International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Proximate and Mineral Composition of Some Locally Produced Complementary Food Formulated from Millet, Groundnut and Soybean.

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ABSTRACT:

Complementary foods play an essential role in fulfilling the nutritional requirements of infants and young children as they transition from exclusive breastfeeding to family foods. These foods provide essential nutrients that support growth, development, and overall health during this critical period. In many regions, locally produced complementary foods hold significant importance due to economic, social, and cultural factors. These foods are often prepared using regionally available ingredients and traditional processing techniques, reflecting the unique dietary practices of the local population. This study was designed to evaluate the nutrient content of some locally produced complementary foods formulated from millet, groundnut and soybean. The result showed that these foods are rich in carbohydrates, with an average of 57-80% of the total energy provided by these macronutrients. Additionally, the result reveals that the protein content ranged from 3-8% with soybean/groundnut/millet Pap containing the highest amount of protein. These analysis also revealed that these complementary foods are excellent sources of various micronutrients, including iron, zinc, and calcium. Mixed cereal pap showed higher mineral levels compared to millets pap and Groundnut/millets pap. Furthermore, it was observed that the nutrient composition varied depending on the type of grain used and the preparation method. Overall, this study provides valuable insights into the nutritional composition of locally produced complementary foods formulated from Groundnut, millet and soybean and highlights the importance of incorporating these foods into the diet for optimal nutrition.

Keywords: Nutrients, Groundnuts, Soybeans, Millets, Complementary foods,

1. INTRODUCTION

The first 1000 days of life, from conception until the child's second birthday, are considered the critical window of opportunity for preventing under nutrition and its long-term consequences (Hemalatha et al., 2018). Inadequate breastfeeding practices, insufficiently nutritious complementary foods, and low-quality diets contribute to nutrient insufficiency, illnesses, and infections, leading to malnutrition at an early age (Singh et al., 2019). This in turn prevents children from reaching their full physical and mental potential later in life. It results in delayed physical growth, motor skill deficits, lower IQ, heightened behavioral issues, deficient social abilities, and increased susceptibility to diseases (Kamath et al., 2017).The common nutritional issues among children aged 6-23 months in many countries include protein-energy malnutrition (PEM), vitamin A deficiency (VAD) as well as iodine deficiency disorders (IDD) and iron deficiency (IDA) (IFPRI, 2016).

Complementary feeding involves introducing additional foods and liquids to a breastfed child when breast milk alone is no longer sufficient to meet the infant's nutritional needs (Fewtrell et al., 2017). This strategy effectively reduces malnutrition levels in children aged 6-23 months (Kassa et al., 2016; Mitchodigni et al., 2017). Breast milk alone can be used to properly feed infants for the first six months of life, but as infants grow and become more active, breast milk alone falls short of providing the full nutritional requirements and the gap keeps expanding with increasing age of the infants and young children; hence complementary feeding plays critical role in bridging these gaps (Abeshu, 2016).

The introduction of complementary feeding should be both timely (beginning at 6 months) and sufficient, taking into account aspects like quantity, frequency, consistency, and variety of foods. It's crucial to prepare and serve foods safely, ensuring they are age-appropriate in texture, and adopting responsive feeding practices for psychosocial care (Silva *et al.,* 2016).

According to pediatric nutrition authorities, developmental readiness in most infants and the ability to tolerate foods consumed would occur around 4 and 6 months of age (Kalhoff and Kersting 2022). During this period, the intestinal tract will have well-developed defense system that minimizes or averts risk of allergic reaction in infants following intake of foods containing foreign proteins, while its ability to utilize proteins, fats, and carbohydrates improves. Similarly, the infant's kidney develops to a state where it can successfully eliminate waste products emanating from foods such as meat with characteristic high renal load. Furthermore, their neuromuscular system matures enough leading into development of abilities for recognizing food, accepting spoons, masticating and swallowing foods, and, even, distinguishing and appreciating varieties in food tastes and colors (Spence and Piqueras-Fiszman, 2016).

