African Journal of Agriculture and Food Science
ISSN: 2689-5331
Volume 8, Issue 3, 2025 (pp. 50-64)
www.abjournals.org

FUNCTIONAL PROPERTIES AND NUTRITIONAL PROFILE OF WHEAT, SOYBEAN AND CARROT POMACE COMPOSITE FLOURS

Gift Mnena Ikyagh[1*], Peter Agorye Adie[1,2],

Christiana Agbenu Adah[1,2], and Titus Ternenge Undo[1].

[1]Centre for Food Technology and Research, Department of Chemistry, Rev. Fr. Moses Orshio Adasu University, Makurdi, Benue State, Nigeria.

[2]Department of Chemistry, Rev. Fr. Moses Orshio Adasu University, Makurdi, Benue State, Nigeria

[*]Corresponding Author's Email: ikyaghgift@gmail.com

Cite this article:

G. M. Ikyagh, P. A. Adie, C. A. Adah, T. T. Undo (2025), Functional Properties and Nutritional Profile of Wheat, Soybean and Carrot Pomace Composite Flours. African Journal of Agriculture and Food Science 8(3), 50-64. DOI: 10.52589/AJAFS-KDANUGSL

Manuscript History

Received: 21 Jul 2025

Accepted: 28 Aug 2025

Published: 17 Oct 2025

ABSTRACT: *Malnutrition is a serious concern in developing nations and can be curbed by blending foods of varying nutritional profiles for novel food products. In this research, composite flours were prepared by combining wheat, soybeans and carrot pomace in different proportions. The functional properties of the fortified flours showed the swelling power in the range of 110.43-117.18 %, water absorption capacity from 2.10-2.66 %, oil absorption capacity from 1.23-1.28 %, Gelation capacity from 4.00-8.00 %, solubility index from 53.50-90.00 %, and dispersibility from 50-60 %. The proximate analysis done was moisture, ash, crude fat, crude fiber, crude protein and carbohydrate contents, which were in the range of 8.31-10.90 %, 0.23-2.50 %, 4.29-9.64 %, 0.56-1.74 %, 15.47-34.21 % and 44.01-67.08 %, respectively. The mineral analysis showed Fe, Zn, Na, Ca and K in the range of 1.99-3.01, 2.98-3.59, 23.00-24.11, 97.00-98.04 and 199.31-207.03 mg/100g, respectively, while the vitamin composition of the composite flours shows the presence of β-carotene in the range of 4.90-6.53 mg/100g , vitamin C ranges from 2.11-2.99 mg/100g, vitamin E content from 0.89-1.37 mg/100g, vitamin B6 from 0.21-1.78 mg/100g, vitamin B12 from 0.02-0.13 mg/100 g though absent in samples B and E, vitamin B5 from 0.27-1.67 mg/100g and B1 from 0.04-1.05 mg/100g. These results showed that the composite flour can be used in the formulation of foods like sausages, noodles, bread, whipped toppings, angel and sponge cakes.*

KEYWORDS: Wheat, Carrot pomace, Soybeans, Composite flours.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

INTRODUCTION

Nowadays, consumers prefer food products that offer multiple benefits. Not only should they have to be sensorially appealing, but they should also be a good source of nutrition to fulfill daily requirements and have extra benefits for health (Azkia *et al*., 2021). The functional and nutritional profile of food products is necessary for determining their suitability in various food fortifications and their health benefits (Awuchi *et al*., 2019). Composite flours are a combination of flours for fortifying bakery products for economic and nutritional purposes (Palamthodi *et al*., 2021).

Wheat (*Triticum aestivum*) is a cereal from the *Graminae* family with almost the highest annual rate of production among grains globally (Palamthodi *et al*., 2021). Most breads, rolls, crackers, cookies, biscuits, cakes, doughnuts, macaroni, spaghetti, puddings, pizza, and a variety of homemade hot and cold breakfast dishes are produced from wheat (David *et al*., 2015). Soybean is a nutrient-dense plant source with essential ingredients of functional foods, as it is a good source of protein containing most of the essential amino acids, vitamins, and minerals. Soybean is rich in Ca, P, and vitamins (A, B, C, and D) (Mohajan *et al.*, 2018). Soybean can prevent kidney diseases, heart diseases, osteoporosis, cancer, diabetes, obesity and blood cholesterol (Sakare *et al.,* 2020). Soybean flour can be used for the fortification of traditional cereal-based foods (Agume *et al*., 2017). Carrots belong to the Apiaceae family and are produced worldwide for food purposes (Ikram *et al*., 2024). It is a root vegetable, mostly orange, purple, red, white or yellow, with a rich source of β-carotene and vitamins like thiamine and riboflavin (Akinyede *et al*., 2020). Carrot pomace is usually regarded as waste, even though it contains 80 % of the carotene in the whole carrot and a good amount of dietary fiber and minerals (Adeola *et al.,* 2017). Carrot pomace can be incorporated in meals like pasta, pastries, cakes, and sausage to reduce the challenge of environmental load (Chepkosgei & Orina, 2021). This research was geared toward assessing the functional properties and nutritional profile of wheat, soybean and carrot pomace composite flours

EXPERIMENTAL

Flours Preparation

The soybeans were collected from Wadata market in Makurdi and prepared as described by Msugh *et al. (2024)* with little modification. The samples were cleaned of dirt by sorting out contaminants such as sand, sticks and leaves, washed with water and oven-dried at 50 ^{o}C. The soybeans were roasted, winnowed and milled using a hammer mill and sieved into fine flour of uniform particle size by passing them through a 2 mm mesh sieve.

