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Nutritional and Phytochemical Profiling of Snack Foods Enhanced with Cashew Pomace

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Abstract

Cashew pomace (CP), a residual by-product of cashew apple processing, has long been regarded as agro-industrial waste. Its potential as a rich source of dietary fibre and antioxidants has been underexplored. Thus, the study aimed to investigate its potential application as a functional ingredient that could enhance the nutritional profile and health-promoting properties of snack products. Fresh cashew fruits were harvested from the biological garden of the Nigerian Stored Products Research Institute (NSPRI). Juice was extracted, and the resulting by-product (CP) was dried for 72 hours and then homogenized. Functional snack formulations were developed by fortifying wheat flour (WF) with cashew pomace flour (CPF) at inclusion levels of 2.5%, 5%, and 10% to produce chin-chin, cookies, and puff-puff. Proximate analysis, functional properties, mineral analysis, antinutrient tests, and antioxidant tests were conducted. Incorporation of CPF at 2.5%, 5%, and 10% significantly increased ash, fibre, and carbohydrate content. Compared to the control sample, fortified snacks showed increased bulk density, water absorption, and swelling capacity. Sensory scoring using a nine-point hedonic scale indicated that CPF can be incorporated in the range of 2.5–5% for snack purposes, whereas higher substitution levels negatively affected some sensory attributes. Although fortification enhanced nutritional quality, it also resulted in increased levels of phytates, tannins, and saponins, indicating potential mineral bioavailability constraints. Incorporating cashew pomace into functional snacks at controlled levels offers a sustainable approach to snack fortification and food waste valorization, with further processing required to mitigate anti-nutritional effects.

Keywords: Cashew pomace, functional foods, health, bio-fortification, food waste

Introduction

Cashew (*Anacardium occidentale*) is a prominent tree nut crop, ranking third next to almond and walnut. Since cashew nuts are so nutritious and delicate, they have a permanent place on the national and international market shelves (Malhotra *et al.*, 2013). However, Cashew apple is an underutilized fruit form (false fruit) from cashew plantations. The cashew apple is a rich source of minerals, vitamins, particularly vitamin C, fibre, starch, proteins, polyphenols, polysaccharides, and antioxidants (Aluko *et al.,* 2023). As a result, it is a key component of many indigenous traditional medicines that treat a wide range of illnesses (Chen *et al.,* 2023). After gathering raw cashew nuts, cashew apples are typically thrown away during cashew plantation harvest operations. But as their nutritional potential is recognised, their use in creating products with added value has increased. Cashew apple jam, sauce, ketchup, and pickle are the only countable goods that may be made from whole apples. Additionally, with a regulated fermentation process, the cashew apple's clear liquid phase could be used to make a limited number of fermented beverages, such as vinegar and feni (cashew apple wine), as well as non-fermented ones, such as juice, syrup, and jelly (Runjala and Kella, 2017).

One of the main by-products or waste materials from the cashew apple processing industry is cashew apple pomace (CAP), the remaining solid matrix from liquid phase processing that is not used (Jeyavishnu *et al.*, 2021). Since cashew apples and cashew apple pomace are perishable, they cannot be used effectively for a variety of products, and their high perishability also limits global trade. However, if it is dried, dehydrated, and ground into a powder, it can be stored for a longer period (Preethi *et al.*, 2021). Drying also eliminates the cashew apple's acridity and disagreeable smell, and the cashew apple pomace flour's (CAPF) anti-nutritional factor, tannin content, is decreased significantly (Ojediran *et al.*, 2024). Snacks and cereal-based extrudates, primarily made from wheat, rice, and maize flour, dominate the current market, but these products lack certain essential minerals and vital nutrients. Cashew apple is known to have a unique nutritional profile as it contains phytochemicals, vitamins, minerals, and dietary fibre (Aluko *et al.*, 2023).