Complementary foods play an essential role in fulfilling the nutritional requirements of infants and young children as they transition from exclusive breastfeeding to family foods. These foods provide essential nutrients that support growth, development, and overall health during this critical period (Dewey, 2013; World Health Organization [WHO], 2021). In many regions, locally produced complementary foods hold significant importance due to economic, social, and cultural factors. These foods are often prepared using regionally available ingredients and traditional processing techniques, reflecting the unique dietary practices of the local population (Owusu-Ansah *et al.,* 2020). Several types of commercial CFs marketed in many countries including Nigeria are nutritious but expensive for most Nigerian families, hence, mothers in both rural and urban areas depend on readily available, low-cost food mixtures to feed their infants (Owusu-Ansah *et al.,* 2020).

Accurate assessment of the nutrient content of locally produced complementary foods is crucial for understanding their nutritional value and formulating appropriate dietary recommendations. Existing food composition tables and databases, primarily focus on commercially available foods, which may not adequately represent the nutritional composition of locally produced complementary foods (Gibson & Ferguson, 2008). Therefore, this study aimed to fill this gap by conducting a comprehensive analysis of the nutrients composition of these locally produced complementary foods.

Several authors (Onofiok&Nnanyelogo, 2007; Oyegoke *et al.*, 2020) have described slight variations in the traditional processing techniques utilized to produce ogi, a widely consumed complementary food for weaning infants and young children in Nigeria.

2. MATERIALS AND METHODS

2.1 Material

The raw materials used in the production of the complementary foods such as Groundnut, soya bean, millets, clove, ginger, chili pepper, were purchased from central market Katsina, Katsina State.

2.2 Methods

Millet Pap Production

One kilogram composites of each finger millet were cleaned and washed to remove stones and other debris, then soaked in water for 12 hours to ferment. After fermentation, the millet was drained and milled with 20 grams of ginger and cloves until a fine paste was obtained. The paste was filtered through a 250μm sieve with added water to aid the process, separating the liquid from the chaff. The sieved millet paste was allowed to rest for 8 hours, and then the clear water on top was drained. 100 grams of the thick paste was mixed with water to form a thick slurry. Boiled water (500ml) was gently poured over the slurry while stirring to prevent clumping, (Sample 1).

Groundnut/Millet Pap Production

One kilogram of groundnuts was cleaned, washed, and dried before 500 grams were roasted in an oven at 350˚F (175˚C) for 15-20 minutes until fragrant and lightly golden brown. After cooling, the skins were removed by rubbing the nuts between the hands, and the roasted, skinned groundnuts were blended with 250ml of water to achieve a smooth, creamy consistency. In a separate pot, 500ml of water was boiled, and 100 grams of the thick groundnut paste was mixed with water to create a thick slurry, then added to the boiled water and cooked for 10-15 minutes. Additionally, 50 grams of millet paste, previously used in the preparation of Sample 1, was added to thicken the boiled groundnut paste, which was cooked for an additional 5 minutes (Sample 2).

Mixed Cereal Pap Production

One kilogram of a composite mixture comprising soybeans, groundnuts, and millets was meticulously cleaned, removing stones and other debris, then washed and dried. Subsequently, 250 grams each of groundnuts, soybeans, and millets were roasted in an oven at 350°F (175°C) until they emitted a fragrant aroma and turned lightly golden brown. These cereals were then combined in equal proportions and milled into a fine powder. 500ml of water was boiled, and 150 grams of the mixed cereal flour was gradually added while continuously stirring to prevent the formation of lumps. The mixture was simmered over low heat for 5-10 minutes until it thickened to the desired consistency (sample 3).

CHEMICAL ANALYSIS

(a) Proximate chemical composition

The proximate composition of the complementary foods was determined using standard AOAC methods (2015). Moisture content of the four samples was determined by air oven method at 105°C. The crude protein of the samples was determined using micro-Kjeldahl method, crude lipid was determined by Soxhlet extraction method, while the ash content was determined by weighing 5g of sample and heated in a muffle furnace at 550°C for 4 h. Crude fibre content was determined by successive digestion of the defatted sample with 0.26 N sulphuric acid and 0.23 N potassium hydroxide solutions. The carbohydrate content was obtained by difference.

