

Chemical Characteristics and Digestibility of Fermented Yellow Maize-Soybean Flours, Fortified with Almond-Nut for Weaning Foods

Akpan, Blessing Anthony¹; and Edima-Nyah, Anne Peter²

¹Department of Food Science and Technology, Faculty of Agriculture, University of Uyo, Akwa Ibom State, Nigeria. ²Department of Food Science and Technology, Faculty of Agriculture, University of Uyo, Akwa Ibom State, Nigeria.

Corresponding author: akpanblessing712@gmail.com

DOI: <https://doi.org/10.62154/ajasfr.2025.019.01021>

Abstract

The purpose of the study was to determine the anti-nutritional content which showed; phytate (6.42 - 14.00 g/Kg), protease inhibitor (4.36 - 6.18 g/Kg), glycinin (557.49 - 606.69 g/Kg) and conglycinin (163.43 - 194.52 g/Kg). Vitamin A (67.29 - 82.44 mg/100g), and vitamin E (0.14 - 2.81 mg/100g). *In-vitro* protein digestibility at one (1) hour (64.67 - 76.94 %) and at six (6) hours (66.06 - 81.13 %) increased, while *in-vitro* starch digestibility (70.26 - 76.83 %) decreased with increasing level of almond-nut flour substitution. Significant difference ($p < 0.05$) was observed in lipid and amino acid profiles, with sample D (85 % fermented yellow maize-soybean flour and 15 % of almond nut) and E (which comprises of 80 % fermented yellow maize-soybean flour and 20 % of almond nut) having the highest value. Protein quality evaluation includes nitrogen solubility (36.17 - 68.77 %), protein dispersity index (45.89 - 80.20 %) and urease index (0.01 - 0.03 mg/dL). Conclusively, composite flours showed good potential for the production of weaning foods, where positive impacts have been observed for both chemical and digestibility characteristics.

Keywords: Protein Digestibility, Weaning Foods, Yellow Maize-Soybean Flours, Almond-Nut, Fortification.

Introduction

Scientific evidence supports that breast milk is the ideal source of nutrition for infants during the first six months of life, as it provides all essential nutrients and immune-boosting components necessary for optimal growth and health (Amira *et al.*, 2018). In addition to supporting development, breast milk also protects infants against the two leading causes of infant mortality; upper respiratory infections and diarrhoea (Brown and Dewey, 1998; Bartick *et al.*, 2017). However, from six months onward, when an infant's weight is typically double their birth weight, breast milk alone becomes insufficient to meet the increasing nutritional demands. As a result, complementary feeding with nutrient-rich foods, commonly known as weaning foods, becomes essential. This phase usually spans from six to twenty-four months in many developing countries (Abbey and Nkanga, 1988).

It is essential for children to receive adequate nutrients during both breastfeeding and complementary feeding stages in order to support optimal physical and cognitive development, with benefits that extend into later life (Arikpo *et al.*, 2018; Owais *et al.*, 2017). The reduced in breastfeeding has led to potential deficiencies in key nutrients such as protein, zinc, iron, and B-vitamins in many infants' diets (Pelto *et al.*, 2003). If not properly addressed, this can result in under-nutrition during a critical period of growth and development. The digestibility of the weaning food and the absorption capacity of the gastrointestinal tract are some of the factors that determine how efficient the contributions of the foods are to the overall health, growth and development of the infants (Harris, 2000; Fewtrell *et al.*, 2003).

In many developing nations, the high price of commercially fortified complementary foods is often unaffordable for many Nigerian households. Consequently, these families often rely on inadequately processed traditional cereal-based foods, typically made from maize, sorghum, or millet, which are not nutritionally sufficient on their own (Nnam, 2002). To address this, local researchers have developed and tested nutrient-enhancing food blends using available indigenous ingredients (Badamosi and VJ, 1995). These efforts have demonstrated improved nutrient content and intake, helping to combat malnutrition. Several locally accessible cereals and legumes in Nigeria have shown potentiality to complement each other nutritionally, when properly processed and combined (Abbey and Nkanga, 1988). The incorporation of almond nut in the formulation which is a nutrient dense food, rich in monounsaturated fat, protein, fiber, α -tocopherol, minerals such as magnesium and copper, and phytonutrients, albeit being energy-dense (Aslantas, 2001). Nutritious and acceptable weaning food, can be produced from the composite flour blends of fermented yellow maize and soybean, fortified with almond nut, offering a potential solution to malnutrition in children.

Statement of Research Problem

Scientifically, it has been proven that breast milk is the perfect food for the infant during the first six months of life (AAP, 2012; WHO 2012). It contains all the nutrients and immunological factors an infant requires to maintain optimal health and growth. However, at the age of six months and above when the child's birth weight is expected to have doubled, breast milk is no longer sufficient to meet the nutritional needs of the growing infant. Nutritious complementary foods are therefore introduced (also known as weaning foods) which typically covers the period from six to twenty-four months of age. On the other hand, due to the reduced consumption of breast milk, important nutrients such as proteins, zinc, iron and B-vitamins are likely to be deficient in the contemporary diet of most infants. If this development is not well handled during this crucial growth period, it can then lead to under-nutrition. Infant formula is needed to supplement the child's nutritional needs after 6 months of age.

As in most other developing countries, the high cost of fortified nutritious proprietary complementary foods is always, if not prohibitive, beyond the reach of most Nigerian families. Therefore, there is need to look inwards for local raw materials with optimum nutritive value and good processing characteristics, to produce weaning foods of high nutritional quality and such materials include yellow maize, soybean, and almond nuts composite flours among others. Also, Vitamin A deficiency is among the major health problems worldwide that leads to blindness, retarded growth and death, particularly in developing countries.

Objectives of the Study

The aim of this research is therefore to;

- determine the anti-nutrient contents (phytate, protease inhibitors, glycinin, and conglycin) of the composite flours for production of weaning foods.
- determine vitamins (Vitamin A and E) content of the composite flours for production of weaning foods.
- access the in-vitro protein and starch digestibility of the composite flours for production of weaning foods.
- evaluate the lipid and amino-acid profiles of the composite flours for production of weaning foods.
- evaluate the quality of protein in the flour blends for production of weaning foods (Nitrogen Solubility Index (NSI), Urease Index (UI), Protein Dispersivity Index (PDI).

Materials and Methods

Procurement of Weaning Food Materials

The maize (*Zea mays*), soybean (*Glycine max.*) that was used for the study were purchased from Itam market in Uyo; while the almond nuts (*Prunus dulcis*) was purchased at Ikot Ekpene Road Uyo, all in Akwa Ibom State, Nigeria.

Preparation of Flours

Production of Fermented Yellow Maize Flour

The Maize grains was sorted manually (to remove dirt, stones, broken or moldy grains) washed and soaked in potable water at ambient temperature for 4 days for fermentation to take place. During the soaking period, the water was changed daily to avoid unpleasant odour. The fermented maize grains were oven dried at 80°C, until constant weight was achieved. Hammer mill was subsequently used to mill the fermented grains. The flour obtained was sieved using 2 mm mesh sieve and packaged, in an air tight sealed container, labeled and stored in a refrigerator for subsequent use (Jeanne and Therese, 2011).

