FUDMA Journal of Agriculture and Agricultural Technology
ISSN: 2504-9496
Vol. 11 No. 1, March 2025: Pp. 116-124

https://doi.org/10.33003/jaat.2025.1101.14

QUALITY EVALUATION OF WEANING FOOD PRODUCED FROM MAIZE FLOUR, AND SUPPLEMENTED WITH AFRICAN YAM BEANS AND PIGEON PEA FLOUR BLENDS

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ABSTRACT

Quality evaluation of weaning food produced from sprouted maize flour (SMF) supplemented with sprouted African yam bean (SAYBF) and sprouted pigeon pea flour (SPPF) was carried out. Most weaning food are inadequate in protein and incorporation using underutilized protein source such as SAYBF and SPPF will improve its nutrition. Maize, African yam bean and pigeon pea were condition and allow to sprout before blending. Five blend formulations were developed with varying proportions of maize and the legumes: 100 % SMF (Sample A) as control, and blends containing 5 - 20 % SPPF with a constant 5% SAYBF (Samples B–E). The blends were analysed for proximate composition, mineral contents, functional properties, antinutrient contents, and sensory characteristics using standard methods. The results showed a significant improvement in the nutritional profile with increasing legume supplementation. The moisture, protein, fat, ash, and energy values increased, while carbohydrate and fiber content decreased. Protein content ranged from 9.2% in the control to 29.5% in weaning food with 75:5:20 blends of SMF, SAYBF and SPPF respectively. Mineral analysis revealed higher levels of magnesium, potassium, calcium, iron, and phosphorus in the legume-fortified samples. Bulk density, water and oil absorption capacities, foam capacity, and foam stability improved with higher legume contents. However, antinutrients like oxalates, tannins, phytates, and saponins also increased but remained within acceptable limits. Sensory evaluation indicated that all the samples were acceptable with the control (100 % SMF) most preferred followed by, 75:5:20 blends of SMF, SAYBF and SPPF respectively. The study demonstrates that incorporating sprouted African yam bean and sprouted pigeon pea into maize-based weaning foods enhances their nutritional and functional properties without compromising acceptability. Use of underutilized legumes could help in combating protein-energy malnutrition in infants in resource constrained environment.

Key words: Weaning food; sprouted maize flour (SMF); African yam bean (SAYBF); sprouted pigeon pea flour (SPPF), and nutritional evaluation

INTRODUCTION

The weaning period is a crucial period in the life of infants. At the age of 5–6 months, most infants begin to eat supplementary semisolid foods. At this stage homogenized infant foods play a major role in their nutrition (Martinez *et al*., 2004). Weaning is` the stage when an infant move from a diet consisting exclusively of breast milk to one which resembles that of adult in the community. It is a process of introducing semi-solid food into the infant diet (Macrae *et al*., 1993). The American Academy of Pediatrics and the World Health Organisation recommended waiting until 6 months to introduce baby food. Weaning foods for a child in a developing country like Nigeria are relatively expensive, out of reach for majority of the people and this may result in malnutrition and pose a risk to the life of a child, particularly if the parents are low-income earners.

Most weaning food commonly sold in Nigeria are composed mainly of cereal grains which contribute about 42% of the total daily calories and 49% of the total daily protein (Keshinro *et al.,* 1993). The maize (corn)-based products are usually in the form of porridges such as pap. Wet sieving and steeping have considerable effects on the protein losses in pap resulting in pap being a poor weaning for infants (Banigo and Muller 1992). This loss of an appreciable proportion of original nutrient contents of pap during its production has led to the development of pap fortifying with legumes.

Cereals are grasses (members of the monocot, family *Poaceae*) composed of the endosperm, germ and bran. They are rich in complex carbohydrate that provides energy. The cereal grains consist of wheat, corn, rice, grain sorghum, barley, oat, rye and millet (Douglas *et al*., 1983). Most of the cereals have abundant fibre especially barley, oat and wheat. Cereals also have soluble bran that aids in lowering blood cholesterol levels. On the other hand, legume is a plant in the family Fabaceae or a fruit of these plants. Legume seeds have the highest concentration of crude protein. They are good sources of B-group of vitamins but low in vitamin A (Ihenkoronye and and Ngoddy, 1985). The use of underutilized legumes such as African yam bean and pigeon pea in the formulation to improve protein availability will have considerable impact in nutrition and promotes their utilization.

The primary aim of this research is to formulate an acceptable weaning food using locally available and underutilize raw materials such as African yam bean and pigeon pea as protein supplement on cereals like maize to improve protein deficiency in infants

MATERIAL AND METHODS

Maize, African yam bean, and pigeon pea were obtained from Wednesday Market, Dutsin-Ma, Katsina State. All the analyses were carried out in the Food Science

Processing Laboratories, Federal University, Dutsin-Ma, Katsina State. All reagents used were of analytical grade.

