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RESEARCH ARTICLE

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Assessing the Acceptability and Nutritional Profile of Sweet Biscuits Enriched with Pea Shell Powder

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ABSTRACT

Background: The goal of this study is to find out how adding pea shell powder affects the nutritional value, sensory qualities and general acceptability of the biscuits. By decreasing food waste and fostering a circular economy, the development of biscuits made from pea pods has the potential to boost customers' health and sustainable food practices.

Methods: The pea shell powder was incorporated at 5% to 15% levels in different formulations. The study utilized a 9-point hedonic scale for sensory evaluation and standard methods for nutritional analysis, including proximate, dietary fiber and minerals.

Result: The organoleptic acceptability showed that the addition of pea shell powder in biscuits influences the sensorial score and obtains higher overall acceptability than control biscuits. The results on the proximate composition of sweet biscuits showed a significant increase in crude protein (6.68-8.23%), crude fiber (0.31-1.42%) and ash (0.47-1.11%) in supplemented sweet biscuits while energy content decreased significantly. The dietary fiber and total mineral contents increased significantly after the incorporation of pea shell powder. Calcium, potassium and magnesium content increased two (194.33 mg/100 g), three (229.58 mg/100 g) and four (204.69 mg/100 g) times, respectively than that of Control. Pea shell powder use in biscuit formulations may also open up new opportunities for the food industry to create Environment friendly and innovative products.

Key words: Dietary fiber, Incorporated, Nutrients, Organoleptic, Pea shell powder.

INTRODUCTION

Over centuries biscuits, also known as cookies, crackers, or other names throughout the world have grown into a crucial component of the modern diet. Bakery food products, particularly biscuits, are currently becoming very popular worldwide among all age groups in both rural and urban areas due to their many appealing qualities, including their widespread consumption, low cost compared to other processed foods, varied taste, ease of availability, good eating quality and relatively long shelf life (Ayo and Olawale, 2003). Biscuits, known for their elevated calorie, fat and carbohydrate levels coupled with a lack of essential fiber, vitamins and minerals, are typically not advised for daily consumption. However, given their widespread popularity and convenience, biscuits serve as an excellent platform for integrating pea pod derivatives, thereby amplifying their nutritional worth. However, with an increasing emphasis on sustainability, there has been a growing interest in exploring alternative and eco-friendly ingredients in food production.

Pea pods, the green peas' outer shell, are often thrown away after being harvested for food. Recent studies have however highlighted its robust nutritional profile, which includes significant amounts of dietary fiber, protein, minerals and other bioactive substances (Beniwal *et al*., 2022). Due to this potential, pea pods are being investigated as a useful component in a variety of food items (Beniwal *et al*., 2022). Peas are grown all over the world and are fed to animals as well as utilized for human use. India, the second-largest producer in the world after China, made up 22.9% (4 million tons) of the total. Pea processing in India generated almost 1 million tons of waste and the peels were discarded as waste (Garg, 2015; Upsana and Vinay, 2018). Fruit and vegetable by-products offer technological or nutritional properties that can be employed for product development and enrichment, making them a potential source of bioactive compounds (Sagar *et al*., 2018). Value addition, fortification and supplementation of goods with plant by-products give suitable nutrition or health benefits for those with degenerative disorders. Recent research has concentrated on the plant's protein or fibers, which are primarily derived from industrial waste. The increase micronutrients and their physiochemical properties while lowering calorie intake, pea shells may be included as functional components in designed foods (Beniwal *et al*., 2022).

This study investigates using by-products like pea shell powder in biscuit formulation, aiming to enhance nutritional

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value while reducing food waste. Assessing sensory attributes, composition, mineral and fiber content, we explore the feasibility of eco-friendly practices in biscuit production. This research promotes sustainable, healthier snacks, contributing to public health and environmental conservation by repurposing by-products in food manufacturing.

MATERIALS AND METHODS

Obtaining the required materials and making pea shell powder

This study was performed in 2018 May, at the Foods and Nutrition department, College of Home Science, CCS, HAU, Hisar, Haryana. Beniwal *et al.* (2022) previously outlined the method for creating pea shell powder, beginning with the procurement of a single batch of peas sourced from Hisar market.

Preparation of samples

Fresh pea pods were shelled and drenched under tap water to remove dirt and impurities. After that, pods were dipped in hot water (60°C for 10 minutes) and outspread over filter paper sheets to drain excess water. Separated the layer manually, chopped finely (edible layer) and dehydrated in shadow (12 hours) at ambient temperature, followed by oven drying (24 hours, 45°C). The dried shells were ground to make a fine powder (sieve size 420 microns) and stored (22±2°C) in air-tight plastic bags for the next step.