In recent years, the increasing consumption of snacks and junk food has raised significant public health concerns. According to Murugesan and Mahendraprabu (2024), these "junk foods," though widely popular for their convenience and taste, contribute minimally to nutritional well-being and have been linked to rising incidences of obesity, diabetes, and other non-communicable diseases, especially in developing countries. As the demand for healthier food options continues to grow, there is an urgent need to reformulate conventional snack foods by incorporating functional ingredients that offer added health benefits, such as reduced risk of diabetes, heart disease, and supporting immune and digestive functions.

Methodology

Procurement of Materials

Mature and ripe cashew fruits were sourced from a local market under clean and safe conditions. Quality refined wheat flour, margarine, salt, vanilla flavour, yeast, baking powder, and vegetable oil were also purchased from a local market in Ibadan.

Preparation of Cashew Pomace Flour

The method described by Akubor (2016) was employed. The fresh cashew fruits were sorted to remove bruised and spoiled fruits, after which they were washed in enough tap water to remove soil, dirt, impurities, and other foreign materials. The nuts of the washed cashew fruits were then removed, and the cashew apple was blended briefly for easy extraction of the juice. The cashew juice was extracted by squeezing using a muslin cloth. The pomace obtained was spread out on a clean tray and dried in a Parabolic Shaped Solar Dryer (PSSD) to constant weight for 48 h, resulting in a final moisture content of 9%.

Formulation of the Composite Flour

Cashew pomace flour (CPF) was incorporated into wheat flour (WF) formulations at substitution levels of 2.5%, 5%, and 10%, as detailed in Table 1.

Preparation of Fortified Cashew Chin-chin

A composite flour blend (140 g) was prepared and combined with sugar (10 g), margarine (7 g), vanilla flavour (2 g), and a pinch of salt to formulate the snack base. The mixture was thoroughly homogenized to ensure uniformity. Chin-chin was prepared according to the method of Adewoyin *et al. (*2025) with some modifications and fried at a temperature of about 150°C.

The dry ingredients (flour, sugar, salt, and vanilla flavour) were weighed and mixed thoroughly. Margarine was added and rubbed in until thoroughly kneaded. A little amount of water was added to form a soft dough. The resulting dough was thinly rolled on a rolling board to give a uniform thickness; after which it was cut into cubes using a knife. The dough cubes were deep-fried in pre-heated vegetable oil in an aluminium pot for about 5 minutes until they were golden brown. The chin-chin was then drained and cooled.

Preparation of Fortified Cashew Cookies

The cookies were prepared according to Rai *et al.* (2014) with some modifications. A dough mixture was prepared using 100 g of composite flour, 50 g of sugar, 50 g of margarine, 20 g of egg, and 4 g of baking powder. The ingredients were thoroughly combined to achieve a uniform consistency suitable for the snack formulation. The butter and sugar were beaten by hand for about 3 minutes until a soft and fluffy texture was achieved. An already whisked egg was then added to the formed mixture and mixed until fully incorporated. The dry ingredients (flour, baking powder, and sugar) were mixed in another bowl and added to the creamed mixture. Manual mixing continued until a dough was formed. The resulting dough was moulded into round balls and was arranged in a pre-heated oven (at 170°C). The cookies were allowed to bake for 12 minutes at a temperature of 135°c showing a golden-brown colour.

Preparation of Fortified Cashew Puff-puff

According to Akubor (2004), 100 g of composite flour was prepared and mixed with 40 g of sugar and 3 g of yeast. The dry ingredients (flour, sugar, and yeast) were mixed thoroughly by hand. Water was then added to the dry ingredient mixture and mixed further, manually. The resulting dough was left to ferment for about an hour. After fermentation, the dough was reshaped into small round balls and deep fried at 150°c in pre-heated vegetable oil for 3 min in an aluminium frying pot until an even golden-brown colour was observed.