Preparation of maize flour

Sprouted maize flour was produced according to the method of Okoye *et al.* (2023). Maize grain was cleaned, washed, soaked (24 h), allow to germinate (48 h at 30 °C), oven dried at 60 °C), dehulled, milled, sieved and milled to obtain sprouted maize flour

Preparation of sprouted African yam bean flour

African yam bean was cleaned, washed, soaked and allowed to germinate (72 h in dark, damp cloth), oven dried (60 °C), dehulled manually, milled, and sieved to get sprouted AYB flour according to the method described by Otegbayo and Alamu (2023).

Preparation of sprouted pigeon pea flour

The method of Igwe *et al.* (2024) was used in the production of sprouted pigeon pea flour. Pigeon pea seeds were sorted, cleaned, washed, soaked (18 h) allow to germinate (48 hrs under moist cloth), oven dried, dehulled, milled and sieved to obtain sprouted pigeon pea flour.

Blend formulation of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Five flour blends each containing 90:5:5 (B), 85:5:10 (C), 80:5:15 (D), 75:5:20 (E), of maize, African yam beans and pigeon pea flour respectively. The 100 % maize flour (A) served as control as shown in

Table 1.

Table 1: Blend Formulation of maize, African yam beans and pigeon pea flour (w/w %)

Sample	SMF	SAYBF	SPPF
A	100	0	0
B	90	5	5
C	85	5	10
D	80	5	15
E	75	5	20

SMF: Sprouted maize flour; SAYBF: Sprouted African yam bean flour;
SPPF: Sprouted pigeon pea flour

Proximate composition of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend

Proximate composition was carried using the methods described by AOAC (2012). Moisture content was assessed by oven drying the sample at 100 °C for 24 h, with weight loss indicating moisture content. Crude protein was determined using the micro-Kjeldahl method. Crude fat was extracted via soxhlet apparatus using organic solvents at 60 °C, and the residue was weighed after drying to determine fat content. Ash content, representing total mineral matter, was determined by incinerating the sample in a muffle furnace at 550 °C. Crude fibre was measured after solvent extraction and incineration, indicating the indigestible plant material, and carbohydrate content was calculated by difference, subtracting all other proximate components from 100 %.

Mineral composition of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend

The mineral composition of the samples was determined using AOAC (2012) standard methods. Magnesium was analyzed using atomic absorption spectrophotometry at 285.2 nm. The sample was dry-ashed, dissolved in dilute HCl, filtered, and compared to standard magnesium solutions. Potassium content was determined by flame photometry. 1 g of the sample was digested in a mixture of concentrated HNO_3, PCA, and H_2SO_4. The digest was analyzed using a flame analyzer for potassium content. Iron was determined colorimetrically. One gram (1 g) of sample was digested, treated with potassium thiocyanate, and the red-colored complex formed was measured at 480 nm using a spectrophotometer and compared to a standard curve. Calcium was measured using an atomic absorption spectrophotometer (Agilent Model 5805) at 239.9 nm. Calcium standards (0.0–9.0 mg/L) were prepared from $CaCO_3$ solution, and the results were interpreted using a standard curve. Phosphorus was determined by ashing 2 g of sample at 600 °C, dissolving in 6N HCl and nitric acid, and reacting the digest with molybdovanadate reagent. The yellow complex was measured at 400 nm against a phosphorus standard (AOAC, 2012).

Functional properties of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Functional properties of the flour samples were determined using standard procedures described by Onwuka (2005). Bulk Density (BD) was measured by filling a 10 ml graduated cylinder with the sample and tapping it repeatedly until volume stabilized. The weight per unit volume was calculated. Water Absorption Capacity (WAC) was assessed by mixing 1 g of sample with 10 ml distilled water, standing for 30 min, and centrifuging at 500 rpm. The absorbed water was measured by subtracting the supernatant volume. Oil Absorption Capacity (OAC) estimated by mixing 1 g of flour with 10 ml vegetable oil (density 0.99 mg/ml), stirring at 1000 rpm, and centrifuging at 3500 rpm. The unabsorbed oil was measured and subtracted from the original volume. OAC was calculated as:

OAC = (Volume of oil absorbed × Density × 100) / Weight of sample.

Swelling Index was determined by adding 50 ml of distilled water to 5 g of the sample in a 50 ml cylinder, then measuring the volume change over 60 minutes. The ratio of final to initial volume gave the swelling index. Foaming Capacity was measured by blending 1 g of sample with 50 ml distilled water, whipping at 1600 rpm for 5 minutes, and recording volume increase after 30 seconds. Foaming capacity was calculated as the percentage increase in volume due to foam formation.

Antinutrient of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Anti-nutritional factors were determined using standard methods (AOAC, 2012; Onwuka, 2005). Oxalates were analyzed by extracting 1 g of sample with 75 ml of 3M H_2SO_4 for 1 hour, filtering, and titrating 25 ml of the filtrate with hot 0.1N $KMnO_4$ until a persistent pink color appeared. Each ml of permanganate equals 0.006303 g oxalate (AOAC, 2012). Tannins were determined by reacting the supernatant of water-extracted samples with Folin-Denis reagent and sodium carbonate. After 90 minutes, absorbance was read at 250 nm. Tannin content was calculated using a tannic acid standard curve (Onwuka, 2005). Phytate was determined by extracting samples with 0.2N HCl, reacting with ferric solution, and then with 2,2-bipyridine. Absorbance was measured at 519 nm and concentration derived from a standard calibration curve (Onwuka, 2005). Saponin content was determined using the method of Obadoni and Ochuko (2001). 20 g of sample was extracted with 100 ml of 20% aqueous ethanol, filtered, and re-extracted. The combined extracts were reduced, transferred to a separating funnel, and shaken with diethyl ether. The aqueous layer was purified with n-butanol, washed with sodium chloride solution, and evaporated. The residue was dried and weighed to obtain saponin percentage.