Composition of sweet biscuits flour

The ratio of refined flour (gm) and pea shell powder (gm) for biscuit preparations, such as:
Control = 100: 00 (refined flour: pea shell powder).
Type I = 95:05 (refined flour: pea shell powder).
Type II = 90:10 (refined flour: pea shell powder).
Type III = 85:15 (refined flour: pea shell powder).

Ingredients used for the preparation of sweet biscuits

Ground sugar (65 gm), ghee (75 gm), milk (35 ml), ammonium bicarbonate (½tsp), sodium bicarbonate (½tsp).

Method

The oven was preheated to 180°C (356°F). Combine powdered pea shells and refined flour in a bowl. Ghee and sugar were creamed with milk. Again creamed after adding sodium and ammonium bicarbonates. To form the dough, thoroughly combine more sieved flour, rolled on a board and using a biscuit cutter, cut it into biscuit shapes. The biscuits were baked at 160°C for 10-20 minutes, cooled and served (Plate 1).

Organoleptic evaluation of value-added sweet biscuits

15 semi-trained participants in the blind test of sweet biscuits were used and variation was assessed according to sensory criteria using 9 Hedonic scales (Peryam and Pilgrim, 1957).

Nutritional evaluation of value-added sweet biscuits

All of the developed sweet biscuits were oven-dried at a constant temperature of 45°C for nutritional analysis. The proximate composition (moisture, crude protein, crude fat, ash and crude fiber) was assessed using the suggested methods (AOAC, 2000). After that, the difference and multiplication approach was used to estimate the total amount of carbohydrates and energy. Using the atomic absorption spectrophotometer technique on digested samples, Lindsey and Norwell (1969) investigated total minerals. Furda (1981) estimated the total, insoluble and soluble dietary fiber.

Chemicals

Suphuric acid, Boric acid, Copper sulphate, Potassium sulphate, Hydrochloric acid, Sodium Hydroxide, Petroleum Ether, Aceton, Alcohol, EDTA, Enzymes (bacterial protease and alpha-amylase), Nitric acid, Perchloric acid.

Equipments

Oven, Micro Kjeldahl Automatic KEL PLUS CLASSIC–DX apparatus, Automatic SOCS plus, Electric muffle furnace, pH meter, Atomic absorption spectrophotometer 2380, (PERKIN-ELMER, USA), Weighing balance (Table Top ASWS-10 Single Pan Balance).

Statistical analysis

ANOVA is used to interpret data (three replications) and the results are presented as mean, standard error. Significant was defined as p 0.05 BY CRITICAL DIFFERENCE (C.D.) value by Sheoran and Pannu (1999).

RESULTS AND DISCUSSION

Cooking qualities

The results (Table 1) of the cooking quality evaluation showed that there were significant variations in the cooked weight and the number of pieces obtained among the different sweet biscuits. The increase in the cooked weight (202 to 212 gm) and the number of pieces (40 to 42), as we move from the control group to Type III could be attributed to variations in the recipe, baking conditions, or both. Furthermore, maintaining a consistent weight of 5 grams for each biscuit in all types suggests a level of precision and quality control in the production process. The uniformity in the weight of the biscuit pieces ensures consistent taste and texture for consumers.