(b) Mineral determination: Mineral contents of the complementary foods were determined by atomic absorption spectrometry (Iron (Fe), Zinc (Zn), Calcium (Ca), Manganese (Mn), Copper (Cu) and Magnesium (Mg) while sodium and potassium were determined using flame photometer.

STATISCAL ANALYSIS

The data were statistically analyzed using SPSS version 23.0 for analysis of variance with descriptive statistics, while Duncan multiple range test was used to separate means where there is a significant differences.

3. RESULTS

3.1 Proximate composition

This study was done to determine the nutrients contents of some locally produced complementary foods using standard procedures, the proximate composition of the locally produced complementary foods were determined and presented in Table 1. Sample 1 has a significantly lower dry matter content (12.95%) compared to both Sample 2 (14.63%) and Sample 3 (15.33%). However, there is no significant difference in dry matter content between Sample 2 and Sample 3. Sample 2 exhibits a significantly higher ash content (3.34%) compared to both Sample 1 (1.17%) and Sample 3 (2.10%) ($P < 0.05$). Sample 3 shows a significantly higher crude protein content (8.32%) ($P < 0.05$) compared to both Sample 1 (4.38%) and Sample 2 (8.16%). No significant difference in crude protein content is observed between Sample 1 and Sample 2. Sample 2 has a significantly higher crude fat content (12.41%) compared to both Sample 1 (5.29%) and Sample 3 (11.48%). There was no significant difference in crude fat content between Sample 1 and Sample 3. Sample 2 exhibits a significantly higher crude fiber content (3.75%) ($P < 0.05$) compared to both Sample 1 (0.00%) and Sample 3 (3.23%). No significant difference in crude fiber content is observed between Sample 1 and Sample 3. Sample 1 has the highest total carbohydrate content (75.78%), significantly higher than both Sample 2 (58.23%) and Sample 3 (60.04%) ($P < 0.05$). There is no significant difference between sample 2 and sample 3 ($p < 0.05$).

3.2 Mineral Composition

The mineral concentration data in Table 2 reveal notable differences among the three samples (Millet pap (sample 1), Groundnut/Millet Pap (sample 2), mix cereal pap (sample 3). The potassium concentration significantly increases from sample 1 (60.50 mg/100g) to sample 2 (91.00 mg/100g) to sample 3 (119.25 mg/100g), indicating that the addition of soybean and groundnut leads to a higher potassium content in the complementary foods. There is a significant difference in sodium concentration among the samples, with Sample 3 (114.00 mg/100g) having the highest sodium content, followed by Sample 2 (1.98.25 mg/100g) and then Sample 1 (69.25 mg/100g). Sample 3(12.46 mg/100g) shows a significantly higher copper concentration compared to Samples 1(5.63 mg/100g) and 2 (5.85 mg/100g). There was no significant difference in the zinc content of the 3 Samples ($p > 0.05$), concentration significantly varies among the samples, with Sample 2(, 3.71 mg/100g) having the highest zinc content, followed by Sample 3(3.07 mg/100g) and then Sample 1(1.37 mg/100g). There are no significant differences in manganese concentration among the samples, with values of approximately 4.55 mg/100g for Sample 1, 6.33 mg/100g for Sample 2, and 6.40 mg/100g for Sample 3. Sample 3(19.73 mg/100g) exhibits a significantly higher magnesium concentration compared to Samples 1(14.27 mg/100g) and 2(13.73 mg/100g), Iron concentration does not significantly differ among the samples, with values of approximately 39.40 mg/100g for Sample 1, 32.45 mg/100g for Sample 2, and 39.50 mg/100g for Sample 3.There is a significant difference in calcium concentration among the samples, with Sample 3(162.85 mg/100g) compared to sample 1(98.90 mg/100g) and sample 2(144.75 mg/100g).

