FUDMA Journal of Sciences (FJS)
ISSN online: 2616-1370
ISSN print: 2645 - 2944
Vol. 9 April Special Issue, 2025, pp 12 - 17
DOI: https://doi.org/10.33003/fjs-2025-09(AHBSI)-3371

QUALITY EVALUATION OF PASTA PRODUCED FROM WHEAT (*Tricuma estivum*), ACHA (*Digitari aexilis*), AND FLUTED PUMPKIN LEAF (*Talfaera occidantalis*) COMPOSITE FLOUR

[1]Salisu Muhammad M., [1]Sogunle Kazeem A., *[1]Idris Zubairu K., [2]Abubakar Garba I. and [1]Abubakar Adam K.

[1]Department of Food Science and Technology, Federal University Dutsin-Ma, 5001, Nigeria
[2]Institute for Agricultural Research, Ahmadu Bello University 1044 Zaria, Nigeria

*Corresponding authors' email: izkaida@fudutsinma.edu.ng
ORCID iD: https://orcid.org/0000-0002-3409-8988

ABSTRACT

Pasta is one of the staple foods of developing countries, usually produced using unleavened durum wheat flour dough. This research evaluated the pasta quality produced from wheat, acha, and fluted pumpkin leaf composite flour. The pasta was made from combinations of acha, wheat, and fluted pumpkin leaf at 100 90:10:0, 85:10:5, and 80:10:10, respectively. The pasta was analyzed for proximate composition, mineral, physical, anti-nutrient, and sensory properties, and this was carried out on the samples with standard methods. The pasta's moisture, protein, fiber, and ash contents ranged from 6.63-13.23 %, 0.92-1.59 %, 7.66-12.02 %, and 7.97-13.78 %, respectively. Sodium, calcium, and magnesium ranged from 30.56-37.24%, 45.58-25.68%, and 208.8-260.5%, respectively. Tannin, phytate, and cyanide ranged from 256.25-287.50%, 196.80-220.80%, and 70.52-75.36%, respectively. Diameter, length, and weight ranged from 0.51-0.53 %, 20.50-23.50 %, and 84.50-91.29 %, respectively. The sensory ratings for aroma, taste, and texture ranged from 6.90-7.60, 6.85-7.55, and 6.95-7.80, respectively. The use of wheat, acha, and fluted pumpkin leaf composite flour in pasta production generally improved their protein, fat, fibre, and ash contents and aids in producing pasta of acceptable qualities from all ratios, However, pasta produced from 100% wheat flour was more acceptable in the sensory characteristics examined.

Keywords: Cereal food, Extruded food, Fluted pumpkin leaf, Fortified pasta, Pasta Products

INTRODUCTION

Wheat (*Triticum aestivum*), a widely cultivated cereal grass, is a staple food globally. It contains 2.10% protein, 14.70% fat, and essential vitamins and minerals such as thiamine, vitamin B, Zn, Fe, Sn, and Mg (Kumar *et al*., 2011; Zubairu *et al*., 2019; Ubbor *et al*., 2022). With a protein content of approximately 13%, wheat is a major source of vegetable protein, though its amino acid profile affects its overall quality (Olayinka and Bhygya., 2018). Durum wheat, rich in gluten proteins gliadin and glutenin, is crucial for high-quality pasta due to its elasticity and chewability (Animasahun *et al*., 2017). Addressing protein deficiencies in cereals like wheat requires integrating legumes for essential amino acids like lysine and tryptophan (Adebowale *et al*., 2009).

The grass Acha (*Digitari aexilis*), native to West Africa, is also called Fundi, Fonio, and Hungry rice (Ayo, 2001). The oldest cereal in Africa is most likely acha, despite its neglect. The local grain acha was unable to keep up with the latest foreign cereals that were processed and milled to make them particularly convenient for consumers because most non-African colonial authorities, missionaries, and agricultural researchers had little interest in or support for local grain agriculture (Keswet *et al*., 2003).

Ancient grains like acha were traditionally used in rural and impoverished regions for sustenance (Ayo *et al*., 2007). Acha cereal is low in sugar and rich in cystine and methionine (Ayo *et al*., 2007). Its high pentosan content lets it absorb water, yielding a viscous solution beneficial for baking (Lasekan, 2013). Despite the challenge in protein extraction (8–11%), acha proteins are more digestible than those from millet and sorghum, owing to their high methionine and cysteine content (Ayo *et al*., 2007). Acha is recognized for its taste and nutritional value, which is potentially advantageous for diabetic-friendly cuisine due to its minimal impact on blood sugar levels from intact grain kernels.