Proximate analysis

The proximate composition of the samples was analysed following the standardized procedures outlined by the Association of Official Analytical Chemists (AOAC, 2016). Moisture content was determined using the air oven method at 105°C (Association of Official Analytical Chemists; AOAC 952.08, 2016) until a constant weight was achieved. Ash content was measured using a gravimetric method (AOAC 930.30, 2016), incinerating the samples at 600°c until a constant weight was achieved. Crude protein content was determined using the Kjeldahl method (AOAC 992.23, 2016). Total protein was multiplied by a protein factor of 6.25. Crude fibre was determined following (AOAC 985.29, 2016) by digesting the samples and precipitating the fibre. Total fat was determined according to the acid hydrolysis method (AOAC 948.15, 2016) using a Soxhlet extractor. The total carbohydrate content was calculated by difference.

Functional properties

Bulk density, water absorption capacity, starch solubility, swelling capacity, swelling power, oil absorption capacity, and water absorption capacity were measured on the various composite samples, including the control sample. Analysis of functional properties was carried out according to the AOAC 2016 guidelines.

Mineral analysis

Ash samples were obtained by incinerating 2 g of each formulation in a crucible using a muffle furnace. The resulting ash was digested with 5 ml of 2M hydrochloric acid (HCl) and was gently heated for 20 min. The digest was then filtered into a 100 ml volumetric flask, and the filtrate was subsequently used for mineral analysis. Concentrations of calcium, magnesium, and potassium were tested for in the control and composite samples following (AOAC 985.35, 2016).

Anti-nutrient analysis

The anti-nutritional factors analysed included tannins, saponins, and phytates in all the composite samples, including the control. Tannin content was determined by the Folin-Denis spectrophotometric method described by Pearson (1976). Phytic content was determined as described by Mecance and Widowsen (1935) using the permanganate titration method. Total saponin content was determined through spectrophotometry according to the Association of Official Analytical Chemists referenced procedures (Chemists, 1990).

Antioxidant analysis

The antioxidant properties of the samples were assessed by determining total phenolic, total flavonoid, and total carotenoids. Analysis was carried out in accordance with standard AOAC (2016) procedures.

Sensory analysis

The composite flours were used to produce three snack products: chin-chin, cookies, and puff-puff. Sensory evaluation of snacks prepared from the various flour blends was conducted using a panel of 20 individuals drawn from the general public. The panel consisted of semi-trained panelists aged 20–60 years who were regular consumers of baked and fried snack products. Panelists were screened for willingness to participate and the absence of food allergies or sensory impairments, and included researchers and university students. The evaluation was conducted while the samples were still fresh. Each panelist evaluated the samples by observing, tasting, and scoring them. The products were assessed for aroma, appearance, taste, texture, and overall acceptability using a nine-point hedonic scale, where 9 = liked extremely and 1 = disliked extremely. Panelists were also allowed to provide general comments on the samples. The sensory evaluation was carried out at the Nigerian Stored Products Research Institute (NSPRI). Individual panelist scores were averaged, and the resulting data were statistically analysed.

Statistical analysis

All analyses were carried out in duplicate, and the data generated were subjected to a One-way analysis of variance (ANOVA) with the aid of IBM Statistics version 23 (IBM Corporation, USA) to analyse the results. Duncan's multiple range tests were used to estimate the statistical difference among mean values of the various treatments at a 5% level of significance. Results were reported as means ± standard error.