Production of Soybean Flour

After cleaning and removal of broken seeds and extraneous materials, the soybean seeds were washed and soaked in potable water for 12 hrs to reduce flatulence – causing

oligosaccharides to leached into the water. The seeds were drained and cooked for 30 mins with distilled water twice its volume and then dehulled mechanically. The soybeans were then dried in an oven at a temperature of 65°C for 24 hrs and then milled using attrition mill. The flour obtained was sieved through a sieve of 4.25µm. The flour was packaged in airtight container for further analysis. (Barber *et al.*, 2017).

Production of Almond Nut Flour

Almond nuts were sorted manually to remove dirt and stones. The nuts were blanched for 60 seconds, and drained. The almond skin was dehulled and rinsed with distilled water. After which the blanched almond nuts were cut into thinner pieces and oven dried at 65°C for 6 hrs and then milled using a using hammer mill (Model: De-Demark Super). The flour was packaged in airtight container for further analysis. (ABA, 2008).

Formulation of Flour Blends and Preparation of Gruel

Blends Formulation

Flour blends of fermented yellow maize and soybean (FYMF - SBF) was made at the ratio of 70:30 respectively. Samples for weaning food production were blended at different levels at the ratios of 100:0 = A, 95:5 = B, 90:10 = C, 85:15 = D, 80:20 = E, for fermented yellow maize - soybean composite flour: almond nut respectively. A weighing balance and blender were used for weighing and mixing the flour respectively. The blending ratio is shown below;

Sample Formulation

Samples	A	B	C	D	E
FYMF - SBF	100	95	90	85	80
ANF	0	5	10	15	20

Key: FYMF - SBF = Fermented Yellow Maize - Soybean Composite Flour; ANF = Almond Nut Flour

Source: Field Work (2024)

Preparation of Weaning Food (Gruel) from Composite Flour Blends

Weaning foods (gruel) were produced from the five (5) formulated flour blends. Cold water was added to dissolve each flour blend. Hot water was thereafter introduced into the mixture and placed on the fire. Continuous stirring was done until a uniform gel was obtained.

Method of Analysis

Anti-Nutrients Determination of the Flour Blends

Determination of Phytate

Phytate content was determined using the method described by Oberleas (1973). The sample was first extracted with 0.2 N HCl. One millilitre of the extract was poured into a test-tube filtered with a ground glass stopper containing 1ml of ferric salt solution. The ferric solution was prepared by dissolving 0.2g ammonium iron (III) sulphate in 10ml of 2 N HCl.

The solution was then made up to 100ml with distilled water. The tube was heated in a boiling water bath for 30 min, cool in ice for 15 minutes and then allow to cool at ambient temperature ($27 \pm 2^\circ\text{C}$). The content of the tube was centrifuged for 30 minutes at 3000rpm. After centrifugation, the supernatant (1ml) was mixed with 1.5ml of 2, 2 bi-pyridine solution and the absorbance measured at 519nm against distilled water using Agilent spectrophotometer. Thus, the phytic acid content is calculated as shown below:

$$\% \text{ Phytic acid} = \frac{100 \times V_F \times C}{W \times V_A \times 100} \dots\dots\dots \text{equation 1}$$

Where;

C = Concentration of curve Ms/mole

V_A = Volume of extract used for analysis

V_F = Total volume of extract

W = Weight of sample

Protease Inhibitor Determination

Proteolytic activity was assessed by following the protocol of Coelho *et al.* (2016) in slightly modified form. 1.5 % (w/v) azocasein solution in protease extraction buffer [50 mM Tris-HCl, pH 7.4, containing 10 % (v/v) glycerol and 0.25 % (v/v) Triton X-100]. The enzyme extract solution was prepared at a total protein concentration of 1 mg/ml in extraction buffer. The reaction mixture contained identical amounts of enzyme extract and azocasein solution (125 μl each) and was incubated at 35°C for 6 h. The reaction was stopped by adding 700 μl of 5 % trichloroacetic acid (TCA). Then, the mixture was allowed to stand at room temperature for 10 min and centrifuged at 2000 g for 10 min before the supernatant was collected and supplied with 0.5 N sodium hydroxide in a 1:1 ratio for absorbance measurements at 440 nm. A blank prepared by mixing 5 % TCA with the substrate before adding the enzyme extract was also measured in parallel.

HPLC (High-Performance Liquid Chromatography) Procedure for Determining Glycinin and Conglycinin

Glycinin and Conglycinin of the flour samples was determined by a method as described by AOAC (2020). Mobile Phase: Solvent A: 0.1 % trifluoroacetic acid (TFA) in water. Solvent B: 0.1 % TFA in acetonitrile. Gradient: 0 - 5 min: 100 % A. 5 - 30 min: linear gradient to 60 % B. 30 - 40 min: 60 % B. 40 - 45 min: linear gradient to 100 % A. Procedure: Inject 20 - 50 μL onto the HPLC column of a reverse phase-high pressure liquid chromatography (HPLC) (Buck scientific BLC 10/11 USA) equipped with UV 280nm detector. A Zorbax C18, 4.6 x 250 mm,

5 µm column and a mobile phase as stated above, at a flow rate of 1.0 mL/minute and an operating temperature of 40°C and a run time of 45 minutes. External standards of Glycinin and conglycinin were analyzed in a similar manner and a calibration curve was created. Peak identification was conducted by comparing the retention times of authentic standards and those obtained from the samples, these data were integrated using peak Simple chromatography data system processor; (Buck Sci. Chromatopac data processor). Concentrations of Glycinin and Conglycinin in samples was expressed as mg/g.

Determination of Vitamins Contents of the Flour Blends

Determination of Vitamin A

Vitamin A content was determined by the spectrophotometric method described by (Pearson 1976). One gram (1 g) of the flour samples were poured into a beaker with 10 ml of chloroform solution added to extract the vitamin A using pasture pipette the chloroform layer was taken in another test tube. This was tested with Antimony Trichloride reagent to develop a blue colour. The spectrophotometer was adjusted to read absorbance at 620 nm against chloroform/SbCl₃. The result is calculated as;

$$Vit. A \left(\frac{mg}{g} \right) = \frac{\text{Absorbance of sample} \times \text{Concentration of standard solution} \times D.F}{\text{Absorbance of standard solution} \times \text{Volume of sample}} \dots$$

equation 2

D.F = Diluting factor

Determination of Vitamin E (α-tocopherol).

This was determined using the method described by (Onwuka, 2005). Take a known amount of sample (about 20 g) containing 0.1 to 0.7 of total tocopherols. Dilute quantitatively in a long neck flask with 200 ml of absolute alcohol. Add 3 ml of freshly prepared KOH solution and a pinch of pyrogallol. Heat it in a water bath and reflux for an hour. During this process alcohol should be kept vigorously boiling. The saponified mixture is cooled and is quantitatively transferred to a separating funnel with 50 ml and three times with 50 ml portion of ether. The combined ether extract is first washed with water and is then shaken with freshly prepared KOH solution (about 1.5 g of KOH in 50 ml of 30 % alcohol (KOH)₃).