Carrot pomace flour was obtained according to the method described by Gull *et al. (2015)* with slight modifications. Fresh carrots were washed thoroughly to remove surface dirt, and the outer layers of the carrots were scraped and blanched at 80 ^{o}C for 2 min to prevent microbial action and stop enzymatic action. After which the water was drained out. The carrots were grated and the juice was squeezed out using a muslin cloth, dried at 60 ^{o}C for 8 h and milled with a hammer mill and sieved to obtain carrot flour.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

African Journal of Agriculture and Food Science
ISSN: 2689-5331
Volume 8, Issue 3, 2025 (pp. 50-64)
www.abjournals.org

Formulation of the Composite Flour

Seven samples (A, B, C, D, E, F and G) were prepared by mixing blended carrot pomace and soybean flour with wheat flour in the proportion indicated in Table 1

Table 1: Mixing ratio of wheat, soybean and carrot pomace composite flour blends

Sample	Wheat Flour	Soybean Flour	Carrot flour
A	100	0	0
B	95	5	0
C	90	5	5
D	85	10	5
E	80	15	5
F	75	20	5
G	70	25	5

KEY A - 100% wheat flour (control), B - 95% wheat flour + 5% soybean flour, C - 90% wheat flour + 5% soybean flour + 5% carrot pomace flour, D - 85% wheat flour + 10% soybean flour + 5% carrot pomace flour, E - 80% wheat flour + 15% soybean flour + 5% carrot pomace flour, F 75% wheat flour + 20% soybean flour + 5% carrot pomace flour, G70% wheat flour + 25% soybean flour + 5% carrot pomace flour

Functional Properties

Swelling Power and Solubility Index

Swelling power and solubility were determined as described by Adegunwa *et al.* (2012). Exactly 1 g of the sample was weighed into a 50 mL centrifuge tube, and 50 mL of distilled water was added and mixed gently. The slurry was heated in a water bath at 70 ^oC, 80 ^oC, 90 ^oC and 100 ^oC respectively for 15 min. During heating, the slurry was stirred gently to prevent clumping of the flour, after which the tube containing the paste was centrifuged at 3000 rpm for 10 min. The supernatant was decanted and the weight of the sediment was recorded. The dry matter content in the sediment gel was determined to get the dry matter content in the gel.

$$Swelling\ power = \frac{Weight\ of\ wet\ mass\ sediment}{Weight\ of\ dry\ matter\ in\ the\ gel} \times 100 \qquad (1)$$

$$Solubility\ index\ (\%) = weight\ of\ dry\ solid\ after\ drying\ x\ 100 \qquad (2)$$

Water absorption capacity (WAC)

Three grams (3 g) of flour were boiled in 200 mL of water until completely cooked, washed with distilled water, then drained for 5 min and weighed immediately. Water absorption was reported as the percentage increase in the weight of the cooked sample compared to the uncooked sample weight.

$$Water\ absorption = \frac{(Weight\ of\ cooked\ noodles - Weight\ of\ uncooked\ noodles)}{Weight\ of\ uncooked\ noodles} \times 100 \qquad (3)$$

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

Oil absorption capacity (OAC)

One gram (1 g) of the flour sample was weighed into a pre-weighed centrifuge tube and 10 mL of distilled water was added. The sample was vortexed for 1 min and allowed to stand for 30 min. After centrifugation at 3000 rpm for 15 min, the supernatant was decanted and the tubes were allowed to drain for 5 min, and then the residue was weighed. The result was calculated by using the equation (4) (Abd Elmoneim and Bernhardt, 2018).

$$Oil\ Absorption\ Capacity = \frac{(m_1)}{m_0} \times 100 \qquad (4)$$

where: m_o = weight of sample taken into analysis, m_1 = weight of sample after supernatant removal.

Least gelation capacity (LGC)

The least gelation capacity was determined by the method described by Adegunwa *et al*. (2012). Ten suspensions of flour blends (2%, 4%, 6%, 8%, 10%, 12%, 14%, 16%, 18%, and 20%) (w/v) in 5 mL distilled water were prepared in test tubes. The test tubes containing the suspension were heated in a boiling water bath for 1 h. The tubes and contents were cooled rapidly under running water and then cooled further for 2 h at 4 ^oC. Next, the tubes were inverted to see if the content would fall or slip off. The least gelation concentration is when the sample from the inverted test tube does not fall or slip off.

Dispersibility

The method described by Adegunwa *et al*. (2012) was adopted. Exactly 10 g of each flour blend was weighed into a 100 mL measuring cylinder and distilled water was added to make up the volume to 100 mL. The setup was stirred vigorously and allowed to settle for 3 h. The volume of settled particles was recorded and subtracted from 100. The difference was reported as percentage dispersibility.

Proximate Analysis

Determination of Percentage Moisture Content

The moisture content of the samples was determined by the oven evaporation method described by Mauer (2024). Exactly 2 g of samples were carefully weighed and placed in a clean, pre-dried crucible, whose weight had been previously recorded. The dish containing the sample was placed in a well-insulated electric oven at 103 ^oC for 3 h. Thereafter, the sample was removed and placed in a desiccator at ambient temperature to cool. This procedure was repeated until a constant weight was obtained. The loss in weight of samples was reported as moisture content and calculated as shown in equation (5).

$$\text{Percentage moisture content \% (MC)} = \frac{W_1 - W_2}{W_1 - W_0} * 100 \qquad (5)$$

Where: W_o is the weight of the empty dish and W_1 is the weight of the dish and sample after drying. W_2 is the final weight after drying, and W_1-W_o is the weight of the sample before drying.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

African Journal of Agriculture and Food Science
ISSN: 2689-5331
Volume 8, Issue 3, 2025 (pp. 50-64)
www.abjournals.org

Determination of total ash

The ash content was done as described by Harris and Marshall (2017) with little modification. Exactly 5 g of the sample was transferred into a pretreated crucible, placed in a furnace and ignited at 650 ^oC for 5 h. After which the crucible was allowed to cool to room temperature, was removed from the furnace and placed in the desiccator for 10 min. The weight of ash was recorded and the ash percentage was calculated from the initial sample weight.

$$\%\ \text{Ash} = \frac{(Weight\ of\ crucible + ash) - weight\ of\ empty\ crucible}{weight\ of\ sample * dry\ matter\ coefficient} * 100 \qquad (6)$$

Dry Matter coefficient = % Solids / 100

Determination of crude fat

Fat content was determined by the method described by Ellefson (2017). Exactly 2 g of the sample was placed in the Soxhlet extraction chamber and allowed to extract for 8 h. The solvent was distilled and collected, and the extract was dried in an oven. The total fat extracted was calculated as follows:

$$\%\ Fat = \frac{W_3 - W_2}{W_1} * 100 \qquad (7)$$

Where: W_1 is weight of sample, W_2 is weight of empty flask, W_3 is weight of flask with extract