Results and Discussion

The proximate analysis indicated the superiority of wheat flour fortified with cashew pomace flour (WF+CPF) over wheat flour (WF) in terms of ash content, crude fibre content, and carbohydrate content. The ash content, which determines the mineral content, was significantly higher in 10%CPF (0.55%) than in the control (0.43%), as shown in Table 2. Also, the WF+CPF samples were found to be a good source of fibre when compared with the control. The table shows the six key nutritional parameters across the four sample groups: Control, 2.5%, 5%, and 10% WF+CP. The moisture content decreases with higher CP levels. The control sample has the highest moisture (11.85%), while 10% WF+CP has the lowest (10.68%). The gradual reduction in moisture content at higher CPF levels may be attributed to the lower hygroscopic nature of dried pomace relative to wheat starch, as well as the stronger water-binding capacity of fibre-bound water, which is less available as free moisture. This reduction is advantageous, as lower moisture levels are associated with improved shelf stability and reduced microbial susceptibility (Adbel-Aziz *et al.*, 2016). The significant drop at 10% suggests WF+CP has a drying effect or binds less water. The ash content increases gradually with increasing CPF inclusion. Ash reflects total mineral content. There was a sharp increase in crude fibre content, especially at 10% WF+CP. Dietary fibre is essential for digestive health (Gill *et al.*, 2021). The marked increase in crude fibre content is linked to the high proportion of insoluble dietary fibre in cashew pomace, including cellulose, hemicellulose, and pectic substances. These fibre fractions persist through drying and milling and are incorporated directly into the wheat flour matrix, thereby enhancing the physiological fibre content of the final product. Comparable fibre increases have been reported in wheat-based products fortified with grape pomace and apple pomace, where fibre enrichment ranged from 2–3 fold depending on inclusion level (Kurcubic *et al.*, 2024). The fat content of the samples shows a decrease with higher WF+CP levels. The control sample has 2.08%, while 10% WF+CP drops to 0.78%. Lower fat content may be desirable for calorie reduction. WF+CP likely dilutes fat concentration or replaces fat-rich ingredients. There is a slight decrease in protein content across all samples, and this can be attributed to dilution or lower protein content in WF+CP. However, the change is not significant, suggesting WF+CP maintains reasonable protein levels. There is also a gradual increase in carbohydrate content. This means that CPF likely contributes more carbohydrates, especially from the carbohydrate-rich cashew pomace. This could affect energy density and glycemic index (Darko *et al.*, 2024).

Functional components such as bulk density, water absorption, and swelling capacity were also found to be high in WF+CP samples compared to the control sample (Table 3). The significant increase in water absorption capacity with CPF inclusion is primarily due to the high dietary fibre content and the presence of hydrophilic polysaccharides such as pectin and hemicellulose in cashew pomace. These compounds possess numerous hydroxyl groups capable of forming hydrogen bonds with water molecules, thereby enhancing water retention within the flour matrix (Karim *et al.*, 2024). The water absorption capacity of the samples rises steadily from 186.25% (control) to 196.55% (10% WF+CP). According to Salehi (2020), enhanced water absorption benefits dough hydration and moisture retention, thereby increasing softness and shelf life in baked goods. Similar increases in water absorption have been reported in mango pomace and apple pomace fortified wheat flours, where fibre-induced hydration was identified as the dominant mechanism (Gumul *et al.*, 2023). Bulk density increases slightly with increasing CPF inclusion from 0.73 g ml^{-1} in the control to 0.79 g ml^{-1} in 10% WF+CP. Higher bulk density suggests better packaging efficiency and may influence the texture of the final product (Ziegelmeier *et al.*, 2015). The increase could be due to the fibrous nature of cashew pomace. Interestingly, oil absorption decreases slightly with increasing CPF, peaking at 207.55% in the control and dropping to 204.35% at 10% WF+CP. Lower oil absorption may reduce greasiness in fried products, which could be desirable for health-conscious formulations. Dispersibility remained relatively stable across all samples, ranging from 73.00% to 74.50%. This consistent dispersibility indicates that CPF inclusion does not significantly affect the flour's ability to reconstitute in water, which is important for instant food applications (Awuchi *et al.*, 2019). An increase was observed in swelling capacity from 5.50% in the control to 9.50% in the 10% WF+CP blend. Higher swelling capacity suggests improved water retention and potential for greater volume in baked products, likely due to the fibre content of cashew pomace. Swelling power decreased with more CPF, from 2.37 in the control to 1.41 at 10% WF+CP. This reduction may indicate a dilution of starch concentration, physical interference by fibre particles, or reduced gelatinization capacity, which could affect product texture. Finally, starch solubility dropped significantly from 8.40% in the control to 3.30% at 5% WF+CP, then slightly rose to 4.80% at 10% WF+CP, which supports the hypothesis of restricted starch gelatinization. Lower solubility may reflect reduced starch availability or altered starch structure resulting from CF inclusion, thereby impacting viscosity and mouthfeel.