Lawal et al. (2021) identify fluted pumpkin (*Telfairia occidentalis*), known as "ugwu" in Nigeria, as the most popular green vegetable grown extensively in the country. Aworh et al. (2015) note that its leaves are rich in vitamins, minerals, and proteins, especially vitamin A, while the seeds are high in protein and oil. Cultivated in West Africa, the plant, known as fluted pumpkin or gourd, is drought-tolerant, perennial, and dioecious, typically trellised. In Nigerian cuisine, its young shoots and leaves form the base of edikangikong soup, and its large seeds (up to 5 cm) are consumed whole, powdered for soups, or used in fermented porridge, providing significant fat and protein (Aworh *et al*., 2009).

Pasta, produced from durum wheat flour, egg, and water, is widely consumed globally for its nutritional benefits and ease of preparation (Gopalakrishnan *et al*., 2011; Petitot *et al*., 2009). It is known for its low-GI carbohydrates and gluten proteins, essential for cooki ng properties (Aravind *et al*., 2012). In Nigeria, where malnutrition and food insecurity contribute to high under-five mortality rates (Adewale *et al*., 2013), plant-based protein sources such as pasta are being considered due to cost and accessibility issues with animal proteins (Laleg et al., 2017). Fortifying pasta with vegetable powders is a strategy to enhance its nutritional value (Simonato *et al*., 2020). This study evaluates pasta quality using composite flour of wheat, acha, and fluted pumpkin leaves to address these challenges.

MATERIALS AND METHODS

Sources of materials

The fluted pumpkin leaf, acha, and high-quality wheat flour devoid of contamination were bought at the Katsina state

central market. A digital weighing scale, measuring cylinder, bowl, knife, mixer, extruder, and kneader were among the equipment acquired from the Food Science and Technology Laboratory at Federal University Dutsin-ma, Nigeria.

Production of acha flour

The acha flour used was produced as described by Ayo and Adewarie (2007). After washing in water to remove any stones and sand, the acha was left to dry for six hours in the sun. The dried acha byproducts were ground using a hammer mill containing a screen size of 0.2 mm sieve, then put into a zip-lock bag ready for use.

Production of fluted pumpkin leaf powder

The production of a fluted pumpkin leaf was reported by De Moura et al. (2015). Following their harvest, the newly cut leaflets were cleaned with purified water, blanched, drained, and freeze-dried (freeze-drying). The dried fluted pumpkin leaves were then pulverized using an electric blender, sieved to produce a powder, and sealed in a zip-lock bag for handling.

Production of pasta made from wheat, acha, and fluted pumpkin leaf flour blends

According to Animasahun et al. (2017), pasta was made using wheat, acha, and fluted pumpkin leaf composite flour, which was created by combining flour blends in different ratios (Table 1). For five minutes, the homogenized mixture was combined with water (50 milliliters for every 100 grams of flour) to facilitate hydration. The Department of Food Science and Technology used a local pasta extruder to create spaghetti (3 mm diameter) out of the produced dough. Following its removal from the pasta roller, the spaghetti was diced and allowed to dry at 45 ^{o}C for seven hours. The dried pasta will then be wrapped for later usage.

Table 1: Formulation of samples

Samples	Wheat flour (%)	Acha flour (%)	Fluted pumpkin leaf powder %
A	100	0	0
B	90	10	0
C	85	10	5
D	80	10	10

Proximate composition

The ash, moisture, protein, fiber, fat, and carbohydrate content of the prepared composite flour was assessed in terms of its approximate composition. The methodology, AOAC (2010), was used in the determination process. By using the difference, the carbohydrate content was determined.