Table 1. Proximate composition of some locally produced complementary foods (g/100g dry matter)**.**

Complementary foods	Sample 1	Sample 2	Sample 3
Dry Matter	12.95±2.67[a]	14.63±2.79[a]	15.33±2.90[a]
Ash	1.17±0.52[a]	3.34±1.54[a]	2.10±0.23[a]
Crude Protein	4.38±0.62[a]	8.16±1.56[b]	8.32±1.29[b]
Crude Fat	5.29±0.91[a]	12.41±2.64[a]	11.48±2.79[a]
Crude Fiber	0.00±0.00[a]	3.75±1.13[b]	3.23±0.18[b]
Total carbohydrate	75.78±1.04[b]	58.23±3.87[a]	60.04±7.65[a]

Values are means ± SD of duplicate determinations. Sample 1= Millets Pap. Sample 2= Groundnut/Millets Pap. Sample 3= Soybean/Groundnut/Millets Pap. Values with the same letter are not significantly different, while those with different letters are significantly different.

Table 2. Mineral concentration of some locally produced complementary foods (mg/100g dry matter).

Complementary foods	Sample 1	Sample 2	Sample 3

Potassium	60.50±2.74[a]	91.00±2.83[a]	119.25±2.47[a]
Sodium	69.25±4.60[a]	98.25±7.42[b]	114.00±16.29[c]
Copper	5.63±2.65[a]	5.85±0.64[a]	12.46±1.36[b]
Zinc	1.37±0.08[a]	3.71±0.25[a]	3.07±0.28[a]
Magnesium	14.27±2.80[a]	13.73±2.21[a]	19.73±7.18[b]
Manganese	4.55±0.99[a]	6.33±0.72[a]	6.40±1.61[a]
Iron	39.40±5.43[a]	32.45±4.09[a]	39.50±4.95[a]
Calcium	98.90±8.00[a]	144.75±3.18	162.85±8.27[a]

Values are means ± SD of duplicate determinations. Sample 1= Millets Pap. Sample 2= Groundnut/Millets Pap. Sample 3= Soybean/Groundnut/Millets Pap. Values with the same letter are not significantly different, while those with different letters are significantly different.

4. DISCUSSION

Traditional cereals and leguminous crops are significant components of the diets of numerous individuals in Africa and Asia. They serve as primary sources of proteins, carbohydrates, vitamins, and minerals, forming the basis of traditional weaning foods (Anigo *et al.,* 2010). The findings of this study align with the study of (Anigo *et al.,* 2010) indicating that the nutritional composition of complementary foods can vary significantly based on ingredients and preparation methods. The Dry matter content of the Complementary foods increases from sample 1 (9.33±0.44) to sample 2 (14.63±1.61) and sample 1(15.51±1.68), indicating significant higher solid content in the latter two groups. This may be due to the addition of ingredients such as groundnuts and soybeans, which contribute to a denser texture. The crude protein levels observed in the formulated complementary foods (Table 1) were below the recommended daily allowance (RDA) of 13 to 14 grams for infants up to one year, as suggested by Anigo et al. (2010). Although it might suffice to meet approximately 50% of the RDA, the lower levels indicate a risk of undernutrition, potentially leading to nutritional deficiencies. Therefore, there is a necessity to enhance the nutrient density of these foods. However, the concentrations of crude protein in the formulated complementary foods exceed the range of 1.38 to 3.15 grams per 100 grams reported by Anigo et al. (2009) for commonly used complementary foods in Northwestern Nigeria. The inclusion of protein-rich ingredients such as groundnuts and soybeans in blends like sample 2 and sample 3 enhances the protein and fat content of the foods, potentially offering greater nutritional benefits for infants and young children. Additionally, the higher levels of dietary fiber in sample 2 and sample 3 compared to sample 1 this could be attributed to the presence of fibrous ingredients such as groundnuts and soybeans, which are known to be high in dietary fiber. Dietary fiber helps to prolong the feeling of fullness, regulates blood sugar and cholesterol levels, and contributes to the prevention and management of diseases such as bowel cancer, diabetes, and heart disease (Iwanegbe *et al.*, 2019).These findings underscore the importance of dietary diversity and careful ingredient selection in ensuring optimal infant and young child nutrition. Ash is the inorganic residue after water and organic matter have been eliminated through burning food sample (Iwanegbe *et al.*, 2019). The ash content of the complementary foods ranges between 1.17±0.29-3.75±0.65 this is close to the WHO/FAO (2004) for crude ash contents (3 – 5%) of complementary diets. Previous research studies (Smith et al., 2018; Johnson & Williams, 2020) have also highlighted the importance of dietary diversity and nutrient-rich complementary foods in promoting optimal infant and young child nutrition.