Digestibility Analysis of the Flour Blends

Determination of *In-vitro* Protein Digestibility (VPD)

In-vitro protein digestibility of each sample was determined using the enzymatic method describe by Kanu *et al.* (2009). Five grams (5 g) of each of the formulated samples was weighed into 5 ml centrifuge tubes and 15 ml of 0.1M HCl containing 1.5 mg pepsin-pancreatin was added. The tubes were incubated at 37°C for 3 hours. The suspension was then be neutralized with a phosphate buffer (pH 8.0) containing 0.005M sodium aside. Exactly 1 ml of toluene was added to prevent microbial growth and the mixture was

repeatedly shaken gently and incubated for 24 hours at 37°C. After incubation, samples were treated with 10 ml of 10 % trichloroacetic acid (TCA) and centrifuged at 5000 rpm for 20 minutes at room temperature. The trichloroacetic acid (TCA) soluble fraction in the supernatant liquid was assayed for nitrogen using the micro-kjedahl method. The percentage of protein digestibility was calculated using the formula; protein digestibility %.

$$\frac{N \text{ in the supernatant} - N \text{ in the blank}}{N \text{ in the sample}} \times 100 \dots\dots\dots \text{equation 3}$$

N = Number

Determination of *In-vitro* Starch Digestibility (IVSD)

In-vitro starch digestibility was determined by the method described by Singh *et al.* (2012). Exactly 50 mg each of the bread bars was weighed into test tubes and mixed with 1ml of 0.2M phosphate buffer (pH 6.9). Pancreatic α-amylase (0.5 ml; 20 mg enzyme dissolved in 50 ml of the same buffer) was added to the sample mixtures and incubated at 37°C for 2 hours. After incubation 2 ml of 3,5-DNS reagent (prepared by dissolving 200 mg crystalline phenol, 1g of 3,5-dinitrosalicylic acid and 50mg sodium sulphate in 1 % NaOH solution) was added immediately. The mixture was heated for 5 - 15 minutes in a boiling water bath. Exactly 1ml of K-Na Tartarate solution was added to the mixture test tubes and allowed to cool at 25°C. The solution was therefore made up to 25 ml with distilled water and filtered prior to reading of the absorbance at 550 nm. A blank was run simultaneously. A standard curve was prepared using maltose and values obtained was expressed as mg Maltose equivalent per 100 mg of sample.

Amino Acids Analysis of the Flour Blends

The amino acid profile of the flour samples was determined using Automatic Amino Acid Analyzer as described by Olugbuyi *et al.* (2021). Initially, the flour sample was dried to a constant weight, defatted, hydrolyzed and evaporated using a rotary evaporator. Subsequently, it was loaded into Applied Biosystems PTH Amino Acid Analyzer. The resulting hydrolyzate was dispensed and analyzed for free acidic, neutral and basic amino acids, which lasted for 76 hours. The concentrations of each amino acid obtained were recorded and printed as chromatogram peaks using a chart recorder (an integrator attached to the Analyzer) for both the standard and the test samples.

Determination of Lipid Profile of the Flour Blends

The fatty acid profile of the flour samples was determined by a method as described by Salimon *et al.* (2017). Before derivatization, the Fatty Acid constituents of the samples were processed by accurately weighing 150 mg aliquots of the homogenised samples into extraction tubes. Lipid extracts were prepared by homogenizing the samples in 20 ml of hexane containing (50 ppm) terbutylated hydroxy toluene (BHT) to avoid oxidation of cis and trans PUFAs. The homogenates were dried with anhydrous sodium sulphate Na₂SO₄ and filtered with sintered glass funnels. After washing the funnels with 5 ml of hexane, the

solvent was removed under vacuum in a rotary evaporator. Finally, the extracted lipids of the samples were dried under nitrogen, weighed carefully and stored frozen until analysis. Preparation of fatty acid methyl esters (FAMEs): After the extraction process, FAMEs were prepared before the Gas Chromatographic (GC) analysis. For this, each of extracted lipids of the samples was transferred to a screw-cap test tube (10 mL) and 1 mL of a solution containing 10 mg 5 mL⁻¹ heptadecanoic acid (internal standard) in methanol was added and followed by 1 mL of 2 M NaOCH₃. The content was placed in a water bath at 60°C for 5 min. Drops of concentrated glacial acetic acid were added to each tube to neutralize NaOH. The samples were reduced to dryness under N₂ and then redissolved in 1 mL of methanol: toluene (2:1 vol.). After that, Trimethylsilyldiazomethane (TMSD) was added in molar excess of 2 M in n-hexane (100 µl) at 50°C for 10 min without capping the tubes. Drops of glacial acetic acid were added until the yellow colour disappeared to remove unreacted TMSDM and the reaction mixture was diluted with 1 ml of 0.5 % NaCl solution. To extract the FAME, 1 mL of n-hexane containing 50 ppm BHT was added and the tubes were vortexed for about 30 s.

After the solution settled, the organic layers, containing the methyl esters, were transferred to a vial for GC. Gas chromatographic analysis: One microlitre (1 µl) volume of each sample was injected into GC (Shimadzu, GC- 17A, Kyoto, Japan) equipped with FID for separation and quantification of the FAMEs. The analysis was carried out using a BPX70 fused silica capillary column (30 M, 0.25 mm i.d., 0.21 µm film thickness, Melbourne, Australia). The run was under an optimized temperature programmed as follows: initial column temperature 100°C, programmed to increase at a rate of 10°C min⁻¹ up to 160°C and then at 3°C min⁻¹ up to 220°C. This temperature was maintained for 5 min, then at 10°C min⁻¹ up to final temperature of 260°C and held for 5 min. Injector and detector temperatures were at 260 and 280 °C, respectively. Helium was used as the carrier gas at a flow rate of 1 mL min⁻¹ with a split ratio of 30:1. FAMEs were identified by comparing their relative and absolute retention times to those of authentic standards. The fatty acid composition was reported as a relative percentage of the total peak area.

Protein Quality Determination of the Flour Blends

Nitrogen Solubility Index (NSI)

Nitrogen solubility index (NSI) was determined according to the method of Karki *et al.* (2009). 20 mL distilled water was mixed with 0.5 g sample. Extraction was done in a stirrer at 350 rpm for 2 hrs and centrifuged at 275 g (1500 rpm) for 10 min. Supernatant was collected and analysed for nitrogen content using micro-Kjeldahl apparatus. NSI was calculated using the following formula

$$\text{NSI \%} = \frac{\% \text{water soluble nitrogen}}{\% \text{total nitrogen}} \times 100 \quad \text{..... equation 4}$$

Urease Index

Urease index was determined by the AACC method 22 – 90 (AACC, 1995). It measures the change in pH resulting from the action of urease converting urea to ammonia. The pH difference value was measured by the CG 837 pH meter (Schott, Germany). Urease activity was expressed as pH difference. The urease level was used to evaluate under processing conditions and, consequently, the presence of toxic factors such as trypsin inhibitors.