Determination of mineral content

An atomic absorption spectrophotometer (210 VGP model) measured calcium (Ca) and magnesium (Mg). Sodium (Na) and potassium (K) were determined using flame photometry. For Ca, 3 ml of sample was pipetted into a test tube, followed by 5 ml of calcium working reagent, and absorbance was read at 512 nm after comparison with a blank. For Mg, another 3 ml of sample was shaken vigorously with carbonitride for 45 minutes, centrifuged, and the supernatant treated with sodium ferric cyanide (2% and 1%), then absorbance was measured at 620 nm against a blank. For Na, 5 ml of sample was treated with 1 ml of 0.67N H_2SO_4, 1 cc of 0.05% titan yellow, 2 ml of 10% NaOH, and 1 ml of 0.01% gum acacia, and absorbance was read at 520 nm. For K, 5 ml of sample was mixed with ammonium, extracted with ditizone extraction solution 1, and absorbance was measured at 520 nm against a blank after centrifugation.

Determination of anti-nutritional composition

Determination of oxalate

Oxalate content was determined using the method outlined by Oke. (2001). A 5 g sample was digested with 190 ml purified water and 10 ml 6 M HCl in a 250 ml flask at 90°C for 4 hours. After centrifugation at 2000 rpm for 5 minutes, the supernatant was diluted to 250 ml. Filtering removed brown precipitate, and three 50 ml aliquots of the supernatant, evaporated to 25 ml each, were cleaned. Titration with concentrated ammonia was conducted until methyl orange's color changed from salmon pink to faint yellow. Heating to 90°C, followed by addition of 10 ml 5% $CaCl_2$, precipitated oxalate. After overnight settling and centrifugation, the precipitate was diluted to 125 ml with distilled water, heated to 90°C, and titrated against 0.05 mg $KMnO_4$ in hot 25% H_2SO_4.

$$\%Oxalate = \frac{100 \times T \times 0.00225}{W} \quad (1)$$

in which T= Titre value

W = Sample weight

Determination of saponin

The Saponin content of samples was determined using the AOAC (2010) method. Samples (2 g each in triplicate) were reflux-extracted in a Soxhlet extractor using methanol and acetone. Acetone removed crude lipid content, while methanol extracted saponin. After extraction with acetone for 3 hours in a 250 cm^3 flask, methanol extraction continued for another 3 hours in a 150 cm^3 flask. Weight changes were recorded to calculate saponin content using the formula in equation (2).

$$Saponin\% = \frac{A-B}{Sm} \times 100 \quad (2)$$

Where A = Extract and flask mass

B = Empty flask's mass

Sm = Sample mass

Determination of physical properties of pasta produced from wheat, acha, and fluted pumpkin leaf composite flour

Diameter

A vernier caliper was used to measure the diameter of the pasta. The jaws of the vernier calliper were closed to ensure that the zeros on the main scale and the vernier scale lined up precisely. Using a magnifying lens, find the main scale division that matches the vernier scale division. How many divisions line up with one another was noted.

Length

The length of the pasta was measured using the meter rule, and an average was chosen.

Weight

Ayo and Adewarie's (2007) method was used to calculate the weight of the pasta. Weighing a balance (model) both

before and after drying allowed us to calculate the weight of the pasta sample.

Sensory analysis

The sensory analysis of pasta was conducted using modified methods from Onwurafor et al. (2020). The test was conducted in the middle of the morning at a laboratory. The products were arranged in an entirely randomized order on tagged plates, and the panelists assessed them accordingly. A 9-point Hedonic scale was used to score the samples' color, scent, taste, mouthfeel, and general acceptability (1 being strongly disliked, 5 being neither like nor dislike, and nine being highly liked). Between assessing the samples, the panelists cleaned their mouths. For comparison, the controls were employed. The panelists comprised twenty-five (25) members selected from the university community.

Statistical analysis

The data were subjected to statistical analysis using Analysis of Variance in Microsoft Office Excel (2016). The statistical software for social science was used to separate the means at a significant level of $p < 0.05$, as Onwurafor et al. (2020) described.

RESULTS AND DISCUSSION

Table 2: Proximate composition of pasta produced from wheat, acha, and fluted pumpkin leaf composite flour

Sample	Moisture (%)	Ash (%)	Fat (%)	Protein (%)	Fibre(%)	Carbohydrate (%)
A	13.23±0.6^{a}	1.38±0.06^{b}	7.66±0.94^{c}	13.05±0.23^{a}	3.32±0.28^{a}	61.34±0.18^{b}
B	8.30±0.52^{b}	0.92±0.12^{b}	9.76±0.36^{b}	7.97±1.14^{b}	2.90±0.05^{a}	70.14±1.05^{c}
C	6.63±0.62^{b}	1.59±0.38^{a}	10.86±0.51^{ab}	9.02±0.29^{b}	3.34±0.14^{a}	68.55±0.91^{a}
D	11.96±1.02^{a}	1.44±0.16^{ab}	12.02±0.02^{a}	13.78±0.74^{a}	3.05±0.14^{a}	57.74±1.52^{c}

Based on duplicate determination, the values are the means with standard deviation. Meaningful variations ($p<0.05$) are displayed by means with different superscripts in the given column.

