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Utilization of Pumpkin Fruit as Functional Ingredients in Biscuit Manufacturing

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ABSTRACT

This study aimed to investigate the effect of replacing wheat flour in biscuits with whole pumpkin, pumpkin pulp and peel powder at levels of 3%, 6%, 9%, 12% and 15%. The chemical composition, physical properties, and sensory attributes of the biscuits were evaluated. Pumpkin peel contained substantial amounts of crude protein and crude fiber, along with high levels of total carbohydrates, carotenoids, phenols, and flavonoids. It also exhibited higher water absorption (82.48%) and oil absorption (57.82%) compared to pumpkin pulp and whole pumpkin. In contrast, pumpkin pulp had the highest bulk density (0.87%) and emulsion stability (44.14%) among the three. Whole pumpkin demonstrated greater emulsion activity (41.18%), foaming capacity (59.85%), and foaming stability (20.33%). The highest contents of phytic acid (0.72%), oxalate (1.72%), saponins (2.44%), and cyanides (0.76%) were found in the peel, followed by whole pumpkin and then pumpkin pulp powder. Replacing wheat flour with whole pumpkin, pumpkin pulp, or pumpkin peel significantly altered the biscuits' chemical composition, affecting moisture, protein, fiber, fat, ash, and carbohydrate content. However, crude protein, ether extract, and available carbohydrates decreased compared to the control biscuits. Additionally, the replacement increased the biscuits' volume, diameter, and thickness while reducing their weight. The biscuits fortified with 3% to 6% pumpkin pulp powder achieved the best balance of nutritional enhancement and sensory acceptability.

1. Introduction

Pumpkin (*Cucurbita* spp.) is a vegetable cultivated worldwide and widely used as a food source. The Asian, European, and American continents account for 88.4% of global production, with China, India, and the Russian Federation being the largest producers. In the State of São Paulo, Brazil, pumpkin production reached 65 thousand tons (FAO, 2019). Pumpkin (*Cucurbita moschata*), a member of the *Cucurbitaceae* family, is an important source of dietary fiber and bioactive compounds such as carotenoids, phenolic compounds, fibers, vitamins, and minerals (Martins & Ferreira, 2017). The beta-carotene found in pumpkins, responsible for their characteristic yellow-orange color, is a major source of vitamin A. Consuming foods rich in carotenoids can help prevent skin diseases, eye disorders, and certain types of cancer (Faustino et al., 2016). The pulp of pumpkin is the primary portion used for processing and consumption. Pumpkins and their by-products contain various phytochemical and antioxidant compounds, which can serve as food ingredients or be utilized as bioactive and nutritional supplements (Genevois et al., 2016). Adding pumpkin powder enhances the nutritional value of baked products, providing vibrant color and improved quality. Using 5% pumpkin powder in such products is expected to yield favorable results by

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incorporating it into the wheat flour mixture during the manufacturing process. This enhances the nutritional profile of baked goods such as biscuits, cakes, and pancakes (Abdulaali & George, 2020). Biscuits are high in carbohydrates and fat but low in fiber, vitamins, and minerals, making them less suitable for daily consumption. However, due to their widespread popularity across all age groups, long shelf life, and appealing taste, they are a common snack. Enriching wheat flour with pumpkin powder can enhance protein content and overall nutritional value (Kumar et al., 2018). This study aimed to utilize pumpkin fruit to improve biscuit quality. Understanding the economic and nutritional benefits of using the whole pumpkin including the pulp and peels can contribute to producing high-quality, fiber-rich biscuits.

2. Materials and Methods

Materials

Wheat flour (72% extraction) was purchased from South Cairo & Giza Flour Mills Company, Talbeya, Giza, Egypt. Fresh pumpkin (*Cucurbita moschata*) was obtained from the Horticultural Research Institute, Agricultural Research Center, Giza, Egypt.

Methods

Technological Methods

Preparation of Dried Pumpkin Parts

Ripe pumpkin fruits were washed with tap water, cut in half, and seeded. The fruit was then divided into two portions as follows:

- The first portion (whole pumpkin) was cut into equal pieces using sharp knives.
- The second portion was peeled to separate the peels from the pulp, and both were then cut into equal pieces using sharp knives.

All portions were preheated in a ventilated oven at 120°C±5 for 15 minutes (Radwan et al., 2017) to inactivate oxidative enzymes, reduce microbial load, and facilitate initial moisture loss. Subsequently, the samples were dried at 60°C±5 until a constant weight was achieved. The dried pumpkin products were then ground separately using a Multi Mill apparatus and passed through a 0.5mm mesh sieve to obtain a fine powder. The powder was further sieved through a 300-mesh sieve for uniformity. The final fine powder was packed in sealed plastic bags and stored at a cool temperature (5°C ±2) until use (Toan & Thuy, 2018). The ingredients for the control and experimental biscuits are listed in Table 1, while the formulations for the experimental sweet biscuits (with and without additives) are shown in Table 2. To prepare the biscuits, sugar and butter were creamed in a mixer, then the egg-vanilla mixture was added and beaten at low speed for 15 minutes. The dry ingredients (wheat flour or its mixtures and baking powder) were stirred together and gradually incorporated into the mixture, followed by continuous beating until a smooth dough formed. The dough was then left to rest for 15 minutes before being rolled out on a biscuit sheet with a rolling pin and cut into circular shapes (5 cm in diameter, 0.3cm thick). The cut dough pieces were placed on a greased tray and baked in an electrically heated oven at 170°C for 12–15 minutes. After baking, the biscuits were allowed to cool at room temperature for 1 hour before sensory evaluation and further analyses (AACC, 2010).