Crude fibre content

The crude fiber was done as described by Adeoye *et al. (2019)* with some modification. Two grams (2 g) of the sample were weighed and transferred into a 250 mL beaker and boiled for 30 min with 100 mL of 0.12 M H_2SO_4 then filtered through a funnel. The filtrate was washed with boiling water until the washing was no longer acidic. The solution was boiled for another 30 min with 100 mL of 0.01 M NaOH solution and filtered with hot water and methylated spirit three times. The residue was transferred into a crucible and dried in the oven at 103 ^oC for 1 h. The crucible with its content was cooled in a desiccator and then weighed (W_1). The residue was taken into a furnace for ashing at 600 °C for 1 h. The ashed sample was removed from the furnace and put into the desiccator to cool and later weighed (W_2). The percentage of crude fiber was calculated thus:

$$\%\ of\ crude\ fibre = \frac{final\ weight\ of\ crucible - initial\ weight\ of\ crucible}{weight\ of\ sample} * 100 \qquad (8)$$

Determination of Total Protein Content

Protein content was determined using the Kjedahl method as described by Chang and Zhang (2017). One gram **(**1 g) of the sample was weighed and placed into digestion tubes. Two copper sulfates were added to the mixture. Thereafter 20 mL of concentrated sulphuric acid was added and the mixture was digested for 5 h until a clear solution was obtained. The sample digest was cooled to room temperature and 100 mL of water was added. The content of the glass tube was transferred to the distillation units. To the digested sample, 50 mL of 50 % NaOH solution was added to neutralize the pH and to convert NH_4^+ to NH_3^-. Steam was bubbled into the sample to entrain the NH_3^- that was formed. NH_3^- was later condensed. The NH_3^- formed was captured in a 50 mL boric acid solution of 4% that contained 6 drops of Tashiro's indicator. When the

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

NH_3^- reacts with Boric acid, the solution turns from red to violet to green (pH 4.4-5.8) due to the color change of the indicator from acid to basic medium. Then 150 mL of the condensate was captured in the boric acid solution. Titration was done with 0.25 mol/L HCl until the solution had a slightly violet color. The moles of nitrogen atoms in the sample was calculated and then the percentage of protein in the sample.

$$\%\ \text{Nitrogen} = \frac{(ml\ of\ standard\ acid - ml\ of\ blank\ )x\ N\ \ of\ acid * 14.oo7}{weight\ of\ sample\ in\ gram} \quad (9)$$

Where: N is normality, blank is mL of standard acid needed to titrate a reagent blank, % crude protein $is\ \%\ Nitrogen * 6.25$ (10)

Determination of Total Carbohydrate

Total carbohydrate content was calculated by the difference, that is, deducting the sum of the percentages of crude protein, lipid, moisture, ash and crude fiber contents from 100%.

Determination of Minerals

The Atomic Absorption Spectrophotometer was used for the determination of Ca, Zn, and Fe content after digestion with 5 mL of concentrated nitric acid as described by Onyenweaku (2024) with some modifications. The sodium and potassium contents were determined by flame photometry as described by Saifullah *et al*. (2019).

Determination of Vitamins

Determination β-carotene

β-carotene was quantified by adopting the methods described by Harijono *et al. (2012)* and Biswas *et al*. (2011). Exactly 1 g of the sample was transferred to glass test tubes, then 5 mL of acetone (4 ºC) was added, and the tube was held for 15 min with occasional shaking at 4 ºC. The solution was vortexed at a high speed for about 10 min. and centrifuged at 1370 rpm for 10 min. The Supernatant was collected into separate test tubes, and the residues were re-extracted with 5 mL of acetone before centrifuging. The corresponding supernatants of samples were put together and filtered individually using Whatman filter paper. The absorbance of the extracts was determined at a 449 nm wavelength with a UV-Vis spectrophotometer.

Determination of Vitamin C

Ascorbic acid was determined as described by Mutiara *et al*. (2012). Standard indophenol solution (a deep blue dye) was prepared by dissolving 0.05 g of 2,6-dichloro Indophenol in water diluted to 100 mL and filtered. To standardize, 0.053 g of ascorbic acid was dissolved in 90 mL of 20% metaphosphoric acid (used in extracting and titrating the vitamin) and diluted with water to 100 mL. About 10 mL of this solution was pipetted into a small conical flask and titrated with indophenol's solution until a faint pink color persisted for 15 s. Exactly 2 mL of the extracted juice from the calyces prepared from each sample was pipetted into a conical flask individually and 5 mL of 20% metaphosphoric acid (as a stabilizing agent) was added and made up to the 10 mL mark with water. Titration was done with the indophenol solution till a faint pink color persisted for 15 s. The vitamin content in the calyces was calculated.

$$\text{Vitamin C in mg/100 g} = \frac{Titre\ value * 0.212 * 100}{weight\ of\ sample} \quad (7)$$

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

Determination of vitamin E

Tocopherol was analyzed as described by Bassey *et al*. (2021). One gram of each sample was weighed, macerated with 20 mL of n-hexane in a test tube for 10 min. and centrifuged for 10 min. at 5000 rpm. The solution was filtered; 3 mL of each filtrate was transferred into dry test tubes in duplicates and evaporated to dryness in a boiling water bath. Following this, 2 mL of 0.5 N alcoholic potassium hydroxide was added and boiled for 30 minutes in a water bath, then 3 mL of n-hexane was added and shaken vigorously. The n-hexane is transferred into another set of test tubes and evaporated to dryness. 2 mL of ethanol was added to the residue. Another 1 mL of 0.2% ferric chloride in ethanol was also added. Then 1 mL of 0.5 % 1,1-dipyridyl in ethanol was added, followed by the addition of 1 mL of ethanol to make it up to 5 mL. The solution was gently mixed and absorbance was taken at 520 nm against the blank.

Determination of Vitamin B6

Vitamin B6 in the sample was determined as described by Kall (2003) with a few modifications using high-performance liquid chromatography (HPLC). The sample (2 g) was hydrolyzed with 0.1 N hydrochloric acid at 121°C for 30 min., followed by neutralization with sodium hydroxide to a pH of 7.0. The hydrolyzed sample was filtered, and a derivatizing agent (O-phthalaldehyde) was added to convert vitamin B6 into its fluorescent form. The derivatized sample was then injected into an HPLC system equipped with a reverse-phase C18 column, using a methanol-water (60:40 v/v) mobile phase at a flow rate of 1.0 mL/min. The fluorescent derivative was detected with a fluorescence detector set at an excitation wavelength of 340 nm and emission at 450 nm. Quantification was achieved by comparing the peak areas of the sample with those of standard pyridoxine solutions.

