Quality Assurance and Safety of Crops & Foods, 2024; 16(3): 139–151

Enhancing biscuits with muskmelon seed flour: a study of physicochemical, textural, and nutritional characteristics

Najla Al Masoud[1†*], Syed Ali Hassan[2†], Taghrid S. Alomar[1], Waqar Mujahid[2], Rana Muhammad Aadil[1,2*]

[1]*Department of Chemistry, College of Science, Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia;* [2]*National Institute of Food Science and Technology, University of Agriculture, Faisalabad, Pakistan*

[†]These authors contributed equally to this work.

***Corresponding Authors**: Najla Al Masoud and Rana Muhammad Aadil, Department of Chemistry, College of Science, Princess Nourah Bint Abdulrahman University, P.O. Box 84427, Riyadh 11671, Saudi Arabia. Emails: nsalmasoud@pnu.edu.sa; dilrana89@gmail.com

Received: 8 June 2024: Accepted: 21 September 2024; Published: 14 October 2024

ORIGINAL ARTICLE

Abstract

The baking industry is continuously innovating to develop new product formulations that appeal to consumers through both taste and enhanced nutritional value. Biscuits, one of the most popular bakery products globally, serve as an ideal medium for the fortification of essential nutrients. Muskmelon seeds, rich in protein, oil, vitamins, minerals, and amino acids, offer a natural source for the fortification of various food products. This research focuses on incorporating muskmelon seed flour into biscuit formulations to enhance protein, dietary fiber, mineral, and phytochemical content while preserving textural quality. Five formulations were tested, with T_0 (control) containing 100% wheat flour, T_1 containing 95% wheat flour and 5% muskmelon seed flour, T_2 containing 90% wheat flour and 10% muskmelon seed flour, T_3 containing 85% wheat flour and 15% muskmelon seed flour, and T_4 containing 80% wheat flour and 20% muskmelon seed flour. The effect of substituting wheat flour with muskmelon seed flour on biscuit development was assessed by examining physical, proximate, textural, nutritional, and sensory characteristics. The inclusion of muskmelon seed flour significantly increased biscuit thickness (from 53.66 ± 0.68 mm to 73.00 ± 0.36 mm) and hardness (from 18.57 ± 0.03% to 47.61 ± 0.02%) to maintain its proper shape and texture while also enhancing crude protein (from 5.69 ± 0.07% to 16.41 ± 0.08%), ash (1.13 ± 0.01% to 1.70 ± 0.05%), and dietary fiber content (from 1.58 ± 0.03% to 1.88 ± 0.04%). Additionally, the substitution improved total phenolic content (TPC, from 85.52 ± 0.05 to 210.54 ± 0.04 mg GAE/mL), total flavonoid content (TFC, from 54.84 ± 0.09 to 142.28 ± 0.03 mg CE/g), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) inhibition (from 48.63 ± 0.04% to 65.54 ± 0.05%). Among various treatments, T_2, which incorporated 10% muskmelon seed flour, was the most acceptable treatment. Further research is recommended to assess sensory characteristics more precisely using trained panelists.

Keywords: food waste management; functional foods; dietary fiber; muskmelon seeds; biscuits

Introduction

The fruit and vegetable industry generates considerable waste throughout production, preparation, and consumption processes, including both solid and liquid by-products. These often-ignored waste materials represent a valuable opportunity for transformation into a range of useful products with diverse applications (Ahmad *et al.*, 2023a; Anjum *et al.*, 2023; Bangulzai *et al.*, 2022; Dohouonan *et al.*, 2022; Fahim *et al.*, 2022; Khan *et al.*, 2022; Mehnaz *et al.*, 2023; Mehwish Ahmad *et al.*, 2023). A major source of this waste stream is commonly discarded peels and seeds that present significant environmental challenges because of their degradation. However, these waste materials are not only problematic but also contain bioactive compounds of substantial importance. These valuable compounds have potential applications in the food, pharmaceutical, and cosmetics industries (Derar *et al.*, 2023; Elihasridas *et al.*, 2023; Ghany *et al.*, 2023; Mohamed *et al.*, 2023; Munir *et al.*, 2023; Widowati *et al.*, 2022). By extracting these compounds from waste materials, industries can produce functional ingredients, thereby optimizing resource utilization and reducing environmental impact (Ahmad *et al.*, 2023b; Devi *et al.*, 2019; Iozon *et al.*, 2023; Yang *et al.*, 2022).