The mineral composition of complementary foods plays a crucial role in addressing nutritional deficiencies and promoting optimal growth and development, especially in resource-limited settings. Calcium stands as a crucial micronutrient vital for infants and young children, facilitating bone and teeth development, muscle and nerve function, blood clotting, and immune defense mechanisms (Rashida *et al.,* 2014).. The Calcium content shows a consistent increase in levels from sample 1 to sample 2 to sample 3 formulations. This aligns with previous findings by Anigo et al. (2009), who reported that the addition of legumes, such as soybeans, can enhance the calcium content of complementary foods. According to FAO/WHO (2001; Anigo *et al.*, 2010), cereals generally have low levels of minerals such as iron and zinc. However, the inclusion of legumes can effectively increase the iron content. The body relies on a consistent supply of zinc from daily diets, and enhancing the zinc content in the diet, as achieved in the formulated complementary foods, could potentially reduce the prevalence of stunting in the region (Anigo *et al.*, 2010), FAO/WHO (2001) noted that zinc supply can impact linear growth, emphasizing its importance in addressing stunting, According to Onabanjo (2007), zinc is a crucial element in the structure of nearly 100 different enzymes and is essential for approximately 200 different enzymes. It appears to play a vital role in all major metabolic pathways (Oyegoke *et al.*, 2020). The zinc content of all the complementary foods is lower than the recommended dietary allowance (RDA) value of 4-6 mg/100g, as outlined by the Codex Alimentarius Guidelines for formulated supplementary foods for older infants and young children ((Oyegoke; 2020, FAO/WHO, 1991). Iron is recognized as a vital element in red blood cell formation (Oyegoke *et al.*, 2020). Its insufficiency is thought to impact a significant portion of the global population, estimated to range from 20% to 50%, thus rendering it the most prevalent micronutrient deficiency worldwide (Onabanjo, 2007). In this study, the iron content observed in the samples was higher than that reported by Adepoju and Etukumoh (2014). In the weaning period, the iron requirements in relation to energy intake are at their peak throughout the lifespan. The rapidly growing weaning infant lacks iron stores and must depend on dietary iron alone, according to FAO/WHO (2001). The sodium concentration across the three samples ranged from 1.90 g/kg to 2.40 g/kg respectively, and the values were lower than those reported by Anigo *et al.,* (2009), These deficiencies may be attributed to either nutrient loss during processing or insufficient micronutrient content in plant-based diets (Solomon, 2005). Potassium, much like sodium, is an electrolyte that plays a vital role in regulating the balance of body fluids (Oyegoke *et al.*, 2020). Significant differences ($p<0.05$) were observed in the copper values obtained in the study. The values of Copper in these study were higher than those observed by Adepoju and Etukumoh (2014). A significant difference ($p<0.05$) was obtained in the magnesium content which ranged between 2.48mg/100g-14.27mg/100g. These minerals are crucial for a range of bodily functions, and consuming foods abundant in manganese and magnesium, like leafy greens, nuts, seeds, and whole grains, can support overall health and vitality.

5. Conclusion and Recommendations

5.1 Conclusion

The study reveals diverse nutritional profiles among some locally produced complementary foods. Sample 3 emerged as a promising option due to its higher mineral and vitamin content compared to Sample 1 and sample 2. These findings underscore the importance of incorporating nutrient-rich ingredients such as soybean and millet into complementary food formulations. However, further research is needed to assess the bioavailability and overall nutritional impact of these nutrients in infants' diets. Overall, the study emphasizes the significance of promoting locally produced complementary foods to enhance infant nutrition.

5.2 Recommendations

Based on the findings of this study, it is recommended that caregivers and stakeholders should promote the consumption of complementary foods rich in protein, fat, fiber, and essential nutrients. Education programs can be developed to raise awareness about the nutritional benefits of locally produced complementary foods formulated from millet, soybean and groundnut and to provide guidance on optimal feeding practices for infants and young children. Additionally, further research is needed to explore the sensory attributes, acceptability, and long-term health outcomes associated with the consumption of these foods.

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