Determination of Vitamin B12

Approximately 3 g of flour was mixed with 15 mL of extraction buffer (8.3 mM sodium hydroxide and 20.7 mM acetic acid, 185 pH 4.5) containing 100 µl of sodium cyanide (1% w/v in water) and extracted in 186 boiling water for 30 min. After cooling, 300 µl of α-amylase (50 mg/mL) was added, and the samples were incubated in a water bath (30 min, 37 □C) to allow the breakdown of starch before centrifugation (6,900 × g, 10 min). Residues after centrifugation were kept in 5 mL of extraction buffer and centrifuged again. After combining the supernatants, the final volume was adjusted to 25 mL with the extraction buffer. After filtration, 10 mL of the extracts was purified through an immunoaffinity column and analyzed with a Waters UHPLC system equipped with a photodiode array detector (at 361 nm) and an Acquity HSS T3 C18 column (2.1 × 100 196 mm, 1.8 µm). The mobile phase was a gradient flow of acetonitrile and MilliQ water with 0.025% trifluoroacetic acid (0.32 mL/min), as explained by Xie *et al*. (2018).

Statistical Analysis

The result of the analysis was expressed as mean + standard deviation and SPSS Statistical Package version 27.0 was used to analyze the variances using a one-way analysis of variance (ANOVA) post-hoc test.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

African Journal of Agriculture and Food Science
ISSN: 2689-5331
Volume 8, Issue 3, 2025 (pp. 50-64)
www.abjournals.org

RESULTS AND DISCUSSION

Results

The result of the functional properties, proximate composition, mineral content and vitamin is presented on Table 2-5.

Table 2: Functional composition of composite wheat-soyflour-carrot pomace flour

Sample	SP (%)	WAC (%)	OAC (%)	LGC (%)	SI (%)	Dispersibility
A	$110.43^{g}\pm0.03$	$2.23^{c}\pm0.02$	$1.24^{bc}\pm0.03$	$4.00^{c}\pm0.00$	$90.00^{a}\pm0.00$	$60.00^{bc}\pm0.00$
B	$116.00^{c}\pm0.30$	$2.24^{bc}\pm0.01$	$1.25^{abc}\pm0.02$	$4.00^{c}\pm0.00$	$90.00^{a}\pm0.00$	$62.00^{ab}\pm2.00$
C	$115.20^{d}\pm0.40$	$2.25^{bc}\pm0.01$	$1.28^{a}\pm0.02$	$4.00^{c}\pm0.00$	$90.00^{a}\pm0.00$	$65.50^{a}\pm0.50$
D	$116.60^{b}\pm0.01$	$2.26^{b}\pm0.02$	$1.27^{ab}\pm0.02$	$6.00^{b}\pm0.00$	$71.00^{b}\pm1.00$	$57.00^{cd}\pm1.02$
E	$117.18^{a}\pm0.03$	$2.24^{bc}\pm0.02$	$1.28^{a}\pm0.02$	$6.00^{b}\pm0.00$	$53.50^{c}\pm3.50$	$55.00^{d}\pm3.00$
F	$111.39^{f}\pm0.03$	2.10d±0.01	$1.28^{a}\pm0.01$	$8.00^{a}\pm0.00$	$72.00^{b}\pm2.00$	$50.00^{e}\pm2.00$
G	$112.59^{e}\pm0.03$	$2.66^{a}\pm0.03$	$1.23^{c}\pm0.03$	$8.00^{a}\pm0.00$	$69.00^{b}\pm3.00$	$50.00^{e}\pm5.00$

KEY: SP – swelling power, WAC – water absorption capacity, OAC – oil absorption capacity, LGC – Least gelation capacity, SI – solubility index

Table 3: Proximate composition of composite wheat-soyflour-carrot pomace flour

Sample	Moisture	Crude Ash	Crude Fat	Crude Fibre	Crude Protein	Carbohydrate
A	$9.94^{b}\pm0.03$	$1.59^{f}\pm0.03$	$4.37^{e}\pm0.07$	$1.57^{b}\pm0.02$	$15.47^{f}\pm0.03$	$67.08^{a}\pm0.23$
B	$9.38^{e}\pm0.03$	$0.23^{g}\pm0.03$	$6.16^{d}\pm0.03$	$0.95^{e}\pm0.03$	$20.98^{e}\pm0.03$	$62.33^{b}\pm0.13$
C	$9.84^{c}\pm0.03$	$2.02^{d}\pm0.03$	$4.39^{e}\pm0.03$	$1.74^{a}\pm0.03$	$24.29^{d}\pm0.03$	$57.75^{c}\pm0.13$
D	$8.93^{f}\pm0.05$	$2.08^{c}\pm0.03$	$4.29^{f}\pm0.03$	$1.07^{d}\pm0.03$	$29.80^{c}\pm0.03$	$53.85^{d}\pm0.15$
E	$9.57^{d}\pm0.03$	$2.09^{b}\pm0.03$	$6.93^{c}\pm0.03$	$0.81^{f}\pm0.03$	$32.00^{b}\pm0.02$	vitamins$^{e}\pm0.12$
F	$10.90^{a}\pm0.03$	$1.87^{e}\pm0.03$	$7.42^{b}\pm0.03$	$0.56^{g}\pm0.03$	$32.01^{b}\pm0.03$	$47.27^{f}\pm0.13$
G	$8.31^{g}\pm0.04$	$2.50^{a}\pm0.03$	$9.64^{a}\pm0.03$	$1.36^{c}\pm0.03$	$34.21^{a}\pm0.03$	$44.01^{g}\pm0.14$

Mean within the same column with different superscripts are significantly different at $p<0.05$

KEY: SP – swelling power, WAC – water absorption capacity, OAC – oil absorption capacity, LGC – Least gelation capacity, SI – solubility index

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

African Journal of Agriculture and Food Science
ISSN: 2689-5331
Volume 8, Issue 3, 2025 (pp. 50-64)