The seeds of bitter melons, watermelons, cucumbers, pumpkin, and other Cucurbit seeds have a broad range of functional characteristics. These seeds are a good source of protein. They are enriched with omega-3 and omega-6 fatty acids that are considered as healthy fats. Cucurbit seeds have high contents of dietary fiber and are beneficial for our digestive tract and help to manage the blood glucose levels. They contain zinc, phosphorus, iron, and magnesium as essential minerals and a good source of vitamin E and B-complex (Polyzos *et al.*, 2023). They contain phenolic acids, carotenoids, and related antioxidants that protect our cells against oxidative stress and lower blood cholesterol levels to improve our heart health (Gade *et al.*, 2022).

Muskmelon is also a member of Cucurbitaceae family and is recognized for its pleasant aroma, refreshing flavor, and sweet pulp. These appealing attributes depends upon the variety and cultivar of the muskmelons. The Asian varieties are highly preferred for the production of beverages, fruit cocktails, nectars, and juices (Devi and Badwaik, 2022). The rind of muskmelon, which is the primary waste product, has been utilized in the extraction of pectin and for the preparation of preserves and pickles. The other waste product of muskmelon is muskmelon seeds that are a rich source of protein and bioactive compounds responsible for several medicinal and nutraceutical properties. The oil in muskmelon seeds normally ranged from 37 to 45% and the protein content ranged from 25 to 37% (Zhang *et al.*, 2022). In everyday practices, the seeds of muskmelon fruits are considered as waste because people are unaware of their nutritional and health effects (Devi and Badwaik, 2022).

To bring innovation in the food industrial sector, it is necessary to adopt technical advancements in the development of novel food products. The 3 important points that are usually taken into account regarding the development of an innovative food product are: convenience of the food product, healthy dietary choices, and sustainable food systems (Horvat *et al.*, 2019).

To fulfill the demands of health-conscious consumers, it is necessary to incorporate functional components to develop new food recipes. In this way, food manufacturers can fulfill the expectations of such people who prefer consumer health and wellness in the choice of their dietary patterns. These days, the food industry sector not only focus the nutritional worth of the food products but also the environmental sustainability to address the global challenges (Zhang *et al.*, 2023). One such avenue is the incorporation of fiber into the bakery products like cakes, bread, muffins, biscuits, and other snacks. In white bread, the incorporation of dietary fiber brings substantial health benefits on a worldwide scale. These changes address the environmental sustainability challenges, promote consumer well-being, and fulfill the nutritional deficiencies (Ciurzyńska *et al.*, 2019; Królak *et al.*, 2022).

Previous investigations on the relevant topics have focused the addition of seeds and kernels, such as sesame seeds, fenugreek seeds, chia seeds, walnuts, pistachio nuts, and almonds to develop new food product recipes but these seeds are not considered as waste products. This research has explored the utilization of muskmelon seeds that are usually discarded as waste products. In this research, the impact of muskmelon seed flour on the nutritional, textural, and physicochemical properties of biscuits have been investigated with an aim to evaluate the extent to which wheat flour can be replaced with the flour of muskmelon seeds to get optimal results in terms of nutritional composition, texture, and overall acceptability.

Materials and Methods

Procurement of raw materials

The necessary ingredients for baking like wheat flour, sugar, eggs, sunflower oil, and baking powder were purchased from local grocery stores located in the region of Faisalabad, Pakistan. The muskmelon seeds were obtained from fresh and fully ripened muskmelons of the "Arka Rajhans" cultivar. These seeds were subsequently washed, cleaned, and sun-dried. Following this, the seeds were crunched into flour and stored in an airtight plastic container.

Chemicals and reagents

All chemicals and reagents, such as sulfuric acid (H_2SO_4), potassium sulfate, copper sulfate, sodium hydroxide (NaOH) solution, boric acid solution, hydrochloric acid (HCl), bromocresol green and methyl red as indicators, Folin–Ciocalteu reagent, sodium carbonate (Na_2CO_3), gallic acid, ethanol, methanol, aluminum chloride ($AlCl_3$), potassium acetate (CH_3COOK), quercetin, catechin, ascorbic acid, 2,2-Diphenyl-1-picrylhydrazyl (DPPH) reagent, and distilled water, were procured from a reputable chemical supply store located in Faisalabad District, Pakistan.