Sensory properties of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Weaning food which was neither too thin nor too thick was prepared by mixing 40 g of each flour sample in 80 ml hot water using a graduated plastic cup. Hot water was obtained using a cordless electric kettle (Sayona, model no. SCK-25). A twenty-five (25) panellists were selected among the students and staff of the Department of Food Science and Technology, Federal University, Dutsin-Ma, Katsina State based on their familiarity and experience with weaning foods. The panelists gave their consents before being recruited for the sensory exercise. Each of the samples coded with a three-digit non-bias number were placed in separate identical plates. Each panelist assessed the coded samples independently in separate sensory booths and they were asked to indicate their preference for colour, taste, texture, aroma and overall acceptability. The panelists were provided with water to rinse their mouths before and after each testing. A 9-point Hedonic scale as described by Singh-Ackbarali and Maharaj (2014) was used with 1 and 9 represented dislike extremely and like extremely respectively.

Statistical Analysis of samples

The data obtained were subjected to analysis of variance (ANOVA) using the statistical package for social science (SPSS) version 23.

RESULTS AND DISCUSSION

Proximate composition of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend

Table 2 showed the result of the proximate composition of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend. The moisture content of the weaning food samples ranged from 4.74 % to 12.01 %. Sample A had the lowest moisture content while Sample E had the highest moisture content. The moisture content of the flour samples increased as the percentage pigeon pea increased, this follows the trend of Akinyele *et al.* (2020) who reported that increased substitution of maize with African yam bean and pigeon pea in weaning formulations led to a gradual increase in moisture content, attributing this to the hygroscopic nature of legume proteins. The lower moisture content in Sample A suggests a higher concentration of dry matter, which is beneficial for shelf stability and microbial resistance. The moisture content of all samples, however, was within the standard limits (13 %) for flour-based products (Alam *et al.,* 2019).

The crude protein contents of the weaning foods increased from 9.20 % to 29.50 % as the proportions of African yam bean and pigeon pea flours increased. This trend reflects the complementary effect of legumes, which are richer in protein compared to maize. Adepeju *et al.* (2011) reported crude protein values ranging from 10.76% to 26.43% in blends of maize with pigeon pea and African yam bean, showing a similar trend of increasing protein with higher legume content. Protein serves as a crucial building block for the body's integrity, which is important for development and the repair of worn-out tissues (Ezegbe *et al.,* 2009). The crude fat contents of weaning food produced from maize flour, African yam beans, and pigeon pea blends ranged from 2.64 % for Sample A, to 5.79 % for Sample E. The fat content of maize is low which reflects the increase in the fat content of the samples progressively as the proportion of African yam beans and pigeon pea increased. Ezegbe *et al.* (2023) reported fat contents that ranged from 4.79% to 6.19% in breakfast cereals produced from flour blends of maize and pigeon pea flour. The higher fat content in their study may be attributed to the higher proportion of pigeon pea flour used. Dietary fat plays a crucial role in enhancing the absorption of fat-soluble vitamins, supplying essential fatty acids as well as volatile compounds crucial for flavour and sensory appeal (Ezegbe *et al.,* 2009).

Table 2: Proximate of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Samples	Moisture (%)	Protein (%)	Fat (%)	Ash (%)	Fibre (%)	Carbohydrate (%)	E (J/ 100 g)
A	4.74±1.21	9.2±0.76	2.64±2.11	2.01±0.33	2.90±0.11	78.51±0.75	1573.32
B	5.11±0.22	17.3±0.32	3.31±0.23	2.57±0.41	2.82±0.32	68.89±1.12	1573.11
C	6.04±0.91	22.4±0.11	4.51±0.91	2.71±0.98	2.77±0.77	61.57±0.94	1581.17
D	6.72±1.01	24.8±0.65	4.63±0.17	3.12±0.28	2.62±0.16	58.11±0.35	1567.9
E	12.01±0.25	29.5±1.01	5.79±0.77	3.35±0.26	2.60±0.12	46.75±0.55	1499.86

A = 100% Sprouted maize flour; B = 90% sprouted maize flour, 5% sprouted African yam bean flour and 5% Sprouted pigeon pea flour; C = 85% sprouted maize flour, 5% sprouted African yam bean flour and 10% Sprouted pigeon pea flour; D = 80% sprouted maize flour, 5% sprouted African yam bean flour and 15% Sprouted pigeon pea flour; E =75% sprouted maize flour, 5% sprouted African yam bean flour and 20% Sprouted pigeon pea flour

The ash content of the samples ranged from 2.01 % to 3.35 %. The ash contents increased with increase in the level of substitution of maize with African yam beans and pigeon pea. The values in this study is higher than fat content (0.6% to 2.0%) reported by Agu and Aluyah (2004), from weaning food produced from maize, soybean, and fluted pumpkin seed flours. The crude fibre content of the weaning food samples ranged from 2.60 % to 2.90 %. Sample E had the lowest crude fibre content while sample A had the highest fibre content. The crude fibre content reduced with increase in the proportions of African yam beans and pigeon pea, as maize has a higher fibre content when compared with African yam bean and pigeon pea. Fibre plays a vital role in infant nutrition, particularly in improving bowel movement, aiding digestion, and preventing constipation.