Table 1. The formula used for preparing biscuits

Ingredients	Amount (g)
Wheat flour 72%	100
Butter	20
Sugar	35
Milk powder	2
Egg	---
Salt	1
Vanillin	1
Water	As required (0-25)

Packaging of Biscuits

After preparation, biscuit pieces (15–20g each) were packaged in transparent polypropylene bags (20/20 microns) and stored at room temperature until chemical and sensory evaluations were conducted (Kulthe et al., 2018).

Analytical Methods

Physical Properties of Biscuits

The physical properties of biscuits, including diameter (mm), thickness (mm), volume (cm^3/g), and weight (g), were determined using the method described by AACC (2010). The specific volume was calculated by dividing the volume (cm^3) by the biscuit weight (g), while the specific weight was determined by dividing the weight (g) by the biscuit volume (cm^3).

Table 2. Formulation for experimental biscuits

Treatment No.	Blends composition
Control	100% Wheat flour 72% extraction
1	97%wheat flour+3% whole pumpkin powder
2	94%wheat flour+6% whole pumpkin powder
3	91%wheat flour+9% whole pumpkin powder
4	88%wheatflour+12% whole pumpkin powder
5	85%wheatflour+15% whole pumpkin powder
6	97%wheat flour +3% pumpkin pulp powder
7	94%wheat flour +6% pumpkin pulp powder
8	91%wheat flour +9% pumpkin pulp powder
9	88%wheat flour+12% pumpkin pulp powder
10	85%wheat flour +15% pumpkin pulp powder
11	97%wheat flour +3% pumpkin peel powder
12	94% wheat flour +6% pumpkin peel powder
13	91% wheat flour +9% pumpkin peel powder
14	88% wheat flour+12% pumpkin peel powder
15	85% wheat flour+15% pumpkin peel powder

Chemical Analyses

Moisture, protein, ash, crude fiber, and ether extract were determined using the methods outlined by AOAC (2016). Total carbohydrates were calculated by difference, as described by Nielsen (1994). Total phenolic compounds were determined using the method of Sultana et al. (2014) and expressed as g/100 g gallic acid. Total flavonoid content was analyzed following the method of Barros et al. (2010), while total carotenoids were determined using the method of Reddy and Sistrank (1980). Phytic acid content was measured according to Wheeler and Ferrel (1971), and oxalate was determined using the titration method described by Day and Underwood (1986). Hydrogen cyanide was quantified using the alkaline titration method (AOAC, 2016). Water absorption capacity was measured following the method of Sosulski (1962), and fat absorption capacity was determined according to Sosulski et al. (1976).

Emulsifying Activity and Emulsion Stability: Emulsifying Capacity

The emulsifying capacity of a 1% (w/w) protein solution was analyzed by stirring it at a constant temperature (20°C) in a one-liter laboratory reactor (IKA) equipped with a stirrer and an Ultra-Turrax emulsifying system (IKA-Werke GmbH & Co. KG, Staufen, Germany). Oil was automatically added using a titration system (Metrohm GmbH & Co. KG, Herisau, Switzerland), while conductivity was continuously monitored to determine the inversion point of the emulsion. The amount of oil added up to the inversion point was used to calculate the emulsifying capacity (ml oil/g protein).

Foaming capacity and stability

The volume of foam only was recorded after 15, 30, 45, 60, 90 and 120 min. of standing at room temperature (~25˚C) as foam stability (FS) according to the following equation:

Foam stability = Total volume - Liquid volume

$$\left[\%\,Volume\ increase\ or\ (Foam\ Capacity) = \frac{Final\ volume - Intial\ volume}{Initial\ volume} \times 100\right]$$

Sensory evaluation

Sensory properties were assessed for all treatments immediately after baking by a panel of 10 staff members from the Food Technology Research Institute, Agricultural Research Centre. The sensory evaluation was conducted following the method described by Hussein et al. (2024).

Statistical analysis

The sensory properties and chemical composition data were analyzed in triplicate for each sample using the F-test and the Least Significant Difference (LSD) at a 0.05 probability level, as performed with SAS statistical software (SAS, 2000).