Proximate composition of pasta produced from wheat, acha, and fluted pumpkin leaf composite flour

Table 2 shows the proximate composition of pasta made with wheat, acha, and fluted pumpkin leaf flour blends. Increasing fluted pumpkin leaf powder significantly ($p<0.05$) improved the proximate composition, reducing moisture and carbohydrates. Moisture content ranged from 13.23% to 6.63%, with the lowest pasta made with 85% wheat, 10% acha, and 5% composite flour. More fluted pumpkin leaf powder led to lower moisture content. Pasta made entirely of wheat flour had the highest moisture content at 13.23%. Omeire and Obasi (2014) found a moisture content of 12.26 kg per 100 kg in pasta made solely with wheat flour. Pasta with 80% wheat, 10% acha, and 10% fluted pumpkin composite flour had a moisture content of 8.30%, and 11.9% in pasta with 90% wheat flour, 10% acha, and 0% fluted pumpkin composite flour. There was a significant difference in moisture content at the 5% probability level. Thus, adding fluted pumpkin leaf powder reduces moisture content and extends shelf life.

The pasta samples had a crude protein level of 13.78% to 7.97%. Adding fluted pumpkin leaf powder, a necessary protein source, significantly increased the protein content. Kumar and Prabhasankars (2015) said that more fluted pumpkin leaves disrupted the protein and starch matrix. Pasta made from wheat, acha, and fluted pumpkin leaf composite flour is an alternate protein source, with the highest protein level at 80% fluted pumpkin leaf composite flour. Incorporating acha and fluted pumpkin leaf flour significantly boosted protein content at the 5% probability level.

The pasta samples had fat contents ranging from 6.66% to 12.12%. Increasing the fluted pumpkin leaf powder raised the pasta's fat content, as noted by Obeagu et al. (2014). Fluted pumpkin is rich in protein, fat, oil, minerals, and vitamins. Pasta with 80% wheat, 10% acha, and 10% fluted pumpkin leaf composite flour had the highest fat content, while 100% wheat composite flour had the lowest. Fat concentrations in pasta with 90% wheat and 10% acha composite flour, 100% wheat composite flour, and 90% wheat and 10% acha composite flour were 7.66% and 9.76%, respectively. There is a significant difference among the pasta samples at the 5% probability level.

Pasta samples ranged in fiber content from 3.34% to 3.55%. The highest fiber content (3.55%) was found in pasta made with 85% wheat flour, while the lowest (3.34%) was in pasta made with 80% wheat and 10% acha composite flour. The addition of powdered fluted pumpkin leaf significantly increased dietary fiber content, attributed to the leaf's high fiber content (Ranien,, 2011). Higher fiber in commonly consumed foods like pasta may enhance health by improving safety and regulating cholesterol levels.

The ash content of pasta ranged from 0.92% to 1.59%. The highest ash content (1.59%) was observed in pasta made from 85% acha and 10% fluted pumpkin leaf flour mixes, consistent with findings by Obeagu et al. (2014). Fluted pumpkin is noted for its rich protein, ash, oil, fat, minerals, and vitamins. Pasta ash content was 1.38% for 100% wheat and 1.44% for 80% wheat with 10% acha composite flour, with a significant difference observed at the 5% probability level.

Pasta samples showed varying carbohydrate content (70.14% to 577.74%). The highest carb content was in pasta with 90% wheat and 10% acha composite flour, while pasta with 80% wheat had the lowest. Adding acha to wheat flour mixes significantly increased carb levels. Pasta blends of 85% wheat and 10% acha had 68.55% carbs, compared to 61.34% in 100% wheat pasta. Omiere and Obasi (2014) found similar carb amounts. Carbohydrate content differed significantly ($p < 0.05$) among samples, decreasing with more fluted pumpkin flour inclusion.