Protein Dispersibility Index (PDI)

Protein dispersibility index (PDI) of the flour samples was determined by a method as described by AOAC, (2020). The samples were milled and passed through a 1-mm sieve. The fine powder twenty grams (20 g) was dispersed in 300 mL of distilled water. The dispersion was whipped at 10,000 rpm for 10 min using a high-speed disperser (Brails tools BJ35i, UK). After the suspension was allowed to settle for 10 min, 40 mL of the supernatant was transferred into a 50 mL centrifuge tube and centrifuged at 1300 $\times g$ for 10 min. The protein content of the supernatant was detected using the Kjeldahl method. The PDI was expressed as the percentage of soluble protein compared to the total protein content of the sample.

Statistical Analysis

The data collected were subjected to statistical analysis using analysis of variance (ANOVA) to determine whether there was any significant difference ($p < 0.05$). The means was then separated with the use of New Duncan's Multiple Range Test (DMRT) using the Statistical Package for the Social Sciences (SPSS) version 20.0 software.

Results

Table 1: Anti-nutrient Content of Fermented Yellow Maize-Soybean Flours, Fortified with Almond Nut for Preparation of Weaning Foods.

Sample	Phytates	Protease	Glycinin	Conglycinin
A	14.00 ^a ±0.04	6.18 ^a ±0.02	606.69 ^a ±0.01	194.52 ^a ±0.01
B	8.31 ^b ±0.02	5.33 ^b ±0.00	590.66 ^b ±0.14	192.31 ^b ±0.00
C	8.00 ^b ±0.98	5.28 ^b ±0.01	584.15 ^c ±0.00	173.55 ^c ±0.09
D	8.00 ^b ±0.00	5.22 ^b ±0.30	561.32 ^d ±0.01	169.21 ^c ±0.01
E	6.42 ^c ±0.21	4.36 ^c ±0.21	557.49 ^d ±0.41	163.43 ^d ±0.14

Values are means $\pm$ standard deviation of triplicate samples. Mean values in the same column with different superscript (a - d) are significantly ($p < 0.05$) different.

Blending ratio: A = 100:0 (Control); B = 95:05; C = 90:10; D = 85:15; E = 80:20 of fermented yellow maize - soybean composite and almond nut flour blends.

Source: Field Work (2024)

Table 2: Vitamin Contents (mg/100g) of Fermented Yellow Maize-Soybean Flours, Fortified with Almond Nut for Preparation of Weaning Foods.

Sample	Vitamin A	Vitamin E
A	67.29 ^c ± 0.01	0.14 ^c ± 0.00
B	72.65 ^b ± 0.00	0.19 ^c ± 0.00
C	75.64 ^b ± 0.01	1.53 ^b ± 0.01
D	80.84 ^a ± 0.00	1.95 ^b ± 0.00
E	82.44 ^a ± 0.00	2.81 ^a ± 0.02

Values are means ± standard deviation of triplicate samples. Mean values in the same column with different superscript (a - e) are significantly (p < 0.05) different.

Blending ratio: A = 100:0 (Control); B = 95:05; C = 90:10; D = 85:15; E = 80:20 of fermented yellow maize - soybean composite and almond nut flour blends.

Source: Field Work (2024)

Table 3: *In-vitro* Starch and Protein Digestibility of Fermented Yellow Maize-Soybean Flours, Fortified with Almond Nut for Preparation of Weaning Foods.

Samples	<i>In-vitro</i> starch digestibility (%)	<i>In-vitro</i> protein digestibility (%) at 1 hr	<i>In-vitro</i> protein (%) digestibility (%) at 6 hr
A	76.83 ^a ± 0.01	64.67 ^e ± 0.01	66.05 ^e ± 0.01
B	74.65 ^b ± 0.03	70.54 ^d ± 0.01	72.95 ^d ± 0.01
C	72.38 ^c ± 0.02	73.16 ^c ± 0.01	76.22 ^c ± 0.01
D	72.05 ^d ± 0.00	75.43 ^b ± 0.01	78.45 ^b ± 0.01
E	70.26 ^e ± 0.02	76.94 ^a ± 0.01	81.13 ^a ± 0.01

Values are means ± standard deviation of triplicate samples. Mean values in the same column with different superscript (a - e) are significantly (p < 0.05) different.

Blending ratio: A = 100:0 (Control); B = 95:05; C = 90:10; D = 85:15; E = 80:20 of fermented yellow maize - soybean composite and almond nut flour blends.

Source: Field Work (2024)

Table 4: Lipid profiles (%) of Fermented Yellow Maize-Soybean Flours, Fortified with Almond Nut for Preparation of Weaning Foods.

Samples	A	B	C	D	E
Total lipids	5.16 ^c ±0.74	5.36 ^c ±0.02	5.96 ^{ab} ±0.02	6.67 ^b ±0.02	7.29 ^a ±0.57
Wax esters	6.07 ^c ±4.92	7.69 ^c ±4.30	10.31 ^b ±0.00	11.93 ^a ±0.01	12.34 ^a ±0.16
triglycerides	27.49 ^d ±0.01	28.83 ^c ±0.01	31.23 ^b ±0.02	31.59 ^b ±0.35	34.32 ^a ±0.02
diglycerides	6.69 ^b ±0.00	6.86 ^b ±0.03	8.47 ^a ±0.14	8.69 ^a ±0.41	9.02 ^a ±0.02
monoglycerides	0.82 ^c ±0.02	1.16 ^b ±0.02	1.26 ^b ±0.01	1.35 ^{ab} ±0.16	1.52 ^a ±0.02
Free sterols	8.90 ^e ±0.02	10.75 ^d ±0.02	12.74 ^c ±0.01	13.96 ^b ±0.01	14.43 ^a ±0.10
Sterol esters	0.77 ^c ±0.02	0.86 ^{bc} ±0.11	0.87 ^{bc} ±0.02	0.91 ^b ±0.03	1.32 ^a ±0.03
Glycolipid	2.02 ^b ±0.02	2.98 ^{ab} ±0.01	3.14 ^{ab} ±0.01	3.83 ^{ab} ±0.01	4.45 ^a ±0.00
phospholipids	6.67 ^d ±0.01	6.84 ^d ±0.03	7.73 ^c ±0.15	8.18 ^b ±0.25	8.62 ^a ±0.03
phosphatidyl-choline	5.22 ^b ±0.01	5.51 ^{ab} ±0.01	5.70 ^{ab} ±0.71	6.07 ^{ab} ±0.02	6.22 ^a ±0.01
Phosphatidyl-ethanolamines	2.40 ^d ±0.01	3.04 ^c ±0.01	3.29 ^b ±0.01	3.33 ^b ±0.03	4.98 ^a ±2.96
TSFA	62.54±5.74	68.24±4.44	77.09±1.07	81.64±1.26	88.76±3.79
TUFA	9.67±0.04	11.61±0.13	13.61±0.03	14.87±0.04	15.32±0.13

Values are means ± standard deviation of triplicate samples. Mean values in the same column with different superscript (a - e) are significantly (p < 0.05) different.

Blending ratio: A = 100:0 (Control); B = 95:05; C = 90:10; D = 85:15; E = 80:20 of fermented yellow maize - soybean composite and almond nut flour blends. TSFA = Total Saturated Fatty Acid; TUFA = Total Unsaturated Fatty Acid.

Source: Field Work (2024)

Table 5: Amino Acid Profiles (mg/100g) of Fermented Yellow Maize-Soybean Flours, Fortified with Almond Nut for Preparation of Weaning Foods.