The chin-chin samples made were scored between 5 and 7 on the 9-point hedonic scale, as seen in Table 4, indicating that the chin-chin made was at least liked slightly. All samples showed comparable aroma scores, with no significant differences (Table 4). Appearance was significantly affected by WF+CP supplementation. The control sample had the highest score, while 5% WF+CP showed the lowest. This may be due to colour changes, surface texture introduced by the fibrous nature of WF+CP. Taste improved significantly at 2.5% WF+CP, indicating that low-level supplementation enhances flavour and taste. However, taste declined at 10%, possibly due to bitterness or off-flavours at higher WF+CP concentrations. The texture remained consistent across all samples, suggesting that WF+CP does not negatively impact mouthfeel or structural integrity. The highest overall acceptability was recorded at 2.5% WF+CP, slightly surpassing the control. This indicates an optimal balance of sensory attributes at low supplementation levels. The overall acceptability declined at 10%, which is likely due to its reduced appearance and taste scores.

The Cookies made were scored between 5 and 7 on the nine-point hedonic scale, as seen in Table 5, indicating that the chin-chin made was at least liked slightly. All samples had statistically similar scores for aroma, with values ranging from 6.25 to 7.25. Thus, there is no compromise in aromatic appeal with the CPF inclusion. Appearance, taste, and texture scores were also statistically similar across all samples. A significant difference was observed in overall acceptability. The control sample received the highest score, followed closely by 2.5% and 5% WF+CP formulations. The 10% WF+CP sample scored significantly lower**,** indicating that excessive inclusion of cashew pomace flour negatively affects consumer preference.

The Puff-puff samples made were scored between 5 and 7 on the nine-point hedonic scale, as seen in Table 6, indicating that the chin-chin made was at least liked slightly. There was no significant difference observed across the samples as regards aroma. Lower CPF levels may have affected the appearance, possibly due to uneven distribution or colour changes. The control and 10% WF+CP samples scored significantly higher than 2.5% and 5% WF+CP. Taste improved significantly with 10% WF+CP (7.62). Lower levels of cashew pomace flour (2.5% and 5%) resulted in reduced taste scores, indicating that minimal WF+CP may dilute flavour quality. As regards texture, control and 10% WF+CP samples shared the highest scores, suggesting better mouthfeel and structural integrity. Lower inclusion levels yielded less favourable texture scores. The 10% WF+CP sample was rated highest (7.92) for overall acceptability, surpassing even the control. This indicates that higher WF+CP levels enhance overall consumer satisfaction.

Across all minerals in Table 7, there was a consistent and significant increase in concentration with rising levels of WF+CP supplementation. This suggests that WF+CP samples are a rich source of these minerals, and their incorporation enhances the nutritional profile of the product. Calcium content increased by 34.5% from control to 10% WF+CP. This is beneficial for bone health and metabolic functions. The progressive increase indicates that fortified samples contribute significantly to calcium enrichment. Zinc increased nearly threefold, and it is crucial for immune function and cellular metabolism. The sharp rise suggests WF+CP samples are particularly rich in zinc, making it valuable for fortification. Magnesium supports muscle and nerve function (Souza *et al.*, 2023), and its doubling increase reflects the mineral density of WF+CP samples. Potassium levels also showed a remarkable increase, and potassium is vital for cardiovascular health and fluid balance (Aburto *et al.*, 2013). The remarkable rise underscores fortified samples' potential as a potassium booster. These minerals are essential for bone health, immune function, and cardiovascular support, indicating that WF+CP fortification can substantially improve the nutritional quality of food products.