The carbohydrate content of the weaning food samples ranged from 46.75 % to 78.51 %. Sample D and sample A had the lowest and the highest carbohydrate contents respectively. The substitution of maize with the legumes led to decrease in the carbohydrate contents of weaning foods. This result is in agreement with the work of Kalu *et al*. (2019), who reported a reduction in the carbohydrate content of up to 50.43 % in flour blends from water yam, yellow maize, and African yam bean. However, the lowest carbohydrate value obtained is much lower than those reported by Okafor and Usman (2013) for breakfast cereals made from African yam bean and maize (59.99–62.31 %). The energy contents of the weaning foods ranged from 1499.86 to 1573.32 J/100 g. there is general decrease in the energy contents of the weaning foods as the maize become more substituted.

Mineral composition of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend

Table 3 showed the result of the mineral composition of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend. The magnesium content of the weaning food samples ranged from 16.54 mg/100g to 25.35 mg/100g. Sample A had the lowest magnesium content while Sample E had the highest. The increase in magnesium content across the samples correlates with the addition of African yam bean and pigeon pea flours, both of which are known to be richer in minerals compared to maize. Potassium contents ranged from 124.29 to 149.32 mg/100g. A continual increase in potassium content was observed as the proportion of pigeon pea inclusion increased. This aligns with findings of Ezeocha *et al*. (2025), who reported significant increases in mineral content, including potassium, with higher proportions of pigeon pea flour.

The iron contents of the weaning food samples ranged from 4.56 mg/100g for sample A to 6.14 mg/100g for sample E. As reported for potassium, the iron contents of the weaning foods increased with increased substitution of pigeon pea with the maize. However, the values reported in this study are lower compared to 8.44 mg/100 g to 33.92 mg/100 g obtained by Adebayo-Oyetoro *et al.* (2019) from weaning food produced from sorghum (Sorghum bicolor) and pigeon pea (*Cajanus cajan*), albeit the samples were allowed to undergo fermentation. Iron is essential in the body to prevent its deficiency which leads to anemia. Calcium contents of the samples ranged from 61.27 mg/100g to 84.53 mg/100g. in the same way, there is increase in the calcium content with the increase in the proportion of African yam beans and pigeon pea, which is in agreement with the work of Adebayo-Oyetoro *et al* (2019) on the effect of co-fermentation on the quality attributes of weaning food produced from sorghum (Sorghum bicolor) and pigeon pea (*Cajanus cajan*). Calcium intake is important in blood clotting, muscle contraction, enzyme activation, development and maintenance of bones and teeth (Okereke *et al*., 2021).

Phosphorus content of the weaning food samples ranged from 38.26 mg/100g in Sample A to 52.79 mg/100g in Sample E. Adenuga *et al*. (2010) found out that substituting maize with pigeon pea in complementary food blends significantly improved the mineral profile, particularly phosphorus. Phosphorus is a component of nucleic acids which plays an important function in the cellular metabolism of other nutrients such as carbohydrate, fat etc. (Okereke *et al*., 2021).

Table 3: Minerals composition of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Samples	Magnesium (mg/100g)	Potassium (mg/100g)	Iron (mg/100g)	Calcium (mg/100g)	Phosphorus (mg/100g)
A	16.54±0.12	124.29±0.09	4.56±0.11	61.27±0.43	38.26±0.42
B	19.10±0.32	137.84±1.08	5.62±0.62	64.31±0.64	46.39±0.21
C	22.79±0.05	144.17±0.53	5.91±0.91	71.33±0.95	48.93±0.11
D	23.76±1.21	147.93±0.28	6.01±0.07	78.19±0.77	50.23±0.92
E	25.35±0.81	149.32±0.75	6.14±1.09	84.53±0.13	52.79±0.07

A= 100% Sprouted maize flour; B = 90% sprouted maize flour, 5% sprouted African yam bean flour and 5% Sprouted pigeon pea flour; C =85% sprouted maize flour, 5% sprouted African yam bean flour and 10% Sprouted pigeon pea flour; D= 80% sprouted maize flour, 5% sprouted African yam bean flour and 15% Sprouted pigeon pea flour; E=75% sprouted maize flour, 5% sprouted African yam bean flour and 20% Sprouted pigeon pea flour