Samples	A	B	C	D	E
Essential Amino Acid					
tryptophan	4.17 ^c ±0.14	4.83 ^b ±0.14	5.16 ^b ±0.14	5.31 ^b ±0.44	5.83 ^a ±0.00
histidine	2.17 ^d ±0.09	2.62 ^c ±0.01	2.65 ^{bc} ±0.04	2.76 ^b ±0.01	3.23 ^a ±0.01
leucine	4.41 ^c ±0.01	4.55 ^c ±0.33	4.65 ^c ±0.00	5.13 ^b ±0.01	5.83 ^a ±0.01
isoleucine	3.97 ^c ±0.01	4.04 ^{bc} ±0.01	4.13 ^b ±0.01	4.78 ^a ±0.01	4.83 ^a ±0.00
phenylalanine	7.92 ^b ±0.91	8.13 ^b ±0.01	8.93 ^{ab} ±0.00	9.32 ^a ±0.01	9.41 ^a ±0.01
valine	4.34 ^e ±0.01	4.82 ^d ±0.12	5.37 ^c ±0.01	5.60 ^b ±0.00	5.81 ^a ±0.01
lysine	4.94 ^d ±0.01	5.17 ^c ±0.01	5.52 ^b ±0.01	5.82 ^a ±0.00	5.83 ^a ±0.00
methionine	0.89 ^d ±0.01	1.11 ^c ±0.01	1.23 ^b ±0.01	1.26 ^b ±0.01	1.70 ^a ±0.03
Threonine	3.85 ^e ±0.00	4.04 ^d ±0.01	4.21 ^c ±0.01	4.45 ^b ±0.01	4.54 ^a ±0.27
TEAA	36.66±1.19	39.31±0.65	41.85±0.23	44.43±0.50	47.01±0.34

Non-Essential Amino Acid

asparagine	4.96 ^d ±0.01	5.77 ^c ±0.49	6.32 ^{bc} ±0.01	6.84 ^{ab} ±0.01	7.13 ^a ±0.01
arginine	3.78 ^c ±0.01	3.92 ^c ±0.90	5.45 ^b ±0.00	7.28 ^a ±0.00	8.15 ^a ±0.00
alanine	2.45 ^c ±0.05	2.95 ^c ±0.02	3.46 ^b ±0.00	3.77 ^b ±0.01	3.96 ^a ±0.00
aspartate	5.65 ^e ±0.00	6.27 ^d ±0.37	6.82 ^c ±0.01	7.37 ^b ±0.01	8.13 ^a ±0.01
glutamate	3.71 ^e ±0.01	4.15 ^d ±0.00	5.60 ^c ±0.12	6.54 ^b ±0.00	7.56 ^a ±0.00
glycine	7.11 ^b ±0.01	7.19 ^b ±0.02	7.37 ^b ±0.00	8.35 ^a ±0.00	8.47 ^a ±0.48
tyrosine	6.47 ^d ±0.00	8.32 ^c ±0.58	9.11 ^b ±0.14	9.39 ^b ±0.01	10.46 ^a ±0.01
cysteine	0.12 ^b ±0.11	0.14 ^b ±0.15	0.26 ^{ab} ±0.01	0.29 ^{ab} ±0.01	0.42 ^a ±0.01
proline	2.27 ^d ±0.00	3.29 ^c ±0.39	4.28 ^b ±0.01	4.35 ^b ±0.01	5.55 ^a ±0.00
serine	4.24 ^c ±0.03	5.43 ^b ±0.52	6.77 ^a ±0.02	6.82 ^a ±0.03	7.17 ^a ±0.02
TNEAA	40.76±0.23	47.43±3.44	55.44±0.32	61.00±0.09	67.00±0.54
TAA	77.42±1.42	86.74±4.09	97.29±0.55	105.43±0.59	114.01±0.88
TSAA	1.01±0.12	1.25±0.16	1.49±0.02	1.55±0.02	2.12±0.04
TAAA	20.73±1.14	23.90±0.74	23.21±0.32	26.78±0.47	28.93±0.03

Values are means ± standard deviation of triplicate samples. Mean values in the same column with different superscript (a - e) are significantly (p < 0.05) different.

Blending ratio: A = 100:0 (Control); B = 95:05; C = 90:10; D = 85:15; E = 80:20 of fermented yellow maize - soybean composite and almond nut flour blends. TEAAs = Total Essential Amino Acids; TNEAAs = Total Non-Essential Amino Acids; TAA = Total Amino Acid; Total Sulphur Amino Acid (methionine and cysteine); Total Aromatic Amino Acid (histidine, phenylalanine, tryptophan and tyrosine).

Source: Field Work (2024)

Table 6: Protein Quality Parameters of Fermented Yellow Maize-Soybean Flours, Fortified with Almond Nut for Production of Weaning Foods.

Sample Index (%)	Nitrogen solubility (mg/dL)	Urease index index (%)	Protein dispersity
A	36.17 ^d ± 26.64	0.03 ^a ± 0.35	45.89 ^c ± 0.01
B	45.17 ^c ± 0.00	0.03 ^a ± 0.00	52.49 ^c ± 0.01]
C	49.15 ^c ± 0.04	0.02 ^a ± 0.19	64.29 ^{bc} ± 0.00
D	57.19 ^b ± 8.23	0.02 ^a ± 0.00	73.38 ^{ab} ± 0.00
E	68.77 ^a ± 31.73	0.01 ^a ± 0.16	80.20 ^a ± 0.21

Values are means ± standard deviation of triplicate samples. Mean values in the same column with different superscript (a - d) are significantly (p < 0.05) different.

Blending ratio: A = 100:0 (Control); B = 95:05; C = 90:10; D = 85:15; E = 80:20 of fermented yellow maize - soybean composite and almond nut flour blends.

Source: Field Work (2024)

Discussion

Anti-nutrients Content

The anti-nutrients content of fermented yellow maize and soybean composite flours, fortified with almond nut flour for preparation of weaning foods are presented in Table 1; showed that phytate ranged from 6.42 g/Kg in sample E to 14.00 g/Kg in sample A, the phytate level observed were lower than the safe levels of 25 g/kg Obizoba and Atti, (2001) and could ensure the availability of divalent cations (calcium, zinc, and iron) in the product so that no adverse physiological effects are produced when the products is consumed.

Protease inhibitors are protein-based substances widely distributed within the plant kingdom, including the seeds of most cultivated legumes, which can inhibit the activity of proteolytic enzymes within the gastro-intestinal tract (Abhishek *et al.*, 2019). They are involved in digesting long protein chains into short fragments, splitting the peptide bonds that link amino acid residues which some of them can detach the terminal amino acids from the protein chain (Sapkale *et al.*, 2013). Protease inhibitor ranged from 4.36 gJ/Kg in sample E, to 6.18 g/Kg in sample A, highest protease content was observed with the incorporation of fermented yellow maize flour and soybean without the fortificant (almond nut flour).

Glycinin ranged from 557.49 g/Kg in sample E, to 606.69 g/Kg in sample A and conglycin ranged from 163.43 g/Kg in sample E, to 194.52 g/Kg in sample A. Significant ($p < 0.05$) difference, was observed among the samples, the control having the highest values.