Organoleptic characteristics

The sensory evaluation of sweet biscuits, (Table 2) varying in refined flour and pea shell powder proportions, demonstrated that Type II (10% pea shells) was preferred. Pea shell powder had a positive impact on aroma, taste and overall acceptability, with all types being categorized as 'liked very much.' Scores for Types I and II were the highest (7.78, 7.77), followed by Type III and the control (7.53, 7.52). Color scores increased for Types I and II, while appearance improved with 5% pea shell supplementation. Type II excelled in aroma (7.92) and texture scores rose to 7.83 for supplemented biscuits. Taste scores were highest for Types I (7.67), II (8.0) and III (7.58). The findings suggest that incorporating pea shells enhances sensory attributes in sweet biscuits. Similar studies have explored the creation of sweet and sweet-salty biscuits using combinations of refined flour and fruit or vegetable by-products, such as mango peel powder (10%), fruit or vegetable residue flour (10-30%), orange peel flour, potato peel powder (5-15%), tomato peel powder (5-20%), pea pods powder (20%) and soy flour (20%), in various ratios. Panelists expressed great enjoyment of mango peel biscuits, as reported by Ajila *et al.* (2008); Ferreira *et al*. (2015); Zaker *et al.* (2016); Dhingra *et al.* (2012); Bhat *et al.* (2015); Garg (2015) and Farzana and Mohajan (2015) respectively. Across these studies, biscuits made with fruit and vegetable by-products instead of refined flour received higher ratings for color, flavor and texture. The consensus was that substituting refined flour with by-products of fruits and vegetables resulted in biscuits with superior scores for color, taste, aroma, texture and overall acceptability. The optimal level of substitution was found to be 5 to 10%; beyond that range (15-20%), sensory scores decreased due to changes in aroma and texture properties, although color scores increased. Studies by Hanan *et al.* (2020) and Fendri *et al.* (2016) demonstrated an enhanced color or sensory score in soup and cake when using pea pod powder. Zhang *et al.* (2021) suggested that natural phytochemicals contribute to improved sensory qualities, such as color, smell and taste. Additionally, Jurasova and Kukurova (2011) observed that substituting 5 to 15% of white flour with lemon and orange by-product powders in biscuits found 10% substitution to be acceptable, with biscuits containing

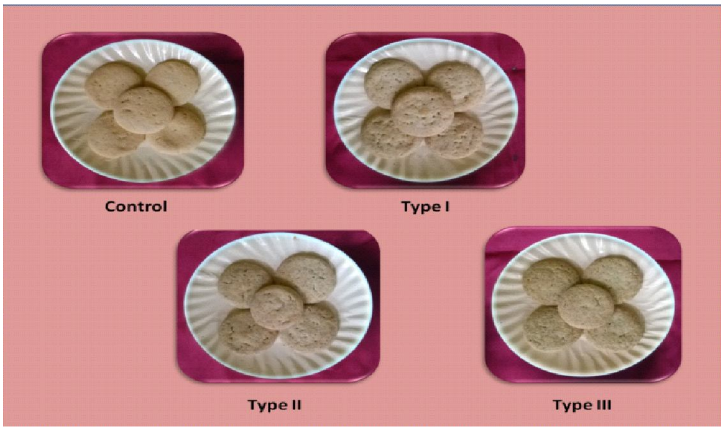

Plate 1: Types of sweet biscuits.

Table 1: Cooking quality of sweet biscuits.

Observations	Control	Type I	Type II	Type III
Cooked wt.	202 gm	207 gm	212 gm	217 gm
No. of pieces	40	41	42	43
Wt. of one piece	5 gm	5 gm	5 gm	5 gm

Wt.- Weight, Control = (RF: 100%), Type I = (RF: PSP:: 95:05), Type II = (RF:PSP::90:10), Type III = (RF:PSP::85:15).
RF = Refined flour, PSP = Pea shell powder.

Table 2: Mean scores of sensory characteristics of sweet biscuits.

Product	Sensory characteristics					
	Colour	Appearance	Aroma	Texture	Taste	Overall acceptability
Sweet biscuits	Scores					
Control	7.58±0.15	7.67±0.14	7.83±0.11	7.33±0.19	7.17±0.17	7.52±0.09
Type I	7.67±0.14	7.92±0.15	7.75±0.13	7.83±0.17	7.67±0.14	7.77±0.65
Type II	7.67±0.14	7.67±0.14	7.92±0.19	7.75±0.18	8.0±0.28	7.78±0.15
Type III	7.33±0.19	7.42±0.19	7.67±0.19	7.67±0.23	7.58±0.36	7.53±0.18

Values are mean ± SE of twelve independent observations, Control = (RF: 100%), Type I = (RF: PSP:: 95:05), Type II = (RF:PSP::90:10), Type III = (RF:PSP::85:15), RF = Refined Flour, PSP = Pea shell powder.

orange waste powder performing better in quality assessment compared to those with lemon waste powder. Furthermore, Hussain *et al.* (2023) concluded that replacing 5% of white flour with orange seed powder resulted in biscuits with satisfactory color, flavor, taste, texture and overall acceptability. Devi *et al.* (2018) found that adding rhododendron powder to wheat flour reduced overall acceptability from 7.70 to 7.10. However, biscuits remained acceptable with up to 10% powder. Thus, a maximum of 15% Rhododendron powder can be used for acceptable quality biscuits. The findings are corroborated by Sahni *et al.* (2018), demonstrating that the inclusion of fruit and vegetable by-products in cookies at supplementation levels of 5 to 15% enhances both sensory scores and functionality. In a previous study reported by Beniwal *et al.* (2022, 2024), it was found that incorporating fresh pea shells increased the sensory score in *tikki*, cutlets and *chapatti*. , Beniwal *et al.* (2024) found that adding pea shells powder to cake and macaroni increased sensory scores by 10 to 20% compared to the their controls.