3. Results and Discussion

Data in Table 3 show no significant difference ($p > 0.05$) in moisture content among whole pumpkin (10.82%), pumpkin pulp (11.10%), and pumpkin peel (10.75%), which aligns with the findings of Hussain et al. (2021). However, these moisture content values were lower than those reported by Abdulaali and George (2020), Kurian and Sathiya (2016); Noor Aziah and Komathi (2009) (7.52%, 7.23%, and 8.77%, respectively). The protein content of raw materials showed significant differences ($p \leq 0.05$), with pumpkin peel having the highest protein content (11.44%), followed by whole pumpkin (10.77%), while pumpkin pulp had the lowest protein content ($p \leq 0.05$). These findings are consistent with Hussain et al. (2021). Regarding fat content, the highest value ($p \leq 0.05$) was found in pumpkin peel (5.29%), followed by whole pumpkin (4.36%), while pumpkin pulp had the lowest fat content (2.82%). These results match those reported by Hussain et al. (2021). For crude fiber content, pumpkin peel had the highest value (21.27%, $p \leq 0.05$), followed by whole pumpkin (16.36%) and pumpkin pulp (14.24%). These values were lower than those reported by Kurian and Sathiya (2016) and Hussain et al. (2021) (12.03% and 13.91%, respectively) but higher than the findings of Achilonu et al. (2017) and Noor Aziah and Komathi (2009) (34.28% and 3.72%, respectively). The ash content was highest ($p \leq 0.05$) in whole pumpkin (9.59%), followed by pumpkin peel (8.20%), while pumpkin pulp had the lowest value (7.84%). These values were higher than those reported by Abdulaali and George (2020); Achilonu et al. (2017) (9.57% and 13.96%, respectively) but lower than the findings of Noor Aziah and Komathi (2009), Kurian and Sathiya (2016), and Hussain et al. (2021) (6.55%, 6.04%, and 6.50%, respectively). For carbohydrate content, pumpkin pulp had the highest value (66.52%, $p \leq 0.05$), followed by whole pumpkin (58.92%), while pumpkin peel had the lowest content (53.30%). These results were lower than those reported by Noor and Komathi (2009) (74.11%), Abdulaali and George (2020) (75.70%); Achilonu et al. (2017) (78.29%).

Table 3. Proximate composition of dried whole pumpkin, pumpkin pulp, and pumpkin peel (g/100g)

Material	Moisture	Protein	Fiber%	Fat	Ash	Total Carbohydrates
Whole pumpkin	10.82^{a}±0.24	10.77^{b}±0.23	16.36^{b}±0.04	4.36^{b}±0.44	9.59^{a}±0.79	58.92^{b}±0.42
Pumpkin pulp	11.10^{a}±0.4	8.58^{c}±0.41	14.24^{c}±0.36	2.82^{c}±0.48	7.84^{c}±0.48	66.52^{a}±0.68
Pumpkin peel	10.75^{a}±02	11.44^{a}±0.11	21.27^{a}±0.23	5.79^{a}±0.41	8.20^{b}±0.30	53.30^{c}±0.70

Means in the same column with different letters are significantly different ($p \leq 0.05$)

Bioactive Compounds of Dried Whole Pumpkin, Pumpkin Pulp, and Pumpkin Peel

Significant differences ($p \leq 0.05$) were observed in the bioactive compound content among different pumpkin fractions (Table 4). Pumpkin peel contained the highest levels of total flavonoids, total phenolics, and total carotenoids, followed by pumpkin pulp and whole pumpkin, consistent with findings reported by Abbas et al. (2020). The phenolic compound content in pumpkin pulp (16.77mg/g) was higher than the 5.70mg/g reported by Sello and Mostafa (2017) but lower than values reported by Muzzaffar et al. (2016) (24.90mg/g) and Carla et al. (2020) (49.69mg/g). For total carotenoids, pumpkin peel exhibited the highest content (2.40mg/g, $p \leq 0.05$), followed by whole pumpkin (2.31mg/g) and pumpkin pulp (0.84mg/g). The carotenoid content in whole pumpkin and pumpkin peel aligned with the 2.37mg/g reported by Hussain et al. (2021). Meanwhile, total carotenoids in pumpkin pulp (0.84 mg/g) were higher than the 2.7mg/100g reported by Sello and Mostafa (2017) but lower than the 24.90 mg/g reported by Carla et al. (2020).

Table 4. Bioactive compounds of dried whole pumpkin, pumpkin pulp, and pumpkin peel (mg/g)

Material	Total flavonoids (mg/g)	Total phenolics (mg/g)	Total carotenoids (mg/g)
Whole pumpkin	$0.42^{c}\pm0.02$	$19.24^{b}\pm0.66$	$2.31^{b}\pm0.17$
Pumpkin pulp	$0.52^{b}\pm0.03$	$16.77^{c}\pm0.13$	$0.84^{c}\pm0.04$
Pumpkin peel	$1.230^{a}\pm0.10$	$36.08^{a}\pm0.42$	$2.40^{a}\pm0.15$

Means in the same column with different letters are significantly different ($p\leq 0.05$)

Anti-nutritional factors of dried whole Pumpkin, Pumpkin Pulp, and Pumpkin Peel

The levels of anti-nutritional factors in dried whole pumpkin, pumpkin pulp, and pumpkin peel are presented in Table 5. Among the three, pumpkin pulp had the lowest levels of anti-nutritional factors, while pumpkin peel contained the highest levels, with whole pumpkin falling in between. Studies by Blessing et al. (2011) and Adebayo et al. (2013) reported lower phytic acid content in pumpkin peel (0.61mg) and pumpkin pulp (0.37mg). Similarly, Mohammed et al. (2014) found lower phytic acid levels in pumpkin peel (0.63mg) but reported a higher content in whole pumpkin (4.03mg). Oxalate content was highest in pumpkin peel (1.72mg), followed by whole pumpkin (1.66mg) and pumpkin pulp (1.23mg). In contrast, Mohammed et al. (2014) and Adubofuor et al. (2018) reported lower oxalate values in pumpkin peel (0.21mg) and pumpkin pulp (0.31mg). For saponin content, pumpkin peel had the highest value (2.44mg), followed by whole pumpkin (2.05mg), while pumpkin pulp had the lowest (1.35mg). Mohammed et al. (2014) found a lower saponin content in pumpkin peel (1.09mg) but a higher value in whole pumpkin (3.05mg). Regarding cyanide levels, pumpkin pulp contained the highest amount (0.76mg), followed by whole pumpkin (0.69mg), while pumpkin peel had the lowest content (0.53mg). However, Mohammed et al. (2014) reported higher cyanide levels in pumpkin peel (0.63mg) and pumpkin pulp (0.87mg).