Table 4: Mineral composition of wheat-soyflour-carrot pomace flour

Sample	B-Car	Vit C	Vit E	Vit B6	Vit B12	B5	B1
A	$6.33^{a}\pm0.06$	$2.97^{ab}\pm0.06$	$1.35^{b}\pm0.00$	$0.98^{c}\pm0.00$	$0.10^{b}\pm0.00$	$0.27^{f}\pm0.00$	$1.03^{c}\pm0.03$
B	$6.53^{a}\pm0.46$	$2.80^{c}\pm0.00$	$1.36^{b}\pm0.00$	$0.98^{bc}\pm0.01$	$0.00^{e}\pm0.00$	$0.37^{e}\pm0.00$	$1.05^{a}\pm0.00$
C	$6.27^{a}\pm0.00$	$2.94^{b}\pm0.02$	$1.37^{a}\pm0.01$	$0.99^{b}\pm0.00$	$0.05^{c}\pm0.06$	$0.37^{e}\pm0.00$	$0.05^{d}\pm0.00$
D	$6.21^{a}\pm0.00$	$2.97^{ab}\pm0.02$	$1.33^{c}\pm0.01$	$0.98^{c}\pm0.01$	$0.03^{d}\pm0.00$	$0.38^{d}\pm0.00$	$0.04^{d}\pm0.00$
E	$6.27^{a}\pm0.01$	$2.99^{a}\pm0.00$	$0.99^{d}\pm0.00$	$1.78^{a}\pm0.00$	$0.00^{e}\pm0.00$	$0.39^{c}\pm0.00$	$1.04^{b}\pm0.00$
F	$5.00^{b}\pm0.00$	$2.11^{d}\pm0.01$	$0.89^{e}\pm0.01$	$0.36^{d}\pm0.00$	$0.13^{a}\pm0.00$	$0.68^{b}\pm0.00$	$1.02^{bc}\pm0.00$
G	$4.90^{b}\pm0.00$	$2.11^{d}\pm0.01$	$0.98^{d}\pm0.01$	$0.21^{e}\pm0.01$	$0.02^{e}\pm0.01$	$1.67^{a}\pm0.00$	$1.00^{c}\pm0.00$

Mean within the same column with different superscripts are significantly different at $p<0.05$

Table 5: Vitamin content of composite wheat-soyflour-carrot pomace flour

Sample	Fe	Zn	Na	Ca	K
A	$2.93^{b}\pm0.05$	$3.01^{c}\pm0.00$	$23.57^{d}\pm0.00$	$97.02^{d}\pm0.00$	$200.00^{b}\pm0.00$
B	$2.99^{a}\pm0.01$	$3.59^{a}\pm0.00$	$24.00^{c}\pm0.00$	$97.00^{d}\pm0.00$	$199.31^{b}\pm0.76$
C	$3.01^{a}\pm0.01$	$3.11^{b}\pm0.01$	$23.00^{e}\pm0.01$	$97.01^{d}\pm0.00$	$199.90^{b}\pm0.00$
D	$2.00^{d}\pm0.00$	$2.98^{f}\pm0.00$	$24.10^{ab}\pm0.00$	$98.00^{b}\pm0.00$	$207.03^{a}\pm6.11$
E	$2.90^{b}\pm0.00$	$3.01^{c}\pm0.01$	$23.99^{c}\pm0.00$	$97.96^{c}\pm0.00$	$200.33^{b}\pm0.58$
F	$2.06^{c}\pm0.00$	$3.00^{d}\pm0.00$	$24.07^{b}\pm0.06$	$98.04^{a}\pm0.00$	$200.00^{b}\pm0.00$
G	$1.99^{d}\pm0.01$	$2.99^{e}\pm0.00$	$24.11^{a}\pm0.00$	$98.00^{b}\pm0.00$	$201.00^{b}\pm0.00$

Within the same column with different superscripts are significantly different at $p<0.05$

DISCUSSION

Functional properties of the composite flours

The swelling power is linked to the association binding in the starch granules as well as the strength and nature of the micelle network. A high swelling index of a flour sample can be as a result of low amylose concentration in that sample (Adegunwa *et al.*, 2012). The swelling power of the composite flour was in the range of 110.43-117.18 %. The result is higher than the 8.33-12.10 % reported on wheat soybeans and sunflower seeds composite flour by Msugh *et al. (2024)* and the 0.84-7.21 % reported on wheat/white beans composite flour by Oa *et al*. (2016). The difference in the result could be as a result of the carrot pomace or sunflower seeds used in the flours, respectively. The water absorption capacity of the composite flour was 2.10-2.66 %. The result is higher than the 0.50-1.22 % reported on soybean-wheat composite flour by Godswill (2019) and not too far from the 1.75-2.18 % of maize-soybeancomposite flour reported by David *et al*. (2022). The high-water adsorption capacity of the composite flour could be attributed to the high content of carbohydrates in the samples (Emeka-Ike and Ike, 2020). The oil absorption capacity (OAC) contributes to a good mouthfeel while retaining the

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

food flavor (Awuchi *et al*., 2019). The oil absorption rate in this research increases as the quantity of soybeans increases. That is, the higher the soybean content, the higher the protein content, the higher the oil absorption, and the better the mouthfeel and flavor (Abah *et al*., 2020). Flours with a good amount of OAC can be instrumental in formulating foods like sausages, whipped toppings, angel and sponge cakes, and chiffon desserts (Godswill, 2019). Gelation capacity is the ability to form a gel-like texture when cooked (Shrestha *et al.*, 2021). A lower gelation capacity suggests that the flour will have a softer, more fragile texture when cooked (Msugh *et al.*, 2024). Samples A, B, and C have a low gelation capacity. This is due to the high starch content in them; the amylose component of starch can re-associate, forming a network of hydrogen bonds that traps water, creating a gel-like structure when heat is applied. Samples F and G have a high LGC due to the low starch content and high protein content (Emeka-Ike & Ike, 2020). The solubility index shows the extent to which the component of the flour or powder material dissolves in water (Nishad *et al*., 2017). Samples A, B, and C have the same solubility index and it is the highest among the samples followed by F, G and D. The high solubility index of samples A, B and C implies they can digest faster. Therefore, it is a better option for most food formulations than the rest of the samples (David *et al*., 2015). The dispersibility of the composite flour was in the range of 50-60 %. Dispersibility of the flour is the ability of the flour to rehydrate with water without the formation of lumps (Palamthodi *et al*., 2020). In this research, sample C has the highest dispersibility (65.50 %), and samples F and G have the lowest value (50 % each). The result is lower than 75.9-82.1 % reported by Mohajan *et al*., (2018) on soybean flour and within 20-70 % reported by Adeola *et al*., (2017) on water yam, pigeonpea and carrot pomace composite flour. The high dispersibility of the samples shows that they can form a good constitution in water, producing a fine paste (Awolu, 2017).