While mineral content improved, the levels of anti-nutritional compounds, tannins, saponins, and phytates also rose significantly, as seen in Table 8. This shows that the nutritional advantage gained from increased mineral levels may be substantially offset by reduced mineral bioavailability. Tannin content increased nearly 19-fold, rising from 0.38 mg/100 g in the control sample to 7.21 mg/100 g at 10% CPF inclusion. Tannins are known to bind dietary proteins and essential minerals, particularly iron, thereby reducing protein digestibility and inhibiting iron absorption (Delimont et al., 2017). The marked increase indicates that CPF-fortified samples, especially at higher substitution levels, constitute a significant source of tannins and may pose nutritional limitations if consumed without further processing techniques. Saponins, which were absent in the control sample, increased substantially with rising CPF inclusion, reaching 16.05 mg/100 g at 10% fortification. Saponins are recognized for their dual functionality in food systems; they exert anti-nutritional effects by interfering with nutrient absorption, causing reduced protein utilization at high concentrations, and they have also been associated with beneficial physiological effects, including cholesterol-lowering, antioxidant, and immune-modulating properties (Timilsena et al., 2023). Their increased presence in CPF-fortified samples, therefore, highlights a complex nutritional balance, where functional health benefits must be weighed against potential reductions in nutrient availability, particularly when consumed as staple foods. Among the anti-nutrients evaluated, phytate showed the most increase, rising from 1.12 mg/100 g in the control to 18.38 mg/100 g at 10% CPF inclusion. Phytates are potent chelating agents that strongly bind divalent minerals such as iron, zinc, and calcium, forming insoluble complexes that limit intestinal absorption (Castro-Alba et al., 2019). This substantial elevation suggests that, despite improved total mineral content, the bioefficacy of these minerals in CPF-fortified wheat flour may be significantly compromised. Consequently, phytate accumulation represents a major nutritional trade-off and underscores the need for targeted processing strategies to enhance mineral bioavailability.

To mitigate the adverse effects of elevated anti-nutritional factors, several processing and formulation approaches can be employed. Fermentation has been widely reported as an effective strategy for reducing phytate and tannin levels through microbial phytase activity, which hydrolyzes phytic acid into lower inositol phosphates with reduced mineral-binding capacity. Similarly, enzymatic treatment using exogenous phytase can be incorporated during dough preparation to significantly degrade phytates and improve mineral bioavailability. Controlled heat treatments, such as roasting or extrusion, may also reduce tannin and saponin levels, although their effectiveness depends on temperature and processing duration. The application of these mitigation strategies is particularly important for higher CPF substitution levels, where anti-nutrient concentrations are most pronounced.

Total phenolics increased more than 7-fold (Table 9). Phenolic compounds are powerful antioxidants that help neutralize free radicals and reduce oxidative stress (Tumilaar *et al.,* 2024). The substantial increase indicates that WF+CP samples are rich in phenolics, thereby contributing significantly to the antioxidant potential of the products. Flavonoids showed a gradual increase, which reflects the bioactive richness of the fortified samples and their potential role in promoting health. Flavonoids are associated with anti-inflammatory, anti-carcinogenic, and cardiovascular protective effects (Ciumarnean *et al.,* 2020). Carotenoid content increased by over 1000%**.** Carotenoids, including beta-carotene and lutein, are essential for eye health and immune function (Abdel-Aal *et al.*, 2013). The rise suggests WF+CP is a valuable source of these pigments, which can enhance the visual appeal and nutritional value of the product.

Conclusion

Fortification of wheat-based snacks with cashew pomace flour up to 5% significantly enhances dietary fibre, mineral content, and antioxidant capacity while maintaining acceptable sensory properties. The functional modifications observed, particularly increased water absorption and swelling capacity, are driven by the hydrophilic and fibre-rich nature of cashew pomace, whereas reductions in swelling power and starch solubility reflect starch dilution and fibre interference with gelatinization. While nutritional enrichment is substantial, the parallel rise in phytates and tannins presents a bioavailability challenge that must be addressed through targeted processing strategies such as fermentation or enzymatic treatment. Overall, cashew pomace flour demonstrates strong potential as a sustainable functional ingredient, which supports waste reduction in the cashew industry and meets the growing consumer demand for healthier, functional foods, bridging the gap between nutrition, sustainability, and convenience.