Functional properties of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend

Table 4 showed the result of the functional properties of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend. The bulk density of the weaning food samples ranged from 0.73 to 0.93 g/ml. Sample A had the lowest bulk density, while Sample E had the highest bulk density. These results were lower than those reported by Bolade *et al*. (2009) who recorded a bulk density range of 2.1–1.9 g/ml in a maize-based non-fermented breakfast cereal. Foods with higher bulk density occupy less space, allowing more products to be transported in a single shipment with better cost (Ezegbe *et al.,* 2025). The oil absorption capacity (OAC) of the samples ranged from 1.97 g/ml for sample A to 2.36 g/ml for sample E. The OAC increased with the level of supplementation. Adelekan and Adebayo (2012) reported that increased legume incorporation led to higher OAC values. Also, Olalude and Oloruntoba (2018) observed that composite flours made from cereals and African yam bean flour had significantly higher OAC than pure maize flour, attributing this to the oil-binding nature of the legume proteins and their surface-active properties. Water absorption capacity (WAC) of the weaning food samples ranged from 1.91 g/ml to 3.06 g/ml, for sample A and sample E respectively. The observed trend in the WAC of the breakfast cereal may be due to an increase in protein content arising to the use pigeon pea flour. A food substance water retention capacity is mostly determined by the water-binding ability of food ingredients (Edith *et al*., 2019).

Foam capacity of the samples ranged from 8.17 % in Sample A to 11.18 % in Sample E. The foam capacity increased with increase in pigeon pea flour inclusion. The addition of pigeon pea flour, which is known for its high protein content (nearly 20–25% protein depending on the variety), might have contributed to the improved foaming characteristics of the blends. Zhou *et al*. (2021) showed that increase in the protein content of the composite flour blends significantly enhances foam formation, as proteins reduce surface tension and help formation of stable films around air bubbles, which is crucial for both foam formation and stability. Foaming stability ranged from 1.92 g/ml in Sample A to 3.98 g/ml in Sample E. Gahfoori *et al*. (2020) observed that the germination process improves protein solubility, which further enhances the foaming properties by making proteins more accessible to form stable films. In this study, the sprouted maize flour, together with sprouted African yam bean and pigeon pea flour, likely benefited from these enhanced functional properties, contributing to the observed improvements in foam stability.

Table 4: Functional properties of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Samples	Bulk density (g/ml)	OAC (g/g)	WAC (g/g)	Foam capacity (%)	Foaming stability (g/ml)

A	0.73±0.11	1.97±0.49	1.91±1.09	8.17±0.13	1.92±0.38
B	0.81±0.93	2.01±0.05	1.97±0.13	9.19±0.54	2.26±0.20
C	0.87±1.70	2.09±0.12	2.11±0.04	9.58±0.09	2.57±0.91
D	0.89±0.95	2.12±0.04	2.43±0.27	10.17±0.32	3.82±0.16
E	0.93±1.11	2.36±0.09	3.06±0.04	11.18±0.26	3.98±1.08

A= 100% Sprouted maize flour; B = 90% sprouted maize flour, 5% sprouted African yam bean flour and 5% Sprouted pigeon pea flour; C =85% sprouted maize flour, 5% sprouted African yam bean flour and 10% Sprouted pigeon pea flour; D= 80% sprouted maize flour, 5% sprouted African yam bean flour and 15% Sprouted pigeon pea flour; E=75% sprouted maize flour, 5% sprouted African yam bean flour and 20% Sprouted pigeon pea flour.

Antinutrient content of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend

Table 5 showed the result of the antinutrient content of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend. The oxalate contents of the samples ranged from 0.98 % to 1.25 %. Sample A (100 % maize flour) had the lowest oxalate content, while Sample E (with the highest level of supplementation) had the highest. Adeoye *et al.* (2019) reported much lower oxalate content (0.08–0.12%) in complementary foods from maize, millet, and pigeon pea. Oxalates affect calcium and magnesium metabolism and their absorption, forms complexes with protein and inhibits peptic digestion (Bheemaiah-Balyatanda *et al*., 2024). Tannin content of the weaning food samples ranged from 0.68 % in Sample A to 1.37 % in Sample E. The increase in tannin content corresponded with increased levels of pigeon pea flour. Adeoye *et al.* (2019) reported lower tannin contents compared to the result in this work. This was likely due lower pigeon pea levels used or combined with other grains like millet, which ultimately resulted in low antinutrient content. Tannins interfere with mineral absorption, reduce bioavailability and bio-accessibility of minerals, reduce protein and carbohydrate digestion, absorption, and palatability. (Bheemaiah-Balyatanda *et al*., 2024).