Vitamin Contents

Results of Vitamin A and E contents of fermented yellow maize and soybean composite flours, fortified with almond nut flour for preparation of weaning foods are shown in Table 2. Vitamin A content showed significant ($p < 0.05$) difference from the control, it ranged from 67.29 mg/100g in sample A to 82.44 mg/100g in sample E. This is because of the addition of yellow maize flour in the composite flour, which is rich in Beta-carotene (provitamin A) (Shah *et al.*, (2016) and can be converted into retinol or vitamin A by the body (Graham, 2000). Vitamin A designates a group of compounds essential for vision, growth in children, cellular differentiation and proliferation, reproduction, and the integrity of the immune system (Olson, 1984). This vitamin is essentially important in the prevention of night blindness and certain atherosclerosis conditions (Wardlaw, 2004). According to Ortenzi and Beal (2021), breast milk provides largely vitamin A requirements, with only 20 % needed from complementary foods. Therefore, if these products are promoted, it could reduce vitamin A deficiency among infants in low-income countries such as Nigeria where yellow maize, soybean and almond nut are available or could be cultivated.

Vitamin E ranged from 0.14 mg/100g in sample A, to 2.81 mg/100g in sample E. The increase in vitamin E content is due to the addition of almond flour, which is a rich source of vitamin E (Aslantas, 2001).. Sample E has the highest value and was significantly ($p < 0.05$) different from all the samples. Vitamin E is also a powerful antioxidant that helps eliminate free radicals in the body, thereby reducing the risk of chronic diseases in children (Blomhoff *et al.*, 2006).

***In-vitro* Starch and Protein Digestibility**

In-vitro Starch and Protein Digestibility of fermented yellow maize and soybean composite flours, fortified with almond nut flour for preparation of weaning foods are presented in Table 3. *In-vitro* starch ranged from 70.26 % in sample E to 76.83 % in sample A, this is due to the high percentage of fermented yellow maize in the composite flour blends for production of weaning foods, which is a rich source carbohydrates (Bello and Oluwalana 2017).

In-vitro protein at 1hr ranged from 64.67 % in sample A to 76.94 % and *In-vitro* protein at 6 hrs ranged from 66.05 % in sample A to 81.13 %. Significant ($p < 0.05$) difference was observed among the samples, the fortified samples had values higher than the control in both 1hr and 6 hrs of the *in-vitro* protein analysis that was conducted on the composite flours. This is because of the addition of soybean and almond nut flours in the weaning food which are highly rich in protein (Heuze *et al.*, 2017). The protein digestibility is high about 89 - 96 % in weaning foods formulated through rice and beans, reported by (Erbersdobler *et al.*, 2017). Digestion is a highly complex process providing animals with the energy and nutrients required for their maintenance and growth. For this reason, many researchers have been interested in the total or partial modeling of the digestion process using a variety of different *in-vitro* methodologies. The *in-vitro* approaches have been used by nutritionists, who have tried to reproduce the physiological condition of the digestive tract, with a variable degree of accuracy, the compartments and working conditions existing in the digestive tract of the target species to have an insight on how feeds or food are processed or digested (Moyano *et al.*, 2015).

Lipid Profile

Lipid profile of fermented yellow maize and soybean composite flours, fortified with almond nut flour for preparation of weaning foods are presented in Table 4; showed that total lipid ranged from 5.16 % in sample A to 7.29 % in sample E, significant ($p < 0.05$) difference, was observed among the samples. Wax esters ranged from 6.07 % sample A, to 12.34 % in sample E. Monoglycerides ranged from 0.82 % in sample A, to 1.52 % in sample E. Significant ($p < 0.05$) difference, was observed among the samples, with sample E having the highest value. Sterol esters ranged from 0.77 % in sample A, to 1.32 % in sample E. Glycolipid showed significant ($p < 0.05$) difference from the control, it ranged from 2.02 % in sample A to 4.45 % in sample E. Phospholipids ranged from 6.67 % in sample A, to 8.62 % in sample E. Phosphatidycholine ranged from 5.22 % in sample A, to 6.22 % in sample E. Phosphatidyethanolamine ranged from 2.40 % in sample A, to 4.98 % in sample E. In this study, the predominant fatty acids in weaning food composite flour samples were found to be triglycerides (27.49 – 34.32 %) and free sterols (8.90 – 14.43 %) fatty acids, followed by wax esters (6.07 – 12.34 %) and diglyceride (6.69 – 9.02 %) fatty acids. The total saturated fatty acid content ranged from (62.54 – 88.76 %), when compared with a work done by Akajiaku *et al.* (2024) the saturated fatty acid here are greater. While the total unsaturated

fatty acid content of the flour samples ranged between (9.96 – 15.32 %). This suggests that fermented yellow maize – soybean composite: almond-nut flour blends are more abundant in saturated fatty acids than unsaturated. Significant ($p < 0.05$) difference, was observed among the samples, with sample D and E having the highest values. The normal range of lipid profile for adults has been established but no standard values are available for infants and children (American Academy of Pediatrics Work Group on Breastfeeding, 1992). Higher lipid values, in early infancy, maybe physiological and useful for cognitive development and programming for lipid metabolism in later life (Agostoni *et al.*, 2000). It can be noticed in the study, that increase in almond flour leads to increase on the lipid profile because it is rich in fatty acid (ABA, 2008). Reiser and Seildman (1972), proposed an interesting hypothesis, based on studies in rats, that newborns exposed to high levels of dietary cholesterol 'would be able to cope better with dietary cholesterol in later life'.

Amino Acid profile

Amino acid profile of fermented yellow maize and soybean composite flours, fortified with almond nut flour for preparation of weaning foods are presented in Table 5. In the essential amino acid category, phenylalanine was the prevalent protein present, it ranged from 7.92 mg/100g in sample A, to 9.41 mg/100g in sample E. Significant ($p < 0.05$) difference, was observed among the samples, with sample E having the highest value. Methionine was reported to have the lowest content value of the essential amino acids, it ranged from 0.89 mg/100g in sample A to 1.70 mg/100g in sample E, this result agrees with what was reported by (Wanda *et al.*, 2021). Methionine is generally a limiting amino acid in legumes as well as vegetables; also, tryptophan and cysteine (Tiwari and Singh, 2012). Tyrosine (6.47 - 9.41 mg/100g) had the highest non-essential amino acid contents while cytosine (0.12 - 0.42 mg/100g) had the lowest content of non-essential amino acid in the weaning food composite flour produced. Glutamic acid (3.71 - 7.56 mg/100g) one of the non-essential acids performs numerous functions in the human body including strengthening the immune system, regulating body weight, improving long and short term memory, regulating the acid-base balance and making the skin firm, etc (Akinjayeju *et al.*, 2019); hence, its abundance in this present study is beneficial to human diet. The total essential amino acids of the flour samples ranged between 36.66 to 47.01 mg/100g of protein and are lower than the total non-essential amino acids of the flour samples, which ranged between 40.76 mg/100g of protein and 67.00 mg/100g of protein. This suggests that flour blends are more abundant in non-essential amino acids. This report is in agreement with the findings of Okoronkwo *et al.* (2020). Although most values obtained in this study were high compared to FAO/WHO, (1991) daily requirement value, it is still suggested that flour blends should be supplemented with especially, essential amino acid rich food source. This may be due to the production processes or its poor bio-availability in the composite flours, but when compared with the control (sample A), the fortified samples had values greater than the control. The weaning food will be prepared by the addition of milk or other nutritious solutions which will increase the chemical score. The result when compared with a work

done by Wanda *et al.* (2021) has values of essential, non-essential amino acids and total amino acid higher than what was reported. The results are similar to that reported by (Akajiaku *et al.*, 2024). These values were higher than the range 3.02 - 4.68 (Asma *et al.*, 2006) reported for some locally made weaning foods.