The energy content of pasta samples ranged from 366.56 to 408.09 kcal. Pasta with 85% wheat flour had the highest energy content, while pasta with 100% wheat and 0% cassava flour had the lowest (Atobatalele & Afolabi, 2016). Biscuits showed significant differences in energy content at a 5% significance level, with relatively high values.

Table 3: Mineral composition of pasta made from wheat acha and fluted pumpkin leaf flour blends

Sample	Calcium (mg/L)	Iron (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Zinc (mg/L)
A	27.06±0.43	17.53±0.00	244.0±0.05	30.56±0.26	14.1±0.21
B	45.58±0.14	12.85±0.00	240.0±0.08	33.5±0.18	6.14±0.06
C	45.39±0.13	37.36±0.41	260.5±0.03	37.24±0.33	10.58±0.01
D	25.68±0.14	28.12±1.25	08.8±0.04	31.92±0.49	10.19±0.01

Based on duplicate determination, the values are the means with standard deviation. Meaningful variations ($p<0.05$) are displayed by means with different superscripts in the given column.

Mineral composition of pasta made from wheat acha and fluted pumpkin leaf flour blends

The calcium content in the samples ranged from 27.06, 3.1245.58, 45.39, and 25.68 mg/L, respectively, according to the mineral composition of the pasta, as indicated in Table 4.3. In mg/L, the iron values were 17.53, 12.85, 37.36, and 28.12, in that order. The magnesium concentration varied between 244.0, 240.0, 260.5, and 208.8 mg/L. In that order, the values for sodium were 30.56, 33.5, 37.24, and 31.92 mg/L. In that order, the zinc values varied from 6.14, 10.58, 10.19, and 14.1 mg/L.

Table 4: Anti-nutrient Contents of pasta made from wheat, acha, and fluted pumpkin leaf flour blends in Mg/100g

Sample	Tannin	Phytate	Oxalate	Saponin
A	215.00	162.00	94.07	47.11
B	219.00	163.50	97.11	47.96
C	223.00	166.50	100.14	48.96
D	227.00	169.50	103.18	49.97

Anti-nutrient content of pasta made from wheat acha and fluted pumpkin leaf composite flour

Table 4 depicts the anti-nutrient composition of wheat, Acha, and fluted pumpkin leaf flour mixes. The flour's tannin level, which varied from 215.00 to 220.00, decreased as the amount of fluted pumpkin was removed. As expected, the tannin content drops from Samples A, B, C, and D. The range of the phytate content is 162.00 to 169.00. The lowest amount of phytate was found in pasta made from 100% wheat, while the highest was in pasta made from 80% wheat, 10% acha, and 5% fluted pumpkin leaves. As the addition of fluted pumpkin leaves increases, the phytate content falls. The pasta produced from 100 wheat had the lowest phytate concentration, whereas pasta made from 80 wheat 10 acha 5 fluted pumpkin leaf had the highest oxalate content, ranging from 94.00 to 103.00. As the inclusion of fluted pumpkin leaves increases, so does the oxalate content. This was consistent with the results of Akwaowo 200, which indicated that the principal antinutrients found in fluted pumpkin leaves include tannins, saponins, phytate, and oxalate. Pasta prepared from 100 wheat had the lowest phytate concentration, while pasta made from 80 wheat 10 acha 5 fluted pumpkin leaf had the greatest oxalate value. The saponin content ranged from 47.11 to 49.97. As the inclusion of fluted pumpkin leaves increases, so does the oxalate content.

Table 5: Physical properties of pasta produced from wheat, acha, and fluted pumpkin leaf composite flours

Sample	Diameter (mm)	Length (cm)	Weight (g)
A	0.52 ± 0.03^{a}	22.50 ± 3.53^{a}	91.29 ± 0.43^{a}
B	0.53 ± 0.04^{a}	21.00 ± 2.8^{a}	88.70 ± 0.00^{b}
C	0.51 ± 0.02^{a}	23.50 ± 2.1^{a}	85.16 ± 0.19^{c}
D	0.53 ± 0.07^{a}	20.50 ± 0.70^{a}	84.50 ± 0.07^{d}

Based on the duplicate determination, the values are the means with standard deviation. Meaningful variations ($p<0.05$) are displayed by means with different superscripts in the given column.