Table 5. Ant nutritional factors of whole pumpkin, pumpkin pulp, and pumpkin peel

Material	Phytic acid (%)	Oxalate (%)	Saponins (%)	Cyanides (%)
Whole pumpkin	0.70	1.66	2.05	0.69
Pumpkin pulp	0.68	1.23	1.35	0.53
Pumpkin peel	0.72	1.72	2.44	0.76

Functional Properties of Dried Whole Pumpkin, Pumpkin Pulp, and Pumpkin Peel

Data in Table 6 indicates that the functional properties of pumpkin significantly influenced the physical characteristics of biscuits. The high water absorption capacity of pumpkin peel flour (82.48%) likely improved dough hydration, enhancing gas retention during baking and contributing to increased biscuit volume. Conversely, the lower bulk density of pumpkin peel flour (0.59g/cm³) may have reduced dough density, allowing for greater expansion. Similarly, the superior foaming capacity of whole pumpkin (59.85%) likely helped stabilize air pockets during mixing, contributing to biscuit lightness. While the high bulk density of pumpkin pulp might have limited dough expansion, the biscuits still exhibited volume gain. Additionally, the emulsifying and foaming properties of whole pumpkin could have influenced air incorporation during mixing, affecting biscuit texture and crumbliness. A comparable bulk density value for whole pumpkin powder (0.87g/cm³) was reported by El Khatib and Muhieddine (2020).

Chemical Composition of Biscuits Prepared with Different Levels of Dried Whole Pumpkin, Pumpkin Pulp, and Pumpkin Peel

The chemical composition of biscuits prepared with various levels of dried pumpkin products is presented in Table 7. Moisture, fiber, and ash contents increased as wheat flour was replaced with pumpkin products, and these values continued to rise with higher substitution levels. In contrast, fat content showed a decreasing trend. The carbohydrate content of biscuits gradually decreased when wheat flour was substituted with whole pumpkin and pumpkin pulp powder, whereas pumpkin peel powder had no significant effect on carbohydrate content. This aligns with the findings of Aly and Seleem (2015), who reported that pumpkin pulp addition increased fiber, ash, and carbohydrate content in Egyptian baked products. Regarding protein content, no significant changes were observed when replacing wheat flour with whole pumpkin up to 9% and pumpkin pulp up to 12%. Additionally, pumpkin peel substitution did not impact protein content at any level. The substitution of wheat flour with pumpkin products significantly influenced the chemical composition of biscuits ($p \leq 0.05$). The increased moisture content at higher pumpkin flour levels may contribute to better texture and prolonged freshness. Furthermore, the higher fiber and ash content, particularly in biscuits containing pumpkin peel, enhances their nutritional value by providing additional dietary fiber and essential minerals.

Table 6. Functional properties of whole pumpkin, pumpkin pulp, and pumpkin peel

Material	Water absorption (%)	Oil absorption (%)	Bulk density (g/cm^3)	Emulsion activity (%)	Emulsion stability (%)	Foaming capacity (%)	Foaming stability (%)
Whole pumpkin (WP)	81.74	39.12	0.72	35.14	42.85	59.58	20.33
Pumpkin pulp (PP)	73.22	35.44	0.87	41.18	44.17	10.00	7.00
Pumpkin peel (PPE)	82.48	57.82	0.59	28.57	41.18	51.20	12.50

Table 7. Proximate composition of biscuits prepared with different levels of whole pumpkin, pumpkin pulp and pumpkin peel (g/100g)