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Table 1: Formulation of composite flour

	Control	Sample A	Sample B	Sample C
Wheat flour	100%	97.5%	95%	90%
Cashew pomace flour	0%	2.5%	5%	10%

Table 2: Proximate analysis of wheat flour and fortified wheat flour samples

	MOISTURE (%)	ASH (%)	FIBRE (%)	FAT (%)	PROTEIN (%)	CHO (%)
CONTROL	11.85 ± 0.05^{b}	0.43 ± 0.13^{a}	0.78 ± 0.03^{a}	2.08 ± 0.13b	3.68 ± 0.18^{a}	81.18
2.5% WF+CP	11.75 ± 0.05^{b}	0.45 ± 0.12^{a}	0.86 ± 0.05^{a}	1.98 ± 0.15^{b}	3.61 ± 0.26^{a}	81.35
5% WF+CP	11.58 ± 0.08^{b}	0.48 ± 0.13^{a}	0.91 ± 0.01^{a}	1.90 ± 0.04^{b}	3.50 ± 0.35^{a}	81.63
10% WF+CP	10.68 ± 0.08^{a}	0.55 ± 0.10^{a}	1.90 ± 0.07^{b}	0.78 ± 0.08^{a}	3.15 ± 0.00^{a}	82.94

Values are mean ± standard error of duplicate determinations. Values with different alphabets are significantly different at (p<0.05). Control: 0% cashew pomace flour, Sample A: 2.5% cashew pomace + wheat flour, Sample B: 5% cashew pomace + wheat flour, Sample C: 10% cashew pomace + wheat flour

Table 3: Functional properties of wheat flour and fortified wheat flour samples

	Bulk density (g/ml)	Water absorption (%)	Oil absorption (%)	Dispersibility (%)	Swelling capacity (%)	Swelling power	Starch solubility (%)
CONT-ROL	0.73 ± 0.02^{a}	186.25 ± 1.35^{a}	207.55 ± 3.95^{b}	74.50 ± 0.50^{a}	5.50 ± 0.50^{a}	2.37 ± 0.07^{b}	8.40 ± 0.10^{c}
2.5% WF+CP	0.75 ± 0.01^{ab}	188.45 ± 1.30^{a}	206.25 ± 0.75^{b}	73.50 ± 0.50^{a}	6.50 ± 0.50^{a}	2.01 ± 0.09^{b}	5.50 ± 0.10^{b}
5% WF+CP	0.77 ± 0.00^{ab}	190.65 ± 0.15^{ab}	206.95 ± 0.85^{b}	73.00 ± 1.00^{a}	8.00 ± 0.00^{b}	1.96 ± 0.21^{b}	3.30 ± 0.10^{a}
10% WF+CP	0.79 ± 0.02^{b}	196.55 ± 2.25^{b}	204.35 ± 4.05^{a}	74.50 ± 0.50^{a}	9.50 ± 0.50^{b}	1.41 ± 0.01^{a}	4.80 ± 0.10^{b}

Table 4: **Sensory analysis on cashew chin-chin produced using wheat flour and fortified wheat flour samples**

	Aroma	Appearance	Taste	Texture	Overall acceptability
CONTROL	7.16 ± 0.42^{a}	7.63 ± 0.19^{b}	7.21 ± 0.31^{ab}	6.79 ± 0.44^{a}	7.47 ± 0.21^{ab}
2.5% WF+CP	7.26 ± 0.28^{a}	6.95 ± 0.42^{ab}	7.74 ± 0.30^{b}	7.21 ± 0.39^{a}	7.58 ± 0.28^{b}
5% WF+CP	6.95 ± .032^{a}	5.84 ± 0.49^{a}	7.37 ± 0.29^{ab}	6.79 ± 0.32^{a}	7.21 ± 0.27^{ab}
10% WF+CP	6.32 ± 0.35^{a}	6.16 ± 0.47^{a}	6.32 ± 0.42^{a}	6.58 ± 0.26^{a}	6.73 ± 0.37^{ab}

Table 5: Sensory analysis on cashew cookies made with wheat flour and fortified wheat flour samples