Physical properties of pasta produced from wheat, acha, and fluted pumpkin leaf composite flour

The physical characteristics of pasta made with a composite flour made of wheat acha, and fluted pumpkin are displayed in Table 5. The pasta samples were produced from 100% wheat flour, 90% wheat, and 10% acha composite flours, 85% wheat, 10% acha, and 5% fluted pumpkin leaf composite flours, and 80% wheat, 10% acha, and 10% fluted pumpkin leaf composite flours had diameters of 0.52 mm, 0.53 mm, 0.51 mm, and 0.53 mm, respectively. Pasta composed of 80% wheat, 10% acha, and 5% fluted pumpkin leaf composite flour had the shortest length, while pasta made from 90% wheat, 10% acha, and 5% fluted pumpkin leaf composite flour had the longest pasta sample, measuring between 20.50 and 23.50 cm. 22.50 cm, 21.00 cm, and 22.50 cm were the lengths of pasta made with 100% wheat flour, 90% wheat, 10% acha, 85% wheat, 10% acha, and 5% fluted pumpkin leaf composite flour, respectively. At the probability level ($p<0.05$), there was no statistically significant difference between the samples' lengths.

Results from Chisenga et al. (2019) were consistent with the flour's performance. They implied that smaller particle sizes improve hydration and raise flour solubility. Including fluted pumpkin leaves reduced the flour samples' surface area and mean volume dispersion.

Table 6: Sensory properties of pasta produced from wheat, acha, and fluted pumpkin leaf composite flour

Sample	Aroma	Taste	Texture	Color	Gen. accept.
A	7.60 ± 0.99^{a}	7.55 ± 0.94^{a}	7.80 ± 0.89^{a}	8.20 ± 1.36^{a}	8.50 ± 0.68^{a}
B	7.25 ± 0.85^{ab}	7.40 ± 0.82^{a}	7.45 ± 0.94^{ab}	7.30 ± 0.97^{b}	7.50 ± 0.82^{b}
C	7.00 ± 0.91^{ab}	7.20 ± 1.10^{a}	7.20 ± 1.36^{ab}	7.35 ± 1.22^{b}	7.35 ± 1.22^{bc}
D	6.90 ± 1.07^{b}	6.85 ± 1.18^{ab}	6.95 ± 0.23^{bc}	7.55 ± 0.99^{ab}	7.15 ± 1.08^{bc}

Based on duplicate determination, the values are the means with standard deviation. Meaningful variations ($p<0.05$) are displayed by means with different superscripts in the given column. Gen. accept. means general acceptability

Sensory analysis of pasta made from wheat, acha, and fluted pumpkin leaf composite flour

The sensory analysis of the pasta made with composite flours is displayed in Table 4. There was a significant difference ($p<0.05$) in the scent of the samples. Pasta made of wheat was preferred for many organoleptic qualities. However, after adding fluted pumpkin leaves, the pasta samples' color, likability, and stiffness scores dropped considerably. Simonato et al. (2020a) showed a comparable decline in the acceptability of pasta fortified with vegetables. Because fluted pumpkin flour was added, adding fluted pumpkin leaf powder reduced the scent scores for every sample. Overall acceptability was thus highest for pasta made entirely of wheat without adding leaves. Additionally, giving consumers access to nutritional information about the samples improved the pasta's acceptance and likability ratings overall, suggesting that they could be more inclined to buy strange but believed to be healthier products (Ayetigbo *et al.*, 2018). Similarly, Sato et al. (2019) proposed that while the market for healthier food items grows, customers should be informed about novel ingredients and healthy product offerings to improve adoption.

CONCLUSION

Adding fluted pumpkin leaf powder to wheat pasta negatively affected sensory perception but improved some techno-functional aspects. Pasta from a composite of wheat, acha, and fluted pumpkin leaf is more nutritious than wheat-only pasta. Replacing 15-20% of wheat flour with this composite is recommended for more nutritious pasta. The fluted pumpkin leaf powder altered the pasta's color and increased its fat content. Wheat-only pasta had better sensory attributes. Further research on shelf life and packaging is needed, which will impact on the marketing of national sustenance goods.

REFERENCES

Adebowale, Boyer, L., Minier, C. & Micard, V. (2009). Fortification of pasta with split pea and fava bean flour; pasta processing and quality evaluation. *Food Research International Journal* 43(2): 634 – 641.

Adewale, B. Daniel, A. Aremu, C. Onye, C. (2013). The nutritional potential and possibilities in African yam bean for African. *International Journal of AgriScience*. 3(1); 8-19.