Nutritional composition

Table 3 illustrates the proximate analysis outcomes, indicating a significant enhancement in nutrient contents with the inclusion of pea shell powder (PSP) in biscuits. Notably, moisture content decreased from 1.41% to 1.15% in biscuits with pea shell powder, potentially contributing to reduced water content in Type II and Type III biscuits. Moreover, protein (6.68% to 8.23%), crude fiber (0.31% to 1.42%) and ash (0.47% to 1.11%) levels exhibited an upward while fat (27.23% to 22.28%) and energy (5128.41 kcal/100gm to 496.35 kcal/100 gm) content demonstrated a declining trend as PSP proportion increased. Total carbohydrate content remained relatively stable across all biscuit types, ranging from 63.92% to 65.25%. These findings underscore the nutritional enrichment potential of pea shell powder in biscuit formulations. In prior research conducted by Dhingra *et al.* (2012), a parallel trend to that observed in our present study was elucidated. It showcased a decline in fat content (19.00-24.15%) coupled with an elevation in ash, crude fiber and carbohydrate content (66.70-75.71%) consequent to the integration of potato peel powder into biscuits. Similarly, findings by Nagrajaiah *et al.* (2015) revealed an augmentation in protein and ash content of cookies upon incorporation of 8% carrot pomace. Bhat *et al.* (2015) demonstrated that the addition of tomato powder to cookies resulted in a noticeable enhancement in protein and ash content, ranging from 5 to 25%. Moreover, Ferreira *et al.* (2015) observed an escalation in protein and crude fiber content with the utilization of fruit and vegetable residue flour at a substitution level of 20 to 35% in conjunction with refined flour. Conversely, a decrease in fat (11.57-9.75 g/100 g) and energy (464-331 Kcal/100 gm) content in sweet and salty biscuits was noted. Zaker *et al.* (2016) documented a reduction in protein and fat content of cookies post-substitution with orange peel powder at a level of 5 to 20%, alongside an increase in total dietary fiber and ash. Our present study's findings align either comparably or lower with those delineated by Farzana and Mohajan (2015), wherein the protein, fiber, ash and energy content in biscuits incorporating soy flour and mushroom (20%) ranged from 11.07-17.86%, 0.48-0.92% and 17.36-20.89%, respectively. It is evident that our findings corroborate with previous research; however, disparities in nutrient content may stem from variations in constituent selection and preparation methodologies employed across studies. The current study's results are aligned with Devi *et al.* (2018), indicating a similar trend of increased ash (0.75 to 1.20%), protein (3.06 to 4.96%) and fiber (0.07 to 0.67%) content in cookies developed by incorporating Rhododendron powder into wheat flour. Beniwal *et al.* (2022, 2024) observed a comparable pattern of nutrient alteration in their study on *tikki,* cutlet, dry vegetable and *chapatti* products with the integration of fresh pea shells. Their findings revealed a decrease in fat content and increase in certain nutrients such as protein, ash and dietary fiber. Building upon these findings, Beniwal *et al.* (2024) reported that the addition of pea shells powder in cake and macaroni accurately aligned with their study, showing a pattern of increased and decreased nutrient content. This aligns with the consistent trend observed across various studies where the addition of fruits and vegetable by-products tends to augment certain nutritional components while diminishing others, ultimately influencing the overall nutrient composition of the final food product.

Table 3: Proximate composition of sweet biscuits (% dry weight basis).

Product	Proximate composition						
Sweet biscuits	Moisture	Crude protein	Fat	Crude fiber	Ash	Total CHO	Energy (Kcal/100 gm)
Control	1.41±0.02	6.68±0.16	27.23±0.59	0.31±0.06	0.47±0.02	63.92±0.17	528.41±4.60
Type I	1.28±0.02	7.20±0.13	25.63±0.48	0.68±0.04	0.67±0.02	64.51±0.19	517.55±4.62
Type II	1.22±0.01	7.70±0.17	23.87±0.30	1.07±0.04	0.90±0.03	65.25±0.40	506.60±2.12
Type III	1.15±0.02	8.23±0.13	22.28±0.41	1.42±0.05	1.11±0.03	65.81±0.20	496.35±4.85
CD (P≤0.05)	0.06	0.49	1.51	0.16	0.09	0.84	13.91

Values are mean ± SE of three independent determinations, Control = (RF: 100%), Type I = (RF: PSP:: 95:05), Type II = (RF:PSP::90:10), Type III = (RF:PSP::85:15), RF = Refined flour, PSP = Pea shell powder, *Significant at P 0.05; NS- Non significant at P>0.05.