Proximate Composition of the Composite Flour

The proximate composition of the composite flour is presented in Table 3, which shows the moisture content of the flours in the range of 8.31-10.90 % which is less than the 10.20-12.22 % reported on wheat-soybean and moringa composite flour by Verem *et al. (2021)* but within the 8.28-10.60 % range of values reported on maize-soybean composite flour by David *et al*. (2022). Moisture content is a vital parameter in the storage behavior of flours. Low moisture content enhances the long shelf life and storage stability of the products (Oa *et al*., 2016). According to Godswill (2019), flours with moisture content less than 10 % exhibit a long shelf life. In this research, all the samples except sample F have a moisture content of less than 10 % implying a long shelf life. The ash content in this research was 0.23-2.50 %. The ash content increases as the content of soybean increases in the samples except for samples B and F. The result of this study can be compared with the 0.77-2.85 % reported by Ekunseitan *et al. (2017)* on wheat mushroom and cassava composite flour and within 0.02-3.95 % of soft wheat and asomdwee cowpea flour reported by David *et al*. (2015). Ash content shows the measure of inorganic matter present in the flour samples (Abe-Inge *et al*., 2020). Sample G has the highest inorganic matter content, while sample B has the lowest content. The crude fat content of the samples was in the range between 4.29-9.64 %, the values are higher as compared to the result reported on wheat-tiger nut composite flour by Oke *et al*., (2016) and 1.52-2.37 % reported on wheat, soybean and moringa leaf composite flour by Verem *et al*., (2021). It can be seen that the sample has enough fat, which can be useful in food formulations. The samples had a crude fiber content of 0.56-1.74 %. The fat content was less than the literature (0.74-2.51 %) reported by Ekunseitan *et al. (2017)* on wheat mushroom and cassava composite flour. The low fiber

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

content may result in minimal cooking loss, though high dietary fiber in food is also important in preventing some diseases like constipation, stroke, obesity and cardiovascular illnesses (Abe-Inge *et al*., 2020). The crude protein (15.47-34.21 %) in the sample increases as the quantity of soybeans increases. Makinde and Taibat (2018) reported a lesser value (3.15-20.45%) on wheat corn almond and coconut composite flour as compared to these findings. The result is also higher than the 16.00-28.13 % reported by Iwe *et al. (2016)* on FARO 44 rice African yam bean and brown cowpea seeds in composite flour. The composite flour can be a good source of protein in food fortification. The carbohydrate content of the flour decreases as the quantity of soybeans increases (67.08-44.01 %) nevertheless, the flour is a good source of carbohydrates and can be used in the production of food like bread and doughnuts. The same trend was also reported by David *et al. (2022)* on maize-soybean composite flour.

Minerals Contents of the Composite Flour

The mineral content of the composite flour as presented in Table 4 shows Fe content in the range of 1.99-3.01 mg/100 g. This result is similar to the 1.98-3.08 mg/100 g reported on maize-soybean flour by David *et al. (2022)* and the 1.2-3.1 mg/100 g on wheat-soybean flour by Akubor and Fayashe (2018). Food produced from this flour will prevent fatigue, weakness and shortness of breath, which are some illnesses caused by the deficiencies of Fe. The Zn content was 2.98-3.59 mg/100 g. The result is a little higher than the 2.85-2.95 mg/100 g reported on wheat-soy composite (Issa Khan *et al*., 2012) and lower than the 3.40-8.3 mg/100 g of cassava, rice, and banana composite flour reported by Udomkun *et al*. (2019). The presence of the Zn in the flour indicates its nutritional value as Zn is responsible for several bodily functions such as blood clotting, taste and wound healing (Skalnaya & Skalny, 2018). The Na content in the study was 23.00-24.11 mg/100g. The result is higher than the 18.10-18.30 mg/100g reported on wheat-soybean composite flour by Akubor and Fayashe (2018) and less than the 22.67-46.78 mg/100g reported on wheat-mushroom and cassava composite flour by Ekunseitan *et al*. The calcium content (97.00-98.04 mg/100g) is higher than the 9.32-14.04 mg/100g reported on maize-soybean composite flour reported by David *et al*. The K content of the flour was 199.31-207.03 mg/100 g and less than 73.50-143.6 mg/100 g of wheat-soybean composite flour reported by Akubor and Fayashe (2018). The presence of these minerals is an indication that flour is a good source of minerals for food formulation.

Vitamins Content of the Composite Flour

The vitamin composition of the composite flour shows the presence of β-carotene in the range of 4.90-6.53. β-carotene is an antioxidant and anti-inflammatory that protects cells from damage (Zheng *et al*., 2022). Vitamin C in this study ranged from 2.11-2.99. Vitamin C helps form collagen and wound healing (Eliseeva and Mironenko, 2018). The vitamin E content of the sample ranged from 0.89-1.37. Vitamin E helps in the reduction of oxidative stress, protection of cell membranes and prevention of some diseases (Rizvi *et al*.,2014). Vitamin B6 was 0.21-1.78, while vitamin B12 was 0.02-0.13 though absent in samples B and E. These vitamins prevent stroke and cardiovascular disorders (Kataria *et al*., 2021). Vitamin B5 (0.27-1.67) helps in the formation of coenzymes, which is key for energy metabolism (Maqbool *et al.,* 2017). B1 (0.04-1.05) is very important for proper cell functioning (Mrowicka *et al.,* 2023).

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

CONCLUSION

The composite flours were made by combining wheat, soybeans, and carrot pomace in varying proportions. The functional analysis, proximate composition, and mineral and vitamin content showed that the composite flour can be used in the production of several food products, such as sausages, noodles, bread, whipped toppings, sponge cakes and many others. Formulation C had the most functional and nutritional characteristics. However, lab tests for such products can be done to allow subsequent commercialization of the composite flours.

REFERENCES

Abah, C. R., Ishiwu, C. N., Obiegbuna, J. E., & Oladejo, A. A. (2020). Nutritional composition, functional properties and food applications of millet grains. *Asian Food Science Journal*, *14*(2), 9-19.