Akwaowo, N. K. (2014). Anti-nutrients in plant-based foods. *Nigeria Food Journal*, v 32, n 1 p 31-37.

Animasahun, Abecassis, J., & Micard, V. (2017). Structuring of pasta components during processing: Impact on starch and protein digestibility and allergenicity. Trends in Food Science & Technology 20(11-12): 521-532.

AOAC (2010). Official method of analysis, 18th ed. Association of Official Analytical Chemicals, Washington, D.C, U.S.A.

Aravind, M., Boyer, L., Minier, C. & Micard, V. (2012). Fortification of pasta with split pea and fava bean flours; pasta processing and quality evaluation. *Food Research International Journal* 43(2): 634 – 641.

Atobatalele & Afolabi, (2016). Assessment of functional properties of different flours. *African Journal of Agricultural Research*, *8*(38), 4849–4852. https://doi.org/10.5897/AJAR2013.6905.

Aworh, B, Makkar, H. P. S., & Becker, K. (2009). Dietary roles of phytate and phytase in human nutrition: *A review. Food Chemistry*, 120, 945-959.

Aworh, B., Kumar, S., Verma, R. K., & Yadav, S. (2015). Nutritional contents and the medicinal properties of wheat: a review. *Life Science and Medical Research,* 22, 1-10.

Ayetigbo, O., Latif, S., Abass, A., & Müller, J. (2018). Comparing characteristics of root, flour, and starch of biofortified yellow-flesh and white-flesh cassava variants, and sustainability considerations: a review. *Sustainability, 10* (9). https://doi.org/10.3390/su10093089

Ayo, J. A.& Adewarie, C (2007). Nutrient and anti-nutrient composition of extruded acha/soybean blends. *Journal of Food Processing and Preservation,* 34: 680-691.

Ayo, J.A. (2001). The effect of acha grain flour on the quality of bread. *International Journal of Food Properties* 4 (2), 341–351. 4.

Ayo, J.A., Ayo, V.A., Nkama, I., & Adewori, R. (2007). Physicochemical in-vitro digestibility and organoleptic evaluation of acha-wheat biscuit supplemented with soybean flour. *Nigerian Food Journal*, 25, 77-79.

Brennan, M. A., & Prinyawiwatkul, C. S. (2018). Gluten-free bakery and pasta products: prevalence and quality improvement. *International Journal of Food Science & Technology,* Effects of blanching with chemical preservatives on functional and antioxidant properties of fluted pumpkin (*Telferiaoccidentalis*) leaf.

Chinma, C. E., Ariahu, C. C., & Abu, J. O. (2013). https://doi.org/10.1016/j.foostr.2020.100139

Chisenga, S. C., Workneh, T. S., Bultosa, G., & Laing, M. (2019). Proximate composition, cyanide contents, and particle size distribution of cassava flour from cassava varieties in Zambia. *AIMS 486 Agriculture and Food*, *4*(4), 869–891. https://doi.org/10.3934/agrfood.2019.4.869

De moura, T. O., Nazamid, S., & Adebowale, A. A. (2015). Functional and pasting properties of tropical breadfruit (*Artocarpus altilis)* starch from Ile-Ife, Osun State. Nigeria. *International Food Restaurants Journal* 16:151–157.

Gao, Y., Janes, M. E., Chaiya, B. (2016). Nutritional contents and the medicinal properties of wheat: a review. *Life Science Medical Research*, 22, 1-10.

Gopalakrishnan, D., & Tavares, G. O. (2011). Evaluation of functional properties of composite flours and sensorial attributes of composite flour biscuits. *Journal of Food Science and Technology*, *52*(6), 3681–3688. https://doi.org/10.1007/s13197-014-1427-2

Keswet , Ortiz, J. R., Cicero, J., & Taveras, F. (2003). Digiteria exilis *is a crop in the Dominican Republic. In: Janick J, Whipkey A, editors.* Supplement to: trends in new crops and new uses. Alexandra: ASHS Press;

Kumar, P., Yadav, R.K., Gollen, B., Kumar, S., Verma, R. K., & Yadav, S. (2011). Nutritional contents and the medicinal properties of wheat: a review. *Life Science and Medical Research*, 22, 1-10.

Kumar, S.B., &Parabhasankar, P.A. (2015). study of the starch profile of rajma beans incorporated noodle dough and its functional characteristics. *Food Chemistry*, *London*, v 180, n.10, p. 124-32.