Treatment	Moisture	Protein	Fiber	Fat	Ash	Total Carbohydrates
100% WF Control)	7.36^{f}±0.19	10.50^{ab}±0.5	0.87^{f}±0.02	21.27^{a}±0.28	1.62^{f}±0.03	65.74^{a}±0.92
Replace with whole pumpkin						
97%WF+3% WP	8.25^{e}±0.22	11.09^{a}±0.09	1.35^{e}±0.10	20.78^{b}±0.14	2.08^{e}±0.10	64.67^{b}±0.62
94%WF+6% WP	9.12^{d}±0.12	10.83^{ab}±0.28	1.82^{d}±0.18	20.3^{c}±0.15	2.20^{d}±0.04	64.24^{c}±0.09
91%WF+9% WP	9.95^{c}±0.27	10.35^{bcd}±0.24	2.30^{c}±0.26	19.77^{d}±0.33	2.43^{c}±0.11	63.77^{d}±0.07
88%WF+12%WP	10.80^{b}±0.16	10.11^{cd}±0.11	2.77^{b}±0.11	19.25^{e}±0.33	2.54^{b}±0.15	63.29^{e}±0.31
85%WF+15%WP	11.68^{a}±0.18	9.72^{d}±0.73	3.26^{a}± 0.22	18.75^{f}±0.13	2.85^{a}±0.10	62.90^{f}±0.46
Replace with pumpkin pulp						
97%WF+3%PP	8.35^{e}±0.09	11.33^{a}±0.19	1.30^{e}±0.06	20.71^{b}±0.07	1.80^{e}±0.04	64.56^{b}±0.37
94%WF+6%PP	9.11^{d}±014	10.68^{ab}±0.31	1.72^{d}±0.28	20.2^{c}±0.14	1.93^{d}±0.05	65.07^{c}±0.36
91%WF+9%PP	9.98^{c}±0.23	10.50^{bc}±0.50	2.14^{c}±0.11	19.62^{d}±0.17	2.16^{c}±0.05	65.58^{d}±0.26
88%WF+12%PP	10.86^{b}±0.20	10.23^{bc}±0.65	2.54^{b}±0.08	19.07^{e}±0.15	2.45^{b}± 0.10	64.71^{e}±0.53
85%WF+15%PP	11.78^{a}±0.12	9.80^{c}±0.10	2.95^{a}±0.04	18.52^{f}±0.28	2.55^{a}±0.05	65.18^{f}±0.63
Replace with pumpkin peels						
97%WF+3% PPE	8.20^{e}±0.35	11.44^{a}±0.22	1.52^{e}±0.07	20.85^{b}±0.47	1.52^{e}±0.13	65.70^{a}±0.06
94%WF+6% PPE	9.05^{d} ±0.28	11.21^{ab}±0.25	2.09^{d}±0.30	20.39^{c}± 0.06	2.07^{d}±0.07	64.85^{a}±0.78
91%WF+9% PPE	9.89^{c}±0.44	11.00^{ab}±0.75	2.75^{c}±0.20	19.95^{d}±0.18	2.33^{c}±0.05	65.15^{a}±0.12
88%WF+12% PPE	10.66^{b}±0.42	10.60^{ab}±0.38	3.32^{b}±0.02	19.48^{e}±0.08	2.51^{b}±0.11	65.33^{a}±0.54
85%WF+15%PPE	11.60^{a}± 012	10.45^{b}±0.80	3.95^{a}±0.40	19.00^{f}±0.20	2.70^{a}±0.14	65.42^{a}±0.62

Means in the same column with different letters are significantly different ($p \leq 0.05$
WF: Wheat flour, WP: Whole pumpkin, PP: Pumpkin pulp and PPE: pumpkin peel

It is evident that pumpkin-enriched biscuits offer a healthier alternative to traditional wheat biscuits. The decrease in fat content with increased pumpkin flour substitution is due to the naturally lower fat content of pumpkin compared to wheat flour, which may contribute to lower-calorie biscuits a desirable trait for health conscious consumers.

Additionally, carbohydrate content decreased when whole pumpkin and pumpkin pulp were used, potentially benefiting individuals seeking lower carbohydrate intake. However, biscuits containing pumpkin peel maintained stable carbohydrate levels, suggesting that energy content remains unchanged while fiber content is enhanced.

Physical properties of biscuits

Physical properties of biscuits were significantly ($p \leq 0.05$) affected by pumpkin flour substitution. The weight and specific weight reduction at higher substitution levels suggest that biscuits become lighter and less dense, appealing to those who prefer a more delicate texture. However, substituting wheat flour with pumpkin powder beyond 12% may lead to excessive weight loss, producing fragile, crumbly biscuits that lack structural integrity. On the other hand, the increase in biscuit volume and diameter is likely due to the fiber content in pumpkin flour, which impacts dough hydration and expansion during baking.

Table 8. Physical properties of biscuits prepared with various levels of whole pumpkin, pumpkin pulp and pumpkin peel.

