Combining legumes and cereals, as seen in these samples, creates a favorable protein profile by addressing amino acid deficiencies present in each therefore enhancing the nutritional value. It's important to note that the recommended protein content in complementary foods should not exceed 5% (CODEXCAC/GL, 1991), making the protein content (15.00%) in sample C compliant with this guideline. This is especially crucial during infancy to meet the demands of rapid growth.

Carbohydrate content, which determines energy value, ranged from 54.12% to 63.15% in the food samples. Sample D exhibited the highest carbohydrate content (63.15%), likely influenced by the elevated carbohydrate content found in maize and plantain (UNCST, 2007). While the carbohydrate content was lower than values reported by Manisha & Pranati (2019) in a cereal-pulse based complementary food study, it is also within the range (30.10-87.20%) reported for complementary foods blended with sorghum, plantain, and soybean (Onoja & Obizoba, 2013). Additionally, the carbohydrate content in sample D is almost the same with the value (63.5%) reported by Nelson *et al.* (2007) for infant food produced from breadfruit and breadnut.

The substantial vitamin A content in the samples likely stemmed from the inclusion of carrots in the flour blend, aligning with similar findings from a study by Bekele & Shiferaw (2020). The iron content in the blend exceeded the value (2.7mg/100g) reported by Uvere *et al.* (2010) in a Maize-Bambara groundnut blend, potentially due to the higher substitution with soybean flour, known for its significant iron content. Incorporating iron-rich complementary foods is very crucial in preventing infant anemia.

The calcium content in the developed complementary food (18.44-26.47 mg/100g) is higher than the the values (6.44-12.14 mg/100g) reported by Onoja *et al.* (2013) but fell below the calcium content (42.6-53.8mg/100g) of weaning foods from maize and cowpea reported by Nti & Plahar (1995).

The substantial reduction in anti-nutrient content of the complementary food samples likely resulted from water soaking during processing. This treatment method enhances nutrient bioavailability by mitigating anti-nutrient levels. The phytate and oxalate content were in line with the findings from Abioye *et al.* (2022) and Oghbaei *et al.* (2016), both emphasizing the nutritional quality improvement achieved through water soaking, a common household practice.

Conclusion

Findings obtained in this study showed that nutrient dense complementary food can be produced from blends of cereal, fruit and legume fortified with groundnut and carrot. The complementary food sample containing 50% maize, 5% plantain, 35% soybeans, 3% date and 3% groundnut was the best in terms of protein and carbohydrate. It also contained a considerable amount of vitamin A, calcium and iron which forms an important component of infant food. The practice of fortifying one type of food with another is very crucial for improving the nutritional qualities of complementary food, making it a viable option for feeding infants. This strategy has the potential to tackle the problem of protein-energy malnutrition in regions greatly impacted by this emergency situation.

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