	Aroma	Appearance	Taste	Texture	Overall acceptability
CONTROL	7.25 ± 0.48^{a}	6.92 ± 0.29^{a}	7.25 ± 0.47^{a}	6.42 ± 0.40^{a}	7.50 ± 0.31^{b}
2.5% WF+CP	6.75 ± 0.33^{a}	6.67 ± 0.38^{a}	7.25 ± 0.35^{a}	6.50 ± 0.26^{a}	7.33 ± 0.26^{b}
5% WF+CP	7.00 ± 0.28^{a}	6.92 ± 0.26^{a}	7.25 ± 0.30^{a}	6.67 ± 0.38^{a}	7.25 ± 0.18^{b}
10% WF+CP	6.25 ± 0.37^{a}	5.92 ± 0.45^{a}	6.58 ±0.38^{a}	5.92 ± 0.42^{a}	6.25 ± 0.54^{a}

Table 6: Sensory analysis of cashew puff-puff made with wheat flour and fortified wheat samples

	Aroma	Appearance	Taste	Texture	Overall acceptability
CONTROL	6.08 ± 0.57^{a}	7.92 ± 0.21^{b}	6.69 ± 0.36^{bc}	7.31 ± 0.38^{b}	7.08 ± 0.45^{bc}
2.5% WF+CP	5.92 ± 0.54^{a}	5.69 ± 0.44^{a}	5.38 ± 0.40^{a}	6.15 ± 0.37^{a}	5.92 ± 0.50^{ab}
5% WF+CP	5.62 ± 0.50^{a}	5.30 ± 0.44^{a}	5.62 ± 0.51^{ab}	5.85 ± 0.46^{a}	5.62 ± 0.55^{a}
10% WF+CP	7.00 ± 0.42^{a}	7.61 ± 0.31^{b}	7.62 ± 0.24^{c}	7.54 ± 0.24^{b}	7.92 ± 0.33^{c}

Table 7: Mineral analysis of wheat flour and fortified wheat flour samples

	Ca (mg/100g)	Zn (mg/100g)	Mg (mg/100g)	K (mg/100g)
CONTROL	16.50 ± 0.38^{a}	0.72 ± 0.30^{a}	30.18 ± 0.82^{a}	95.68 ± 0.75^{a}
2.5% WF+CP	18.40 ±0.17^{ab}	1.41 ± 0.30^{b}	37.89 ± 0.23^{b}	133.21 ± 3.44^{b}
5% WF+CP	19.49 ± 0.38^{b}	1.86 ± 0.30^{c}	48.23 ± 0.34^{c}	193.45 ± 6.09^{c}
10% WF+CP	22.20 ± 0.93^{c}	2.13 ± 0.01^{d}	65.35 ± 0.60^{d}	288.77 ± 3.52^{d}

Table 8: Anti-nutrient analysis of wheat flour and fortified wheat flour samples

	Tannins (mg/100g)	Saponin (mg/100g)	Phytate (mg/100g)
CONTROL	0.38 ± 0.02^{a}	0.00 ± 0.00^{a}	1.12 ± 0.03^{a}
2.5% WF+CP	2.35 ± 0.30^{b}	5.38 ± 0.27^{b}	3.52 ± 0.04^{b}
5% WF+CP	3.86 ± 0.13^{c}	9.25 ± 0.13^{c}	4.17 ± 0.06^{b}
10% WF+CP	7.21 ± 0.22^{d}	16.05 ± 0.70^{d}	18.38 ± 0.84^{c}

Table 9: Antioxidant analysis of wheat flour and fortified wheat flour samples

	Total phenolic	Total flavonoid	Total carotenoids
CONTROL	26.69 ± 1.55^{a}	11.74 ± 0.39^{a}	0.11 ± 0.02^{a}
2.5% WF+CP	69.19 ± 0.94^{b}	17.00 ± 0.62^{b}	0.42 ± 0.00^{b}
5% WF+CP	80.90 ± 1.66^{c}	24.66 ± 0.03^{c}	0.71 ± 0.02^{c}
10% WF+CP	199.66 ± 1.69^{d}	29.98 ± 10.15^{d}	1.22 ± 0.03^{d}