Abd Elmoneim, O., & Bernhardt, R. (2018). Combination effect of germination and fermentation on functional properties of sorghum flour. *Current Journal of Applied Science and Technology*, *30*(1), 1-12.

Abe-Inge, V., Asaam, E. S., Agbenorhevi, J. K., Bawa, N. M., & Kpodo, F. M. (2020). Development and evaluation of African palmyra palm (Borassus aethiopum) fruit flour–wheat composite flour noodles. *Cogent Food & Agriculture*, *6*(1), 1-20

Adegunwa, M. O., Bakare, H. A., & Akinola, O. F. (2012). Enrichment of noodles with soy flour and carrot powder. *Nigerian Food Journal*, *30*(1), 74-81.

Adeola, A. A., Idowu, M. A., Adepoju, Y. D., Adesina, O. T., Oyewade, S., Olunlade, B. A., & Ohizua, E. I. R. (2017). Chemical, functional and sensory properties of water yam, pigeonpea and carrot pomace flour blends. *Annals: Food Science & Technology*, *18*(1). 57-64

Adeoye, B. K., Adeleye, K. A., Ani, I. F., Akinlade, A. R., Ngozi, E. O., & Ajuzie, N. C. (2019). Quality evaluation of bread enriched with mushroom powder. *IOSR J. Environ. Sci. Toxicol. Food Technol.,(IOSR-JESTFT)*, *13*(6), 11-18.

Agume, A. S. N., Njintang, N. Y., & Mbofung, C. M. F. (2017). Effect of soaking and roasting on the physicochemical and pasting properties of soybean flour. *Foods*, *6*(2), 1-10

Akinyede, A. I., Oluwajuyitan, T. D., & Dada, J. B. (2020). Influence of substitution on amino-acid profile, physicochemical and sensory attributes of breakfast cereal from millet, soy cake, rice bran and carrot pomace blends. *MOJ Food Process Technol*, *8*(1), 19-27.

Akubor, P. I., & Fayashe, T. O. (2018). Chemical composition, functional properties and performance of soybean and wheat flour blends in instant fried noodles. *South Asian Journal of Food Technology and Environment*, *4*(2), 690-699.

Awolu, O. O. (2017). Optimization of the functional characteristics, pasting and rheological properties of pearl millet-based composite flour. *Heliyon*, *3*(2), 1-17

Awuchi, C. G., Igwe, V. S., & Echeta, C. K. (2019). The functional properties of foods and flours. *International Journal of Advanced Academic Research*, *5*(11), 139-160.

Azkia, M. N., Wahjuningsih, S. B., & Wibowo, C. H. (2021). The nutritional and functional properties of noodles prepared from sorghum, mung bean and sago flours. *Food Res*, *5*(2), 65-69.

Bassey, N. O., Eteng, O. E., Nelson, V. A., Essien, N. M., Udo, E. P., Ogar, B. A., & Udosen, E. O. (2021). Proximate and Phytochemical Screening: Evaluation of Minerals and Vitamin Composition of (Hypoestes rosea) Plant harvested in Calabar, Cross River State, Nigeria. *FUDMA JOURNAL OF SCIENCES*, *5*(4), 229-234.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

Biswas, A. K., Sahoo, J., & Chatli, M. K. (2011). A simple UV-Vis spectrophotometric method for determination of β-carotene content in raw carrot, sweet potato and supplemented chicken meat nuggets. *LWT - Food Science and Technology*, *44*(8), 1809–1813.

Chang, S. K., & Zhang, Y. (2017). Protein analysis. *Food analysis*, 315-331.

Chepkosgei, T. M., & Orina, I. (2021). Quality and sensory properties of instant fried noodles made with soybean and carrot pomace flour. *African Journal of Food Science*, *15*(3), 92-99.

David, O. A., Daniel, E. E., Agbenu, A. C., Nyerere, A. C., Praise, A. J., & Ape, S. (2022). Nutritional composition and functional properties of maize–soya bean composite flour. *Global Journal of Research in Chemistry and Pharmacy*, *1*(01), 007-017.

David, O., Arthur, E., Kwadwo, S. O., Badu, E., & Sakyi, P. (2015). Proximate composition and some functional properties of soft wheat flour. *International Journal of Innovative Research in Science, Engineering and Technology*, *4*(2), 753-758.

Ekunseitan, O. F., Obadina, A. O., Sobukola, O. P., Omemu, A. M., Adegunwa, M. O., Kajihausa, O. E., ... & Keith, T. (2017). Nutritional composition, functional and pasting properties of wheat, mushroom, and high quality cassava composite flour. *Journal of food processing and preservation*, *41*(5), 1-8

Eliseeva, T., & Mironenko, A. (2018). Vitamin C (ascorbic acid)–description, benefits and where it is found. *Journal of healthy nutrition and dietetics*, *2*(4), 33-44.

Ellefson, W. C. (2017). Fat analysis. *Food analysis*, 299-314.

Emeka-Ike, P. C., & Ike, C. C. (2020). Evaluation of physicochemical properties and microbiological safety of pumpkin (Cucurbita pepo) seed composite flours. *GSC Biological and Pharmaceutical Sciences*, *12*(3), 061-072.

Godswill, A. C. (2019). Proximate composition and functional properties of different grain flour composites for industrial applications. *International Journal of Food Sciences*, *2*(1), 43-64.

Gull, A., Prasad, K., & Kumar, P. (2015). Effect of millet flours and carrot pomace on cooking qualities, color and texture of developed pasta. LWT - Food Science and Technology, 63(1), 470–474.

Harijono, T. M. K., Estiasih, T., & Sriwahyuni, E. (2012). Nutrient Content of Kelor (Moringa Oleifera Lamk) Leaves Powder Under Different Blanching Methods. *Food and Public Health*, *2*(7), 296-300.

Harijono, T. M. K., Estiasih, T., & Sriwahyuni, E. (2012). Nutrient Content of Kelor (Moringa Oleifera Lamk) Leaves Powder Under Different Blanching Methods. *Food and Public Health*, *2*(7), 296–300.

Harris, G. K., & Marshall, M. R. (2017). Ash analysis. *Food analysis*, 287-297.

Ikram, A., Rasheed, A., Ahmad Khan, A., Khan, R., Ahmad, M., Bashir, R., & Hassan Mohamed, M. (2024). Exploring the health benefits and utility of carrots and carrot pomace: a systematic review. *International Journal of Food Properties*, *27*(1), 180-193.