Preparation of biscuits

The standard recipe comprised 250 g of wheat flour, 125 g of sugar, 135 g of sunflower oil, 8 g of baking powder, and 1 egg. Initially, the oil and egg were combined in a mixer to achieve a creamy texture. Following this, all other ingredients were added, and mixing continued for approximately 2 min. The resulting dough was removed from the mixer bowl, cut, and shaped into biscuits. The biscuits were then baked in an electric oven at 180°C for 12 min, adhering to the general biscuit-making procedure outlined by the American Association of Cereal Chemists (AACC, 2000). Five treatments were prepared: T_0 (100% wheat flour), T_1 (5% replacement of wheat flour with muskmelon seed flour), T_2 (10% replacement), T_3 (15% replacement), and T_4 (20% replacement). These treatments were designed to assess the effects of substituting wheat flour with muskmelon seed flour at varying levels on the physicochemical, textural, and nutritional properties of biscuits.

Physical analysis of biscuits

The 6 biscuits were placed edge to edge and then Vernier caliper with 0.01 mm accuracy was used to determine the diameter of biscuits. The average diameter in mm was calculated by dividing the value by 6 for each biscuit sample under study. In the same way, 6 biscuits were stacked upon each other to determine their mean thickness in mm after dividing the measured thickness by 6. After that, the diameter of biscuits was divided by their thickness to obtain spread ratio (Man *et al.*, 2021).

Color analysis

For color analysis, a colorimeter (SCM: SCP-60, Pakistan) was used to determine the L*, a*, and b* values. The L* value represents the luminosity or brightness of the sample ranging from 0 (dull or dark) to 100 (bright or white). The a* value indicates the redness or greenness of the sample color in which positive values show redness and negative values show the green end of the color spectrum. Similarly, the b* value shows the yellowness or blueness of the sample color in which positive values reflect the yellow color while negative values reflect the blue color (Jukić *et al.*, 2019).

Texture analysis

In texture analysis, the hardness and cohesiveness of the biscuits' matrix were determined by using a CT3 Texture Analyzer (Brookfield Engineering Labs, Middleboro, MA, USA). The analyzer was based on a 6 mm cylindrical probe (TA41) and a 10 kg of load cell. A compression test was performed on all the samples under study by following a trigger load of 5 g, a target distance of 5 mm, and post-test speeds of 3 mm/s. These standards gave reliable measurement of the textural properties for biscuits (Man *et al.*, 2021).

Proximate composition analysis

The proximate compositions of the muskmelon seeds and muskmelon seeds fortified biscuits were analyzed by following the protocols described in the methods of the Association of Official Analytical Chemists (AOAC, 2016). The control biscuits (without addition of muskmelon seed flour) and those with incorporation of muskmelon seed flour were evaluated for moisture, ash, fat, and fiber contents. The protein content was determined using the Kjeldahl method, with a nitrogen-to-protein conversion factor of 5.7. Additionally, the total carbohydrate content (%) was calculated using Equation (1):

$$\text{Total carbohydrates (\%)} = 100 - [\text{moisture (\%)} + \text{ash (\%)} + \text{protein (\%)} + \text{oil (\%)} + \text{fiber (\%)}] \quad (1)$$

Antioxidant analysis

Total phenolic content (TPC)

For TPC, 1 g of the biscuit sample was treated 3 times with 85:15 v/v MeOH (100 mL of acidified methanol) by continuous stirring and then subjected to the Folin-Ciocalteu method. Briefly, in a 100 mL volumetric flask, 5 mL of Folin Ciocalteu's reagent was combined with 100 mL of methanolic extract. Then 5 mL of sodium carbonate solution (7.5%) was added, and the flask was filled up to the mark of 100 mL with distilled water. The final mixture was allowed to stand in the dark for about 90 minutes and then absorbance was measured at 760 nm (1700 UV/VIS spectrophotometer) (Chiș *et al.*, 2018).

Total flavonoid content (TFC)

For TFC, the aluminum chloride ($AlCl_3$) method was used and the results were expressed as milligrams of catechin equivalents (CE) per gram of dry weight (DW) of the sample (Jiang *et al.*, 2021).