Kumar, V., Sinha, A. K., Makkar, H. P. S., & Becker, K. (2010). Dietary roles of phytate and phytase in human nutrition: A review. *Food Chemistry*,120, 945-959.

Laleg, K. Barron, C. Cordelle, S. Schlich, P. Walrand, S. Micard, V. (2017). How the structure, nutritional and sensory attributes of pasta made from legume flour is affected by the proportion of legume protein. LWT-Food Science and Technology. 79. https://doi.org/10.1016/j.lwt.2017.01.069

Lasekan, O. (1994). Chemical composition of acha *(Digitariaexilis)* flour. *Nigerian Food Journal*, 12: 19 – 23.

Lawal, M. O., Sanni, O., Oluwamukoni M., Fogliano, V., Linnemmann A. R. (2021). The addition of fluted pumpkin (*Telfairia occidentalis)* leaf powder improves the techno-functional properties of cassava pasta. *Food Structure*. 30; 100241. https://doi.org/10.1016/j.foostr.2021.100241

Obeagu, J. (2014). Effect of different levels of fluted pumpkin leaf (*Talfaira occidentalis*). *Food journal*. v. 37, n. 1 p 69-7, (2014).

Oke, (2001). Evaluation of quality and sensory characteristics of spaghetti made from plantain and wheat flour blends. *Journal of Food Processing and Nutritional Science* 23(1): 93-104.

Olayinka & Bhygya, S. (2018). Quality characteristics of pasta Enriched with mustard protein isolate. *Journal of Food Science* 73(5): 5229-5237

Omeire, G. C., Obasi, N. E. (2014). Acceptability of noodles produced from blends of wheat acha and soybean composite flours. *Nigerian Food Journal*, 32, (1); 31-37,

Onwurafor, Aremu, M. O., & Ibrahim, H. (2020). Mineral content of some plant foods grown in Nigeria: A Review. *Journal of Food Science and Quality Management* 29: 73-89.

Ortiz, J. R., Cicero, J., & Taveras, F. (2012). Digiteria exilis *is a crop in the Dominican Republic. In: Janick J, Whipkey A, editors.* Supplement to: trends in new crops and new uses. Alexandra: ASHS Press;

Petitot, M., Abecassis, J., & Micard, V. (2009). Structuring of pasta components during processing: Impact on starch and protein digestibility and allergenicity. *Trends in Food Science & Technology*, 20(11-12): 521-532.

Ranien, K. (2011). Dietary fiber type reflects physiological functionality, a comparison of grain fiber. nutritional reviews, New York, v.69. n.1, p 9-21,

Sato, J. L. (2019). Sensorial and physicochemical qualities of pasta prepared with amaranth. Maringa, v. 37, n. 1 p 69-7, 2019,

Sigafoos, J., Lancioni, G., & Rispoli, M. (2021). Gluten-free and casein-free diets in the treatment of autism spectrum disorders: A systematic review. *Research Aut. Spect. Disord.* 4, 328-339.

Simonato, Adeleke, R. O., & Oyedeji, J. O. (2020). Functional properties of wheat and sweet potato flour blend. *Pakistan Journal Nutrition* 96(8): 535–538.

Simonato, B., Tolve, R., Rainero, G., Rizzi, C., Sega, D., Rocchetti, G., & Giuberti, G. (2020a). Technological, nutritional, and sensory properties of durum wheat fresh pasta fortified with *Moringa oleifera* l. leaf powder. *Journal of the Science of Food and Agriculture*. https://doi.org/10.1002/jsfa.

Ubbor, S., Ezeocha, C. V., Okoli, J., Agwo, O., Olaoye, O., & Agbai, I. (2022). Evaluation of biscuits produced from wheat (*Triticum aestivum*), tiger nut (*Cyperus esculentus*), and orange fleshed sweet potato (*Ipomoea batatas*) flours. *FUDMA Journal of Sciences*, *6*(4), 254–261. https://doi.org/10.33003/fjs-2022-0604-1072

Zubairu, I. K., Mansir, A., & Ahmad, T. (2019). Evaluation of breakfast cereals produced from finger millet, wheat, soybean, and peanut blends. *International Journal of Food Sciences*, *2*(4), 17–24. https://doi.org/10.47604/ijf.984