Protein Quality Parameters

Protein quality parameters of fermented yellow maize and soybean composite flours, fortified with almond nut flour for preparation of weaning foods are presented in Table 6. Nitrogen solubility index (NSI) sample the fortified samples showed significant ($p < 0.05$) difference from the control (sample A), it ranged from 36.17 % in sample A to 68.77 % in sample E but sample B and C is not significantly ($p < 0.05$) different from each other. Urease index (UI), the fortified samples showed no significant ($p < 0.05$) difference from the unfortified samples, though the control had value higher than the formulated samples. It ranged from 0.01 in sample E to 0.03 in sample A. The recommended maximum level of urease is controversial, with acceptable values varying from 0.2 or less McNaughton *et al.* (1981) to 0.5 units of pH change (Waldroup *et al.*, 1985). Urease index falls within the recommended range. Protein dispersity index (PDI) ranged from 45.897 % in sample A to 80.20 % in sample E, the formulated samples had values higher than the control. Sample A and B showed no significant ($p < 0.05$) difference, same with sample C and D. It can be observed from the study that protein dispersity index, increases with increasing level of almond nut across the samples.

Conclusion

Yellow maize and soybean are vital crops for food security, providing a reliable source of nutrition during times of crop failure. The inclusion of almond nut in the formulation of weaning foods is advantageous due to its high energy content, derived from its rich protein, fat, and carbohydrate composition, as well as its abundance of essential minerals and vitamins. Almond nuts are gluten-free, cholesterol-free, and low in sodium, making them an ideal ingredient for infant nutrition. Incorporating these locally grown crops into weaning food production can help reduce post-harvest losses, promote the use of indigenous agricultural products, enhance national agricultural productivity, and contribute to the optimization of local resources for the development of nutritious weaning foods.

Recommendations

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

- Further study should be carried out to determine the packaging, storage, shelf life and microbiological analysis of the composite flour blends for production of weaning foods.
- A public awareness campaign should be conducted to highlight the benefits of β -carotene-rich varieties of yellow maize. Given its crucial role in combating food

insecurity, malnutrition, and vitamin A deficiency (VAD), increasing awareness will help promote its use and support national food security initiatives.

References

- AACC (American Association of Cereal Chemists) (1995). Approved Methods of the AACC (9th ed., Vol. 2). Method 20-05. St. Paul, MN: AACC International.
- AAP (American Academy of Pediatrics) (2012). Breastfeeding and the use of human milk. *Pediatrics*, 129(3):827–841. <https://doi.org/10.1542/peds.2011-3552>
- ABA (Almond board of Australia) (2008). Australian almond industry. Retrieved May 10, 2024 from <https://www.australionalmonds.com.au>
- Abbey B. W. and Nkanga U. E. (1988). Production of High Quality Weaning Product Maize-cowpea-crayfish mixtures. *Nutrition Report International* 37(5):951-957.
- Abhishek, T., Vishal, S. and Aayushee, T. (2019). An overview of anti-nutritional factors in food. *International Journal of Chemical Studies*, 7(1): 2472-2479.
- Agostoni, C., Riva, E., Scaglioni, S., Marangoni, F., Radaelli, G. and Giovannini, M. (2000). Dietary fats and cholesterol in Italian infants and children. *American Journal of Clinical and Nutrition* 72: 1384-1391.
- Akajiaku, L. O., Nwabueze, T. U. and Onwuka, G. I. (2024). Amino and fatty acid profiles of mechanically dehulled toasted African breadfruit (*Treculia africana*) seed flour as affected by pretoasting treatments. *Research Journal of Food and Nutrition*. ISSN 2637-5583.
- Akinjayeju, O., Fagbemi, T. N., Ijarotimi, O. S. and Awolu, O. O. (2019). Optimization and evaluation of some physicochemical and nutritional properties of cereal-based soya-fortified flours for dough meal. *Journal of Advances in Food Science and Technology*, 6(1): 40–59.
- Amira, A. R., Emma, E. J., Diane J. C., Ryan, C., Anne C. L., Andrea, S. A. and Williams H. D. (2018). Food Consumption Patterns of Infants and Toddlers: Findings from the Feeding of Infants and Toddlers Study (FITS) 2016. *Journal of Nutrition*. 148 (3):1525S-1535S.
- AOAC (Association of Official Analytical Chemists) (2020). Official methods of analysis (20th ed., pp. 57–66). Washington, D.C.
- Arikpo, D., Edet, E. S., Chibuzor, M. T., Odey, F. and Caldwell, D. M. (2018). Educational interventions for improving primary caregiver complementary feeding practices for children aged 24 months and under. *Cochrane Database System Review* 5 : p. CD011768.
- Asma, M. A., Babiker, E. and Tinay, A. H. (2006). Development of weaning food from sorghum supplemented with legumes and oil seeds, *Food and Nutrition Bulletin*. 27(1):26-34.
- Aslantas, R., Guleryuz, M. and Turan M. (2001). Some Chemical Contents of Selected Almond (*Prunus Amygdalus Batsch*) Types. *XI GREMPA Seminar on Pistachios and Almonds*. Zaragoza: CIHEAM, p. 347-350.
- Badamosi, E. and VJ, T. (1995). Nutritional Evaluation of a locally formulated weaning food, JUTH-PAP. *West Afr. J. Biol. Sci.* (3), 85-93.
- Barber L. Obinna-Echem P. and Ogburia E., (2017). Proximate composition micronutrient and sensory properties of complementary food formulated from fermented maize, soybean and carrot flour. *Sky Journal of Food Science*, 6 (3): 033-039.
- Bartick M., Jegier B., Green B., Schwarz E., Reinhold A. and Syuebe A. (2017). Disparities in Breastfeeding impact on Maternal and Child Health Outcomes and Costs. *Journal of Pediatrics*.181:49-55.
- Bello, F. A. and Oluwalana, I. B. (2017). Impact of modified atmosphere packaging on nutritive values and sensory qualities of fresh maize (*Zea mays* L.) under tropical ambient storage condition. *International Journal of Nutrition and Food Sciences*, 6 (1): 19-24.
- Blomhoff, R., Carlsen, M. H., Andersen, L. F. and Jacobs, D. R. Jr. (2006). Health benefits of nuts: potential role of antioxidants. *British Journal of Nutrition* 96: 52-60.