Phytate contents ranged from 0.56 % in Sample A to 1.17 % in Sample E. As the proportion of African yam beans and pigeon pea flour increased, the phytate content also increased. Phytates are naturally occurring antinutrients in legumes and cereals. The increasing trend was due to the rising levels of pigeon pea, which is known to be rich in phytates. Despite sprouting which generally reduces phytates the cumulative addition still results in a higher phytate content in the weaning foods. Edeoga *et al.* (2020) observed phytate levels between 0.12% and 0.45% in breakfast cereals made from guinea corn, pigeon pea, and mango flour, which is lower than in this result. Phytates chelate several mineral elements, especially zinc, iron, calcium, magnesium, manganese and copper, and interfere with their absorption and utilization. (Lopez *et al*., 2002; Konietzny and Greiner, 2003; Bheemaiah-Balyatanda *et al*., 2024). Phytate has been suggested to limit the proliferation of breast cancer cells (Shamsuddin et al., 1996), cervical cancer (Ferry et al., 2002), prostate cancer (Singh et al, 2003) and HepG2 hepatoma cell lines (Vucenik et al.,1998) in humans. Saponin content ranged from 0.17 % to 0.28 % across the samples, with Sample A having the lowest value and sample C having the highest value. Saponin as well increased with increase in the proportion of pigeon pea. Saponins, though potentially bitter and known to reduce nutrient absorption, may offer antioxidant and cholesterol-lowering benefits in small quantities. Saponins reduce nutrient (Vitamins A and E and lipids) absorption, interfere with integrity of epithelial cells, thyroid and gut functions.

Table 5: Antinutrient of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blend

Samples	Oxalate	Tannin	Phytate	Saponin
A	0.98±0.84	0.68±0.29	0.56±0.08	0.17±0.44
B	1.07±0.21	0.79±0.74	0.77±0.58	0.26±0.76
C	1.12±0.22	1.02±0.14	0.81±0.35	0.28±0.39
D	1.19±0.64	1.25±0.05	0.98±0.06	0.21±0.21
E	1.25±0.18	1.37±0.29	1.17±0.72	0.24±0.89

A= 100% Sprouted maize flour; B = 90% sprouted maize flour, 5% sprouted African yam bean flour and 5% Sprouted pigeon pea flour; C =85% sprouted maize flour, 5% sprouted African yam bean flour and 10% Sprouted pigeon pea flour; D= 80% sprouted maize flour, 5% sprouted African yam bean flour and 15% Sprouted pigeon pea flour; E=75% sprouted maize flour, 5% sprouted African yam bean flour and 20% Sprouted pigeon pea flour

Sensory evaluation of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blends

Table 6 showed the result of the sensory evaluation of weaning food produced from maize flour supplemented with African yam beans and pigeon pea flour blend. The colour scores of the samples ranged from 6.18 for sample D to 7.23 for sample A. This result shows that sample A had the most preferred colour. The taste scores ranged from 5.76 (Sample C) to 7.65 (Sample A). Generally, increasing pigeon pea flour resulted in a decrease in taste mean score, which could be due to increased intensity of beany flavor.

Aroma scores ranged from 6.26 (Sample C) to 7.11 (Sample B), indicating moderate preference across all samples. Mouthfeel scores ranged from 5.86 to 7.45. Sample C had the lowest mouthfeel score while sample A had the highest score, indicating that the panelists preferred the texture of the control sample. The increase in legume content slightly reduced mouthfeel acceptability, probably due to changes in texture and consistency. Overall acceptability scores ranged from 5.95 in Sample C to 7.40 in Sample A. Sample E, despite higher supplementation, recorded 6.52, showing improved acceptability compared to Samples B, C, and D. Increase legume supplementation affects the sensory characteristics. The overall acceptability values reported by Edima-nyah *et al*. (2019) were lower compare with the results obtained in this study.

Table 6: Sensory properties of weaning food produced from maize flour, and supplemented with African yam beans and pigeon pea flour blends

Samples	Colour	Taste	Aroma	Mouthfeel	Overall acceptability
A	7.23±0.32	7.65±0.49	6.53±0.09	7.45±0.82	7.40±0.71
B	6.55±0.09	6.16±0.33	7.11±0.10	6.18±0.27	6.07±0.08
C	6.31±0.03	5.76±0.19	6.26±0.61	5.86±0.21	5.95±0.04
D	6.18±0.37	5.81±0.82	6.45±0.01	6.01±0.18	6.01±0.17
E	6.99±0.26	6.89±0.37	6.44±0.27	6.16±0.88	6.52±0.36

A= 100% Sprouted maize flour; B = 90% sprouted maize flour, 5% sprouted African yam bean flour and 5% Sprouted pigeon pea flour; C =85% sprouted maize flour, 5% sprouted African yam bean flour and 10% Sprouted pigeon pea flour; D= 80% sprouted maize flour, 5% sprouted African yam bean flour and 15% Sprouted pigeon pea flour; E=75% sprouted maize flour, 5% sprouted African yam bean flour and 20% Sprouted pigeon pea flour

CONCLUSION

There is improvement in the proximate composition of maize-based weaning food through inclusion with African yam bean and pigeon pea flour as it offers higher percentages of protein, fats, and ash with a corresponding increase in the mineral content especially in magnesium, potassium, iron, calcium, phosphorus while antinutrients composition increased as seen in oxalate, tannin, phytate and saponin contents. Functional properties also improved in terms of bulk density, oil absorption capacities, water absorption capacities, foaming capacity and foaming stability. Production of weaning from formulation of maize, African yam bean and pigeon pea in the ratio 75:5:20 should be adopted as it had better nutritional, functional and sensory quality attributes.