Treatments	Weight (g)	S-weight	Volume (cm^3)	S-volume	Diameter (cm)	Thickness (mm)	Spread ratio
100% WF (Control)	12.50^a±0.50	2.77^a±0.22	4.50^f±0.50	0.36^f±0.03	4.66^b±0.34	0.69^a ±0.01	6.75^a±0.67
Replace with whole pumpkin %							
97%WF+3% WP	11.59^b±0.15	2.22^b±0.05	5.19^e±0.05	0.40^e±0.01	5.02^a±0.30	0.71^a±0.02	6.85^a±0.60
94%WF+6% WP	10.92^c±0.17	2.09^c±0.03	5.30^d±0.06	0.45^d±0.01	5.10^a±0.10	0.72^a±0.01	7.12^a±0.04
91% WF+9% WP	10.70^d±0.11	2.00^d±0.02	5.39^c± 0.01	0.49^c±0.06	5.15^a±0.13	0.73^a±0.03	7.13^a±0.13
88%WF+12% WP	10.53^e±0.11	1.93^e±0.03	5.44^b± 0.02	0.55^b±0.70	5.26^a±0.02	0.74^a±0.01	7.17^a±0.07
85%WF+15% WP	9.14^f±0.22	1.66^f±0.04	5.50^a± 0.02	0.60^a±0.02	5.28^a±0.07	0.77^a±0.02	6.97^a±0.20
Replace with pumpkin pulp %							
97%WF+3% PP	10.72^b±0.80	2.49^b±0.18	5.31^e±0.30	0.40^e±0.03	5.10^a±0.50	0.66^a±0.10	7.23^a±2.30
94%WF+6% PP	10.17^c±0.05	2.31^c±0.10	5.40^d±0.50	0.43^d±0.01	5.20^a±0.20	0.66^a±0.10	7.30^a±0.94
91%WF+9% PP	9.46^d±0.54	2.13^d±0.09	5.44^c±0.06	0.46^c±0.02	5.30^a±0.15	0.69^a±0.02	7.22^a±0.45
88%WF+12% PP	8.92^e±0.08	1.62^e±0.16	5.50^b±0.50	0.61^b±0.06	5.35^a±0.50	0.72^a±0.04	7.33^a±0.27
85%WF+15% PP	8.67^f± 0.23	1.52^f±0.09	5.70^a±0.20	0.65^a±0.04	5.40^a±0.40	0.75^a±0.06	7.30^a±0.08
Replace with pumpkin peel %							
97%WF+3% PPE	12.22^b±0.25	2.42^b±0.40	4.96^e±0.05	0.39^e±0.05	4.99^a±0.17	0.70^a±0.09	6.90^a±0.53
94%WF+6% PPE	11.56^c±0.06	2.31^c±0.42	5.10^d±0.90	0.43^d±0.44	5.00^a±0.10	0.73^a±0.02	6.85^a±1.56
91%WF+9% PPE	10.27^d± 0.27	1.58^d±0.08	6.50^c±0.50	0.63^c±0.10	5.10^a±0.20	0.75^a±0.50	6.80^a±0.65
88%WF+12% PPE	9.20^e± 0.20	1.35^e±0.03	6.80^b±0.30	0.73^b±0.02	5.13^a±0.37	0.77^a±0.05	6.64^a±0.05
85%WF+15% PPE	8.93^f ±0.60	1.28^f±0.09	6.99^a±0.51	0.77^a ±0.05	5.20^a±0.20	0.78^a±0.08	6.58^a±1.10

Means in the same column with different letters are significantly different ($p \leq 0.05$
WF: Wheat flour, WP: Whole pumpkin, PP: Pumpkin pulp and PPE: pumpkin peel

Higher fiber levels, especially from pumpkin peel, contribute to increased water absorption, which results in softer and more aerated biscuits. While the increase in volume and diameter can enhance the visual appeal of biscuits, excessive expansion may lead to textural inconsistencies, making the biscuits either too soft or brittle. The optimal balance between structure and texture seems to occur at a 6% substitution level, where biscuits retain their desirable shape and consistency. The spread ratio remained consistent across all formulations, indicating that pumpkin powder does not negatively affect dough flow behavior, which is crucial for maintaining uniformity in biscuit production. The increase in thickness, particularly in high-fiber formulations, suggests an improved structural composition, which may contribute to a more crisp texture, a key factor in consumer preference. In conclusion, the findings suggest that substituting wheat flour with pumpkin powder, particularly at the 6% level, improves the physical properties of biscuits without compromising texture or acceptability. However, higher substitution levels (≥12%) may negatively affect product stability, leading to fragility and reduced quality. These results contrast with those of Toan and Thuy (2018), who reported that the spread ratio in processed biscuits increased from 6.49 to 9.27 as the ratio of wheat flour replacement with pumpkin pulp powder increased.

Sensory evaluation of the biscuits

The sensory properties of biscuits prepared by substituting wheat flour with various levels of dried whole pumpkin, pumpkin pulp, and pumpkin peel are presented in Table 9. The results indicated that biscuits made with pumpkin pulp, followed by whole pumpkin, received higher overall acceptability scores compared to those made with pumpkin peel. The decline in sensory evaluation scores was more evident in formulations with higher pumpkin substitution levels (≥12%), suggesting that an excessive fiber content may negatively impact both texture and taste stability. As shown in the same table, biscuits with a 3 to 6% substitution level maintained the highest acceptability scores, making this substitution range the most suitable for maintaining quality over time.

Table 9. Sensory evaluation of biscuits prepared with various levels of dried whole pumpkin, pumpkin pulp and pumpkin peel

Treatments	Characteristics				
	Color (20)	Odor (20)	Taste (20)	Texture (20)	Overall palatability (20)
100%WF(Control)	15.50^{e}	17.60^{a}	17.90^{a}	17.50^{a}	17.25^{a}
97%WF+3% WP	15.55^{e}	17.30^{ab}	16.00^{bcd}	17.00^{a}	16.46^{bcd}
94%WF+6% WP	16.07^{d}	16.80^{abc}	15.50^{cde}	16.80^{a}	16.29^{bcde}
91% WF+9% WP	16.60^{c}	16.50^{abc}	15.70^{bcde}	15.00^{bcd}	15.95^{def}
88%WF+12% WP	16.65^{c}	15.90^{bcd}	15.70^{bcde}	14.40^{cd}	15.66^{ef}
85%WF+15% WP	17.00^{e}	15.73^{bcd}	15.30^{de}	15.27^{bc}	15.82^{ef}
97%WF+3% PP	16.58^{c}	17.20^{abc}	16.30^{bcd}	17.10^{a}	16.80^{ab}
94%WF+6% PP	17.00^{bc}	16.90^{abc}	16.90^{b}	15.90^{b}	16.68^{abc}
91%WF+9% PP	17.05^{bc}	16.70^{abc}	16.00^{bcd}	15.00^{bcd}	16.19^{cdef}
88%WF+12% PP	17.20^{b}	16.50^{abc}	15.70^{bcde}	14.80^{bcd}	16.05^{def}
85%WF+15% PP	17.40^{b}	15.00^{d}	14.10^{f}	14.30^{cd}	15.63^{ef}
97%WF+3% PPE	15.76^{de}	16.80^{abc}	16.70b^{c}	15.00^{bcd}	16.07^{def}
94%WF+6% PPE	15.88^{de}	16.50^{abc}	16.00^{bcd}	14.60^{bcd}	15.75^{ef}
91%WF+9% PPE	16.98^{bc}	16.40^{abc}	14.50^{ef}	13.80^{d}	15.60^{f}
88%WF+12% PPE	17.18^{b}	16.60^{abc}	15.60^{bcde}	12.80e	15.80^{ef}
85%WF+15%PPE	17.76^{a}	15.70^{cd}	15.10^{de}	14.50^{bcd}	14.92^{g}
LSD (P≥0.05)	0.329	0.895	0.810	0.860	0.404