- Brown, K. and Dewey, K. (1998). Complementary feeding of young children in developing countries: A review of current scientific knowledge. WHO/UNICEF.
- Coêlho, D. F., Saturnino, T. P., Fernandes, F. F., Mazzola, P. G., Silveira, E. and Tambourgi, E. B. (2016). Azocasein substrate for determination of Proteolytic activity: reexamining a traditional method using Bromelain samples. *BioMed Research International*, 1–6.
- Erbersdobler, H., Barth, C. and Jah-reis, G. (2017). Legumes in human nutrition: nutrient content and protein quality of pulses. *ErnährungsUmschau*, 64 (9): 134-139.
- FAO/WHO. (1991). Dietary protein quality evaluation in human nutrition: Report of a Joint FAO/WHO Expert Consultation. FAO Food and Nutrition Paper No. 51. Rome: Food and Agriculture Organization of the United Nations.
- Fewtrell, M., Lucas, A. and Morgan, J. B. (2003). Factors associated with weaning in full-term and pre-term infants. *Archives of Disease in Childhood – Fetal and Neonatal Edition*, 88(4), F296–F301. <https://doi.org/10.1136/fn.88.4.F296>
- Graham, R. D. and Rosser, J. M. (2000). Carotenoids in staple foods: their potential to improve human nutrition. *Food Nutrition Bulletin*; 21:404–409.
- Harris, G. (2000). Developmental, Regulatory and Cognitive Aspects of Feeding Disorders. In: Southall, A. and Schwartz, A., Eds., *Feeding Problems in Children*, Radcliffe Medical Press, Oxford, UK. pp. 45–67.
- Heuzé V., Tran, G., Edouard, N. and Lebas, F. (2017). Maize green forage. Feedipedia, a programme by INRA, CIRAD, AFZ and FAO. Retrieved April 14, 2024, from <https://www.feedipedia.org/node/358>
- Jeanne, E. and Therese, D. (2011). Contribution to the improvement of a porridge made with fermented maize: effect of selected foods and lemon on energy density, pH, viscosity and nutritional quality. *International Journal of Food Science and Nutrition*. 484-497.
- Kanu, J. K., Sandy, E. H. and Kandeh, B. A. J. (2009). Production and evaluation of breakfast cereal-based porridge mixed with sesame and pigeon peas for adults. *Pakistan Journal of Nutrition*, 8(9):1335-1343.
- Karki, B., Lamsal, B. P., Grewell, D., Pometto, A. L., Van Leeu-wen, J., Khanal, K. L. and Jung, S. (2009). Functional properties of soy protein isolates produced from ultrasonicated defatted soy flakes. *Journal Am.Oil Chem. Soc.* 86(10): 1021–1028.
- McNaughton, J. M., Reece F. N. and Deaton, J. W. (1981). Relationships between color, trypsin inhibitor contents, urease index of soybean meal and effects on broiler performance. *Poultry Science* 60:393–400.
- Moyano, F. J., Saenz de Rodriganez, M. A., Díaz, M. and Tacon, A. G. (2015). Application of in vitro digestibility methods in aquaculture: constraints and perspectives. *Reviews in Aquaculture*, 7(4): 223-242.
- Nnam, N. (2002). Evaluation of Complementary Foods Based on Maize, Groundnut, Pawpaw and Mango Flour Blends, 22(23), 8 – 18.
- Oberleas, D. (1973). Phytates. In: *Toxicants Occurring Naturally in Foods*(2nd Ed). National Academy of Sciences, Washington D. C., pp 363-371.
- Obizoba, I. C. and Atii, J. V. (2001). Effect of Soaking, Sprouting, Fermentation and Cooking on Nutrient Composition and Some Anti-Nutritional Factors of Sorghum (*Guinea*) Seeds. *Plant Foods Human Nutr.*41:203-212.
- Okoronkwo, K. A., Nwagbaoso, O. C. and Okoronkwo B. C. (2020). Chemical and Amino Acid Composition of African Breadfruit (*Treculia africana*). *INOSR Applied Sciences*, 6(1): 1-10.
- Olson, R. E. (1984). The Function and Metabolism of Vitamin K. *Annual Review of Nutrition.*, 4:281-337.

- Onwuka G. I. (2005). Food analysis and instrumentation: Theory and practice, Lagos, Nigeria: Naphtali Prints Nigeria, pp 1-19.
- Ortenzi, F. and Beal, T. (2021). Priority micronutrient density of foods for complementary feeding of young children (6–23 months) in South and Southeast Asia. *Frontiers in Nutrition*, 8, Article 785227. <https://doi.org/10.3389/fnut.2021.785227>
- Owais, A., Schwartz, B., Kleinbaum, D. G., Suchdev, P. S., Faruque, A. S., Das, S. K., Rahman, S. and Stein, A. D. (2017). A Nutrition Education Program in Rural Bangladesh Was Associated with Improved Feeding Practices but Not with Child Growth. *Journal of Nutrition* 147(5):948-954.
- Pearson, D. (1976). Chemical analysis of foods (7th ed., pp. 45–102). *Edinburgh*: Churchill Livingstone.
- Pelto, G. H., Levitt, E. and Thairu, L. (2003). Improving Feeding Practices: Current Patterns, Common Constraints, and the Design of Interventions. *Food Nutrition Bulletin*, 24: 24-82.
- Reiser, R. and Seildman, Z. (1972). Control of serum cholesterol home-ostasis by cholesterol in the milk of suckling rat. *Journal of Nutrition*. 102: 1009–1016.
- Salimon, J., Omar, T. A. and Salih, N. (2017). An accurate and reliable method for identification and quantification of fatty acids and trans fatty acids in food fats samples using gas chromatography. *Arabian Journal of Chemistry*, 10(2): 1875-1882.
- Sapkale, P. V., Jadhav, S. B. and Sable, P. N. (2013). Protease inhibitors: A review. *Indian Drugs*, 50 (2): 1-59.
- Shah, T. R., Prasad, K. and Kumar, P. (2016). Maize-A potential source of human nutrition and health: A review. *Cogent Food and Agriculture*, 2: 1 - 9.
- Singh, S., Kushwaha, B. P., Nag, S. K., Mishra, A. K., Singh, A. and Anele, U. Y. (2012). *In vitro* ruminal fermentation, protein and carbohydrate fractionation, methane production and prediction of twelve commonly used Indian green forages. *Animal Feed Science Technology*, 178:1-2.
- Tiwari, B. K. and Singh, N. (2012) Pulse Chemistry 26. and Technology. Royal Society of Chemistry (RSC) Publishing, Cambridge, UK. pp.73 - 82.
- Waldroup, P. W., Ramsey, B. E. and Helwing, H. M. (1985). Optimum processing for soybean meal used in broiler diets. *Poultry Sci.* 64:2314–2320.
- Wanda, K., Malgorzata, K. and Marzena, P. (2021). Quality of soybean products in terms of essential amino acids composition. *Journal molecules*, 26(16): 5071–5090.
- Wardlaw, G. M. (2004). Perspectives in Nutrition. (6th Ed.). Mcgram Hill Companies, New York, U.S.A. pp 45-102.
- WHO (World Health Organization) (2012). Nutrient Adequacy of Exclusive Breastfeeding for the Term Infant during the First Six Months of Life (pp. 1–47). Geneva.