ACKNOWLEDGEMENTS

The authors acknowledged tetfund for funding this research work, as part of IBR programme.

CONFLICT OF INTERESTS

The authors declared no conflict of interest, as this work has not been published elsewhere, and is not under consideration for publication in any other journal.

REFERENCES

Adebayo-Oyetoro, A. O., Ogundipe, O. O., Lofinmakin, F. K. and Oyawoye, O. M. (2019). Effect of Co-fermentation on the Quality Attributes of Weaning Food Produced from Sorghum (*Sorghum bicolor*) and pigeon pea (*Cajanus cajan*). *African Journal of Food Science*, 13(4), 78–85.

Adelekan, A. O. and Adebayo, S. S. (2012). Nutritional, Functional, and Sensory Properties of Complementary Food Formulated from Maize, Soybean, and Pigeon Pea. *Journal of Nutrition and Food Sciences*, 2(3), 1–8.

Adenuga, W., Abiodun, B. J. and Igbabul, B. D. (2010). Development and Evaluation of a Complementary Diet from Blends of Maize (Zea mays), Soybeans (Glycine max), and Pigeon Pea (*Cajanus cajan*). *African Journal of Food, Agriculture, Nutrition and Development*, 10(3), 2275–2288.

Adeoye, B. K., Olaofe, O., Fagbemi, T. N. and Sobukola, O. P. (2019). Development and Nutritional Evaluation of Complementary Foods from Maize, Millet, and Pigeon Pea. *Nigerian Journal of Nutritional Sciences*, 40(2), 108–117

Adepeju, A. B., Gbadamosi, S. O., Adeniran, A. H. and Omobuwajo, T. O. (2011). Functional and Pasting Characteristics of Breadfruit (*Artocarpus altilis*) Flours. *International Journal of Food Properties*, 14(2), 370–379

Agu, H. O. and Aluyah, E. I. (2004). Production and Chemical Analysis of Weaning Food from Maize, Soybean, and Fluted Pumpkin Seed Flour. *Nigerian Food Journal*, 22, 1–5.

Akinyele, K. N., Emma-Okon, B. O., Fajobi, A. O., Morakinyo, A. E. and Oyedapo, O. O. (2020). Studies of the Anti-hyperglycemic and Antioxidant activities of the extract of Aerial Yam (Dioscorea bulbifera). *Journal of Medicinal Plants Research*, 5(10), 503-514.

Alam, M. S., Kaur, J., Khaira, H. and Gupta, K. (2019). Development and Evaluation of Nutritious Weaning Food using Sorghum and Legumes. *Journal of Food Science and Technology*, 56(4), 2103–2112.

AOAC. (2012). *Official Methods of Analysis of AOAC International* (19th ed.). Gaithersburg, MD: AOAC International.

Banigo, E. B. and Muller, H. G. (1992). Manufacture of *Ogi* (a Nigerian fermented cereal porridge): Comparative Evaluation of Corn, Sorghum and Millet. *Journal of Food Science*, 37(2), 216–219.

Bheemaiah-Balyatanda, C., Nataraja, T. N. and Saritha, V. S. (2024). Antinutritional Factors in Legumes: Role in Mineral Absorption and Strategies for Reduction. *International Journal of Nutrition and Food Sciences*, 13(1), 1–11.

Bolade, M. K., Adeyemi, I. A. and Ogunsua, A. O. (2009). Production and Evaluation of maize-Based Non-fermented Breakfast Cereals. *Nigerian Food Journal*, 27(1), 78–86.

Douglas, J. H., Babcock, B. A. and Smale, M. (1983). Cereal Grains: Properties and Utilization. *Food Technology Review*, 10(3), 45–55.

Edeoga, H. O., Okwu, D. E. and Mbaebie, B. O. (2020). Nutritional and Phytochemical Composition of Some Leafy Vegetables used in Traditional Medicine. *Journal of Medicinal Plants Research*, 14(2), 122–130.

Edima-nyah, A., Etim, I. E. and Etuk, E. U. (2019). Sensory Evaluation of Complementary Food Formulated from Unripe Plantain, Sweet Potato, and Soybean. *Journal of Food Research*, 8(6), 59–66.

Edith, E. N., Ifeanyi, E. N. and Chinazaekpere, N. U. (2019). Water Absorption and Functional Properties of Legume and Cereal Flour Blends. *Nigerian Journal of Food Technology*, 36(1), 40–49.

Ezegbe, O. B., Echeta, N. N. and Agim, E. I. (2023). Physicochemical and Sensory Qualities of Breakfast Cereal Blends of Maize and Pigeon pea. *International Journal of Food Science and Nutrition*, 8(1), 45–52.

Ezegbe, O. B., Uzochukwu, S. V. A. and Achi, O. K. (2009). Nutrient and Sensory Properties of Breakfast Cereals Produced from Maize and Pigeon Pea. *Nigerian Food Journal*, 27(2), 132–140.