Means in the same column with different letters are significantly different (p≤ 0.05
WF: Wheat flour, WP: Whole pumpkin, PP: Pumpkin pulp and PPE: pumpkin peel

4. Conclusion

The results of this study indicate that pumpkin fruit (whole pumpkin, pumpkin pulp, and pumpkin peel) can be effectively utilized as functional ingredients in biscuit formulations. The inclusion of pumpkin powder significantly influenced the chemical, physical, and sensory properties of the biscuits. Pumpkin peel exhibited the highest protein, fiber, and bioactive compound content, making it a valuable ingredient for improving the nutritional value of bakery products. Replacing wheat flour with pumpkin powder increased moisture, fiber, and ash content while reducing fat and carbohydrate levels. Additionally, the biscuit volume and diameter increased, whereas weight decreased. content while reducing fat and carbohydrate levels. Additionally, the biscuit volume and diameter increased, whereas weight decreased. Sensory evaluation showed that biscuits containing 3 to 6% pumpkin pulp powder substitution had the best overall acceptability, suggesting it as the optimal level for maintaining good sensory properties while enhancing nutritional quality. These findings highlight the potential of using pumpkin fruit in biscuit production to improve their health benefits.

References

AACC (2010). Approved method of America association of cereal chemists published by the American Association of Cereal Chemists, Ins, Minnesota USA.

Abbas, H.M., Huang, H.X., Huang, W.J., Xue, S.D., Yan, S.J., Wu, T.Q., Li, J.X. and Zhong, Y. (2020). Evaluation of Metabolites and Antioxidant Activity in Pumpkin Species. Natural Product Communications, 15(4):1-11.

Abdulaali, Shamaail and George, Saher. (2020). Preparation of Pumpkin Pulp and Peel Flour and Study Their Impact in the Biscuit Industry. Journal of Biology, Agriculture and Healthcare, Vol.10(6):25-33.

Achilonu, M.C., Nwafor, I.C., Umesiobi, D.O., and Sedibe, M.M. (2017). Biochemical proximates of pumpkin *(Cucurbitaeae spp*.) and their beneficial effects on the general well-being of poultry species. Journal of Animal Physiology and Animal Nutrition, 102(1):5-16.

Adebayo, O.R., Farombi, A.G. and Oyekanmi, A.M. (2013). Proximate, mineral and anti-nutrient evaluation of pumpkin pulp (*Cucurbita pepo*). Journal of applied chemistry, 4(4):25-28.

Adubofuor, J., Anomah, J.W. and Amoah, I. (2018). Anti-nutritional factors and mineral composition of pumpkin pulp and functional properties of pumpkin-wheat composite flour for bread preparation. Int. J. Innov. Food Sci. Technol., 1(1):11-19.

Aly, Mona and Seleem, Hinar. (2015). Gluten-Free Flat Bread and Biscuits Production by Cassava, Extruded Soy Protein and Pumpkin Powder. Food and Nutrition Sciences, 06:660-674.

AOAC (2016). Official Methods of Analysis, 18^{th} ed. Association of Official Analytical Chemists, Washington, USA.

Barros, L., Carvalho, A.M. and Ferreira, I.C. (2010). Leaves, flowers, immature fruits and leafy flowered stems of Malva sylvestris: a comparative study of the nutraceutical potential and composition. Food and Chemical Toxicology, 48(6):1466 -1472.

Blessing, A.C., Ifeanyi, U.M. and Chijioke, O.B. (2011). Nutritional evaluation of some Nigerian pumpkins (*Cucurbita* spp*.).* Fruit, vegetable and cereal science and biotechnology, 5(2):64-71.

Carla, M.B., Joa, D.S.C., Elisa, E.N.C., Priscila, C.C., Rafaela C.P. and Eduardo. B.V.B. (2020). Nutritional and functional potential of pumpkin (*Cucurbita moschata*) pulp and pequi (*Caryocar brasiliense Camb*.) peel flour. J. Food Sci. Technol., 57(10):3920-3925.

Day, R.A. and Underwood, A.L. (1986). Quantitative analysis 5^{th} ed. Prentice. Hall publication 701.