Issa Khan, M., Muhammad Anjum, F., Pasha, I., Sameen, A., & Nadeem, M. (2012). Nutritional quality and safety of wheat-soy composite flour chapattis. *British Food Journal*, *114*(2), 239-247.

Iwe, M. O., Onyeukwu, U., & Agiriga, A. N. (2016). Proximate, functional and pasting properties of FARO 44 rice, African yam bean and brown cowpea seeds composite flour. *Cogent Food & Agriculture*, *2*(1), 1-10

Kall, M. A. (2003). Determination of total vitamin B6 in foods by isocratic HPLC: a comparison with microbiological analysis. *Food Chemistry*, *82*(2), 315-327.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

Kataria, N., Yadav, P., Kumar, R., Kumar, N., Singh, M., Kant, R., & Kalyani, V. (2021). Effect of vitamin B6, B9, and B12 supplementation on homocysteine level and cardiovascular outcomes in stroke patients: A meta-analysis of randomized controlled trials. *Cureus*, *13*(5). 14958

Luca, M. I., Ungureanu-Iuga, M., & Mironeasa, S. (2022). Carrot pomace characterization for application in cereal-based products. *Applied Sciences*, *12*(16), 1-15

Makinde, F. M., & Taibat, A. A. (2018). Quality characteristics of biscuits produced from composite flours of wheat, corn, almondand coconut. *Annals: Food Science & Technology*, *19*(2). 216-223

Maqbool, M. A., Aslam, M., Akbar, W., & Iqbal, Z. (2017). Biological importance of vitamins for human health: A review. *J. Agric. Basic Sci*, *2*(3), 50-58.

Mauer, L. J. (2024). Moisture and total solids analysis. In *Nielsen's Food Analysis* (pp. 233-260). Cham: Springer International Publishing.

Mohajan, S., Orchy, T. N., & Farzana, T. (2018). Effect of incorporation of soy flour on functional, nutritional, and sensory properties of mushroom–moringa-supplemented healthy soup. *Food science & nutrition*, *6*(3), 549-556.

Mrowicka, M., Mrowicki, J., Dragan, G., & Majsterek, I. (2023). The importance of thiamine (vitamin B1) in humans. *Bioscience Reports*, *43*(10), 1-18.

Msugh, C. T., Adah, C. A., & Asemave, K. (2024). Quality evaluation of composite flour from wheat, soybean and sunflower seeds for bread making. *African Journal of Agriculture and Food Science. 7*(3), 265-283

Mutiara, K. T., Harijono, H., Estiasih, T., & Sriwahyuni, E. (2012). The nutrient content of kelor (Moringa oleifera Lamk) leaves powder under different blanching methods. *Food and Public Health*, *2*(6): 296-300

Nishad, P. K., Maitra, S., & Nilima, J. (2017). Physiochemical, functional and sensory properties of developed health drink from minor millets. *International Journal of Home Science*, *3*(2), 503-506.

OA, O., Ubbor, S. C., & Okakpu, C. J. (2016). Use of composite flours of wheat and white beans (Phaseolus vulgaris) in bread making: influence on quality indices.

Oke, E. K., Idowu, M. A., & Omoniyi, S. A. (2016). Proximate, functional, pasting and rheological properties of wheat-tiger nut composite flour. *Annals: Food Science & Technology*, *17*(2), 411-421

Onyenweaku, E. O. (2024). Functional Properties and Heavy Metal Content of Some Swallows made from Edible Flours. *Nigeria Agricultural Journal*, *55*(1), 118-124

Palamthodi, S., Shimpi, S., & Tungare, K. (2021). A study on nutritional composition and functional properties of wheat, ragi and jackfruit seed composite flour. *Food Science and Applied Biotechnology*, *4*(1), 63-75.

Rizvi, S., Raza, S. T., Ahmed, F., Ahmad, A., Abbas, S., & Mahdi, F. (2014). The role of vitamin E in human health and some diseases. *Sultan Qaboos University Medical Journal*, *14*(2), 157-168

Saifullah, W., Khan, N., Mengal, P. W., Baqi, A., & Manan, A. (2019). Profiling of various elements in Haloxylon griffithii and Convolvulus leiocalycinus using atomic absorption spectroscopy and flame photometry. *Pure and Applied Biology*, *8*(2), 1535-1542.

Sakare, P., Jadhav, M. L., & John, H. (2020). Study on physical properties of soaked soybean and functional properties of germinated soy flour. *Journal of The Institution of Engineers (India): Series A*, *101*, 787-794.

Shrestha, S., van't Hag, L., Haritos, V. S., & Dhital, S. (2021). Lupin proteins: Structure, isolation and application. *Trends in Food Science & Technology*, *116*, 928-939.

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL

Skalnaya, M. G., & Skalny, A. V. (2018). Essential trace elements in human health: a physician's view. *Tomsk: Publishing House of Tomsk State University*, *224*, 42-64.

Udomkun, P., Tirawattanawanich, C., Ilukor, J., Sridonpai, P., Njukwe, E., Nimbona, P., & Vanlauwe, B. (2019). Promoting the use of locally produced crops in making cereal-legume-based composite flours: An assessment of nutrient, antinutrient, mineral molar ratios, and aflatoxin content. *Food Chemistry*, *286*, 651-658.

Verem, T. B., Dooshima, I. B., Ojoutu, E. M., Owolabi, O. O., & Onigbajumo, A. (2021). Proximate, chemical and functional properties of wheat, soy and moringa leaf composite flours. *Agricultural Sciences*, *12*, 18-38.

Xie, C., Coda, R., Chamlagain, B., Edelmann, M., Deptula, P., Varmanen, P., ... & Katina, K. (2018). In situ fortification of vitamin B12 in wheat flour and wheat bran by fermentation with Propionibacterium freudenreichii. *Journal of Cereal Science*, *81*, 133-139.

Zheng, W. V., Xu, W., Li, Y., Qin, J., Zhou, T., Li, D., ... & Chen, Z. (2022). Anti-aging effect of β-carotene through regulating the KAT7-P15 signaling axis, inflammation and oxidative stress process. *Cellular & Molecular Biology Letters*, *27*(1), 1-26

Article DOI: 10.52589/AJAFS-KDANUGSL
DOI URL: https://doi.org/10.52589/AJAFS-KDANUGSL