Ezeocha, C. V., Nwosu, J. N. and Ejiofor, C. A. (2025). Evaluation of Breakfast Cereals from Flour Blends of Maize and Pigeon pea. *African Journal of Food, Agriculture, Nutrition and Development*, 25(1), 11000–11016.

Ferry, S., Matsuda, M., Yoshida, H. and Hirata, M. (2002). Inositol hexakisphosphate blocks tumour cell growth by activating apoptotic machinery as well as by inhibiting the Akt/NFkB-mediated cell survival pathway. *Carcinogenesis*, 23, 2031–2041.

Gahfoori, M., Ghahraman, T. and Yousefi, R. (2020). Effects of Germination on Functional and Nutritional Properties of Legumes: A review. *Journal of Food Biochemistry*, 44(7), e13278.

Igwe, V. S., Okorie, S. U. and Onuegbu, N. C. (2024). Production and Nutritional evaluation of germinated pigeon pea flour. *Journal of Agricultural and Food Science Research*, 12(2), 89–97.

Ihenkoronye, A. I. and Ngoddy, P. O. (1985). *Integrated Food Science and Technology for the Tropics*. London: Macmillan Press.

Kalu, F. A., Ezeocha, C. V., & Oti, E. (2019). Nutritional composition of flour blends from water yam, yellow maize, and African yam bean. *Journal of Food Science and Technology*, 56(10), 4440–4447.

Keshinro, O. O., Olatunde, G. O. and Oladiran, A. O. (1993). Nutrient Composition and Acceptability of Soy ogi Fortified with Pigeon Pea Flour. *Plant Foods for Human Nutrition*, 43(3), 229–234.

Konietzny, U. and Greiner, R. (2002). Molecular and catalytic properties of phytate degrading enzymes (phytases). *International Journal of Food Science and Technology*, 37, 791–812.

Lopez, H. W., Leenhardt, F., Coudray, C. and Rémésy, C. (2002). Minerals and phytic acid interactions: Is it a real problem for human nutrition? *International Journal of Food Science and Technology*, 37, 727–739.

Macrae, R., Robinson, R. K. and Sadler, M. J. (1993). *Encyclopedia of Food Science, Food Technology and Nutrition* (Vol. 8). San Diego: Academic Press.

Martinez, C. R., Krieger, I. and Branco, R. J. (2004). Complementary feeding: A Critical Step in the Growth of Infants. *Journal of Pediatric Nutrition*, 21(4), 205–212.

Obadoni, B. O. and Ochuko, P. O. (2001). Phytochemical Studies and Comparative Efficacy of the Crude Extracts of Some Homeostatic Plants in Edo and Delta States of Nigeria. *Global Journal of Pure and Applied Sciences*, 8(2), 203–208.

Okafor, C. A. and Usman, M. A. (2013). Chemical and Sensory Evaluation of Breakfast Cereal Produced from African yam Bean and Maize. *Nigerian Journal of Agriculture, Food and Environment*, 9(4), 30–35.

Okereke, J. N., Okechukwu, R. I. and Ogu, N. C. (2021). Nutritional Importance of Minerals in Human Diet: A Review. *International Journal of Advanced Academic Research*, 7(2), 15–30.

Okoye, J. I., Mazi, E. A. and Agbo, B. C. (2023). Effects of Sprouting on the Nutritional Quality of Maize

Flour. *Journal of Food Biochemistry*, 47(1), e13500.

Onwuka, G. I. (2005). *Food Analysis and Instrumentation: Theory and Practice*. Lagos: Naphtali Prints.

Otegbayo, B. O. and Alamu, E. O. (2023). Production and Nutritional Evaluation of Sprouted African Yam Bean Flour. *Nigerian Journal of Food Science and Technology*, 41(3), 55–63.

Shamsuddin, A. M., Yang, G. Y. and Vucenik, I. (1996). Novel anti-cancer functions of IP6: Growth inhibition and differentiation of human mammary cancer cell lines in vitro. *Anticancer Research*, 16, 3287–3292.

Singh, R. P., Agarwal, C. and Agarwal, R. (2003). Inositol hexaphosphate inhibits growth, and induces G1 arrest and apoptotic death of prostate carcinoma DU145: Modulation of CDKI-CDK-cyclin and pRb-related protein-E2F complexes. *Carcinogenesis*, 24, 555–563.

Singh-Ackbarali, D. and Maharaj, R. (2014). Sensory Evaluation as a Tool in Determining the Acceptability of Innovative Products Developed by Undergraduate Students in Food Science and Technology at the University of Trinidad and Tobago. *Journal of Curriculum and Teaching*, 3(1), 10–27.

Vucenik, I., Tantivejkul, K., Zhang, Z. S., Cole, K. E., Saied, I. and Shamsuddin, A. M. (1998). IP6 treatment of liver cancer. I. IP6 inhibits growth and reverses transformed phenotype in HepG2 human liver cancer cell line. *Anticancer Research*, 18, 4083–4090.

Zhou, L., Deng, Y., Zhang, H. and Liu, R. (2021). Effect of Protein Concentration on Foaming Capacity and Stability of Legume Protein Isolates. *Journal of Food Engineering*, 304, 110–115.