El Khatib, S. and Muhieddine, Mariam. (2020). Nutritional Profile and Medicinal Properties of Pumpkin Fruit Pulp. 10.5772/intechopen.89274.

Fao (2019). Food and agriculture organization of the United Nations." Rome, http://faostat. fao. org 403.

Faustino, J.F., Ribeiro-Silva, A., Dalto, R.F., Souza, M.M.D., Furtado, J.M.F., Rocha, G.D.M. and Rocha, E.M. (2016). Vitamin A and the eye: an old tale for modern times. Arquivos Brasileiros de Oftalmologia, 79:56-6.

Genevois, C.E., Flores, S.K., and Pla, M.D. (2016). Byproduct from pumpkin (*Cucurbita moschata Duchesne ex poiret*) as a substrate and vegetable matrix to contain *Lactobacillus casei*. Journal of Functional Foods, 23:210-219.

Hussain, A., Kausar, T., Din, A., Murtaza, M.A., Jamil, M.A., Noreen, S. and Ramzan, M.A. (2021). Determination of total phenolic, flavonoid, carotenoid, and mineral contents in peel, flesh, and seeds of pumpkin (*Cucurbita maxima*). Journal of Food Processing and Preservation, 45(6):15542.

Hussein, A.M.S., Abd El-Aal, H.A., Morsy, N.M., Hassona, M.M. (2024). Chemical, rheological, and sensory properties of wheat biscuits fortified with local buckwheat. Foods and Raw Materials, 12(1):156-167.

Kulthe, A.A., Thorat, S.S. and Khapre, A.P. (2018). Effects ofdifferent packaging materials on the sensory characteristics of β-carotene enriched pearl millet based cookies during storage. The Pharma Innovation J., 7(4): 914-918.

Kumar, R., Xavier, K.M., Lekshmi, M., Balange, A., and Gudipati, V. (2018). Fortification of extruded snacks with chitosan: Effects on techno functional and sensory quality. J. of Carbohydrate polymers, 194:267-273.

Kurian, Anjali, E and Sathiya, K. (2016). Nutritional Composition and Antioxidant Activity of Pumpkin Wastes. Research Journal of Pharmaceutical, Biological and Chemical Sci., 6:336-344.

Martins, N. and Ferreira, I.C. (2017). Wastes and by-products: Upcoming sources of carotenoids for biotechnological purposes and health-related applications. Trends in Food Science and Technology, 62:33-48.

Mohammed, S.S., Paiko, Y.B., Mann, A., Ndamitso, M.M., Mathew, J.T. and Maaji, S. (2014). Proximate, mineral and anti-nutritional composition of *Cucurbita maxima* fruits parts. Nigerian J. of Chemical Research, 19:37-49.

Muzzaffar, S., Jan, R., Wani, I.A., Masoodi, F.A., Munaff Bhat, M., Wani, T.A. and Wani, G.R. (2016). Effect of preservation methods and storage period on the chemical composition and sensory properties of strawberry crush. Cogent Food and Agric., 2(1):1178691.

Nielsen, S.S. (1994). Chemical Composition and Characteristics of Foods. International to the Chemical Analysis of Foods. Published by Jones and Bartlett, Inc. pp. 142.

Noor Aziah, A.A. and Komathi, C.A. (2009). Physicochemical and Functional Properties of Peeled and Unpeeled Pumpkin powder. Journal of food sci., 74:328-333.

Radwan, H.M., Dyab, A.S. and Masoud, M.R. (2017). Production of High Quality Dehydrated Food Products by Simple Technique for Small Projects. Egypt. J. Agric. Res., 95(3):1233-1249.

Reddy, N.N and Sistrank, W.A. (1980). Effect of cultivar, size, storage and cooking method carbohydrates and some nutrient of sweet potatoes. J. food Sci. 45:682-686.

SAS (2000): Statistics analysis system. SAS Users Guide: Statistics Version 5th Ed., SAS. Institute Inc., Cary N.C.

Sello, Amany A. and Mostafa, Mona Y.A. (2017). Enhancing antioxidant activities of cupcakes by using pumpkin powder during storage. J. of Food and Dairy Sci., 8(2):103-110.

Sosulski, F.W., Garratt, M.O. and Slinkard A.E. (1976). Functional properties of ten legume flours. International J. of Food Sci. and Tech., 9:66-69.

Sosulski, F.W. (1962). The centrifugal method for determining flour absorption in hard red spring wheat. Cereal Chem., 39:344-350.

Sultana, B., Anwar, F., Mushtaq, M., Aslam, M. and Ijaz, S. (2014). In vitro antimutagenic, antioxidant activities and total phenolic of clove (*syzgium aromaticum* L.) seed extracts. Pakistan J. of Phamaceutical Sci., 27(4):893-899.

Toan, N.V. and Thuy, N.T.T. (2018). Production of high-quality flour and the made biscuits from pumpkin. International J. of Food Sci. and Nutrition, 3(5):157-166.

Wheeler, E.L. and Ferrel, R.E. (1971). A method for phytic acid determination in wheat and wheat fractions. Cereal Chem., 48:312-320.

Yasumatsu, K., Sawada, K., Moritaka, S., Misaki, M., Toda, J., Wada, T., and Ishii, K. (1972). Whipping and Emulsifying Properties of Soybean Products. Agric. and Biological Chemistry, 36(5):719-727.