Table 4 shows the dietary fiber content (as a percentage of dry weight) in sweet biscuits. As the proportion of pea shell powder (PSP) increased in the formulation (from 5% to 15%), there was a significant increase in total dietary fiber, insoluble dietary fiber and soluble dietary fiber content in biscuits. The highest dietary fiber content was observed in biscuits with 15% PSP incorporation. The total, insoluble and soluble dietary fiber ranged from 2.76 to 5.53, 2.14 to 4.40 and 0.62 to 1.13 g/100 g, respectively. Ajila *et al.* (2008) found that incorporating mango peel powder (5-20%) into sweet biscuits increased total, soluble and insoluble dietary fiber content. Similarly, Nagarajaiah *et al.* (2015) observed enhanced levels of soluble and insoluble dietary fiber (ranging from 1.39-4.33% and 1.09-2.94%, respectively) by incorporating carrot pomace in baked goods at 4%, 8% and 12% levels. Zaker *et al.* (2016) reported increased dietary fiber content in cookies supplemented with orange peel powder. Variations in dietary fiber content across studies are attributed to different techniques and formulations using leftover fruits and vegetables in baked goods. Beniwal *et al.* (2022, 2024) highlighted the significance of pea shell powder in elevating dietary fiber content (21.04%) in products like *tikki*, cutlet, dry vegetable and *chapatti.* Beniwal *et al.* (2024) noted that incorporating pea shell powder into products such as cake and macaroni led to increased dietary fiber content, highlighting pea shell powder as a valuable source of dietary fiber (Beniwal *et al.,* 2022).

Table 5 illustrates the total mineral content (mg/100 g, dry weight basis) of sweet biscuits. With the inclusion of pea shell powder at 5%, 10% and 15% levels, there was a significant increase in calcium, iron, zinc, magnesium, potassium, sodium and manganese compared to the control. Specifically, the calcium content increased from 86.33 mg/100 g in the control to 194.33 mg/100 g in Type III biscuits, showing a significant increase of 125.67%. The magnesium content increased from 56.75 mg to 204.69 mg/100 gm while potassium content rose from 77.98 mg to 229.59 mg/100 gm with the incorporation of pea shell powder in sweet biscuits, indicating substantial increases of 260.11% and 194.52% respectively. Similar increasing trends were observed in pea shell powder (5% to 15%level) incorporated biscuits compared to control (refined flour) for iron (2.93 to 4.11 mg/100 gm), zinc (0.69 to 1.16 mg/100 gm), sodium (14.57 to 20.72 mg/100 gm). Manganese (0.62 to 0.65 mg/100 gm) content was almost similar in all types that were not affected by pea shell powder incorporation. The significant increase in all minerals indicates the potential of pea shell powder to enhance the mineral content of sweet biscuits. The enriched mineral composition observed in the present study potentially augments the nutritional value of the biscuits, rendering them a more wholesome dietary option. Our findings surpass those documented by Farzana and Mohajan (2015), who reported iron concentrations ranging from 1.56% to 1.99% in soy flour-based biscuits. Consistent with prior research by Mousa *et al.* (2021) and Garg (2015), the incorporation of pea pod powder substantially enhances the mineral content of food products *e.g.* crackers and biscuits. However, our mineral content findings deviate from

Table 4: Dietary fiber content of sweet biscuits (% dry weight basis).

Product	Dietary fiber		
Sweet biscuits	Total dietary fiber	Insoluble dietary fiber	Soluble dietary fiber
Control (RF: 100)	2.76±0.12	2.14±0.07	0.62±0.04
Type I (RF: PSP::95:05)	3.67±0.17	2.88±0.11	0.78±0.04
Type II (RF:PSP::90:10)	4.57±0.20	3.66±0.07	0.94±0.04
Type III (RF:PSP::85:15)	5.53±0.12	4.40±0.11	1.13±0.06
CD (P≤0.05)	0.52	0.31	0.15

Values are mean ± SE of three independent determinations, Control = (RF: 100%), Type I = (RF: PSP:: 95:05), Type II = (RF:PSP::90:10), Type III = (RF:PSP::85:15), RF = Refined flour, PSP = Pea shell powder, *Significant at P 0.05; NS- Non Significant at P>0.05.

Table 5: Total minerals content of sweet biscuits *(*mg/100 g, dry weight basis).

Product	Total minerals						
Sweet biscuits	Calcium	Iron	Zinc	Magnesium	Potassium	Sodium	Manganese
Control	86.33±1.45	2.93±0.07	0.69±0.04	56.75±2.33	77.98±5.29	14.57±0.52	0.62±0.01
Type I	122.33±1.86	3.22±0.08	0.80±0.03	105.39±2.11	126.00±5.22	16.43±0.48	0.63±0.01
Type II	148.00±1.73	3.73±0.08	0.93±0.02	155.36±2.43	174.12±5.15	18.48±0.41	0.64±0.01
Type III	194.33±1.76	4.11±0.06	1.16±0.02	204.69±2.11	229.58±6.51	20.72±0.67	0.65±0.01
CD (P≤0.05)	5.66	0.23	0.09	7.45	18.45	1.75	0.02

Values are mean ± SE of three independent determinations, Control = (RF: 100%), Type I = (RF: PSP:: 95:05), Type II = (RF:PSP::90:10), Type III = (RF:PSP::85:15), RF = Refined flour, PSP = Pea shell powder, *Significant at P 0.05; NS- Non significant at P>0.05.

those reported by Sharoba *et al*. (2013). Our observations align with the study conducted by Hussain *et al.* (2023), wherein the substitution of 5% of wheat flour with orange seed powder yielded biscuits of commendable quality, addressing deficiencies in trace minerals such as calcium, magnesium, potassium, zinc, manganese and selenium. Furthermore, Dei *et al.* (2018) demonstrated a significant increase in iron content (from 3.90 to 4.19 mg/100 g) upon incorporating rhododendron powder into wheat flour. Sahni *et al.* (2018) highlighted the nutritional enhancement potential of fruit and vegetable by-products, particularly in terms of fiber and mineral content, up to 15% levels when utilized in bakery products. Notably, Robinson *et al.* (2019) elucidated the presence of various bioactive compounds in peas and their pods, advocating for their health benefits, particularly for individuals adhering to plant-based diets and those afflicted with lifestyle disorders. The heightened mineral content observed in the supplemented biscuits corroborates the recent findings of Beniwal *et al.* (2022), indicating pea shell powder is a valuable mineral source. Beniwal *et al.* (2024) observed that the inclusion of pea shell powder in products like cake and macaroni enhanced the mineral content 2-3 times compared to their controls. This potential has prompted investigations into the utilization of pea pods as beneficial ingredients across various culinary applications. Furthermore, Beniwal *et al.* (2022) underscored the significance of pea shell powder in enhancing protein (17.76%), dietary fiber (21.04%) and essential mineral content, showcasing its versatility in dishes such as *tikkis*, cutlets, dry vegetables and *chapatti* (Beniwal *et al.* 2024). Moreover, Beniwal *et al.* (2022) highlighted the presence of carbohydrates, amino acids, alkaloids, tannins and phytosterols in pea shells methanolic extracts. Their research underscores the functional attributes of pea shell powder, facilitating nutrient enrichment and the incorporation of bioactive components into food formulations.

CONCLUSION

The addition of pea shell powder to sweet biscuits substantially boosted their nutritional content, notably increasing levels of crude protein, fat, crude fiber and ash. Calcium, potassium and magnesium content saw remarkable increases, up to two, three and four times higher than the control group, respectively. This suggests pea shell powder is a promising functional ingredient for enhancing biscuit nutrition and appealing to health-conscious consumers. However, further research on sensory properties and consumer acceptance is needed to fully evaluate product quality and marketability. With growing consumer demand for nutrient-dense options, biscuits fortified with pea shell powder offer a lucrative market opportunity. Additionally, the study highlights the eco-friendly potential of using pea pods in food formulations, paving the way for innovative and sustainable product development in the food industry.

Conflict of interest

As authors of this manuscript, we affirm that we have no conflicts of interest to declare. However, we understand the importance of transparency in scholarly publishing and thus wish to disclose any relevant affiliations or financial interests that could potentially influence our work.

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