DPPH Inhibition

Spectrophotometer and the DPPH method was used to assess the radical scavenging activity. 3.9 mL of a DPPH solution was mixed with 0.1 mL of phenolic extracts and incubated at room temperature for 30 min. Then the absorbance was measured at 515 nm using a 1700 UV/VIS spectrophotometer in which methanol was run as blank. A negative control was also prepared by combining 3.9 mL of DPPH solution with 0.1 mL of methanol (Jiang *et al.*, 2021). The radical scavenging activity was calculated using Equation (2):

$$\text{RSA}\ (\%) = \frac{\text{ABS (DPPH)} - \text{ABS (sample)}}{\text{ABS (DPPH)}} \times 100 \qquad (2)$$

Microstructural analysis by scanning electron miscroscopy (SEM)

To determine the morphology and microstructural properties of the biscuits, scanning eletron microscopy was used at an operating voltage of 8 kV. The samples were cut into rectangular pieces and then subjected to an ion sputter coater for gold coating (Jiang *et al.*, 2021).

Fourier transform-infrared (FTIR) spectroscopy

To identify the stretching vibrations due to functional groups and spectral changes, FTIR spectroscopy was employed using a Nicolet iS 10 FTIR spectrometer (Thermo Fisher Scientific, USA). The analysis was performed with the transmittance range of 4000 to 500 cm^{-1} with a resolution of 4 cm^{-1} (Kumar *et al.*, 2018).

Sensory evaluation of biscuits

In the University of Agriculture, Faisalabad, Pakistan, 50 students aged from 20-25 years were participated in the sensory evaluation of the biscuits as untrained panelists. The panelists had prior experience in sensory evaluation of the food products, but an additional 1-hour discussion meeting was held to again tell them about the rating scale used for sensory assessment of the biscuits. Using a 9-point scale, where 9 signified 'like extremely' and 1 denoted 'dislike extremely,' the students assessed aroma, sweetness, crunchiness, oiliness, and overall acceptability of biscuit samples (Klunklin and Savage, 2018).

Statistical analysis

All values were recorded in triplicate and expressed as mean ± standard deviation. The results were statistically analyzed using a one-way ANOVA under a completely randomized design (CRD) with significance levels set at $P \leq 0.05$ for significant differences and $P \leq 0.01$ for highly significant differences, using the Statistix 8.1 software. Pair-wise comparisons were conducted using *post hoc* Tukey's test (Montgomery, 2017).

Results and Discussion

Physical analysis

The fortification of muskmelon seed flour had a significant ($P \leq 0.05$) impact on the diameter, thickness, and spread ratio of biscuits. The results indicated that the spread ratio of muskmelon seeds-fortified biscuits significantly decreased ($P \leq 0.05$), while thickness was significantly increased ($P \leq 0.05$) by increasing the amount of muskmelon seed flour in the recipe as shown in Table 1. The possible reduction in spread ratio might be associated with increased dietary fiber and protein content and the increased level of muskmelon seed flour, which is comprehended to have more water-binding capacity (Kaur *et al.*, 2019). During mixing, if more water is present, then it dissolves more sugar in dough. The initial viscosity of the dough is decreased, and biscuits spread faster during the process of baking. The flour components having capacity to absorb more quantity of water reduce the solubility of sugar in dough. As a result, the initial viscosity of dough increases, and the cookies spread less during the process of baking (Kaur *et al.*, 2019). Our results align with that of Wani *et al.* (2012), in which the cookies were made by including protein isolate of watermelon seeds in wheat flour, resulting in a lower spread ratio.

As muskmelon seed flour level is increased, the thickness of biscuits is also increased. It is due to influence of protein (gluten) present in the dough. The expansion of gluten is not restricted during the baking process of biscuits. An inverse correlation was observed between gluten content and diameter of biscuits. During the process of baking, gluten present in the dough formed a web in biscuits and the biscuits underwent an apparent glass transition, gained mobility that allowed it to integrate and forming a web. The continuous formation of web increased the viscosity of dough and stopped the flow of biscuits (Miller *et al.*, 1997).

Statistical analysis revealed that the diameter of biscuits had significantly ($P \leq 0.05$) decreased by increasing the amount of muskmelon seed flour in the recipe (Table 2). The decrease in diameter could be attributed to increased protein content in the flour blend, as reported by Saha *et al.* (2011). These results are in accordance with the findings of Hooda and Jood (2005). Ullah *et al.* (2016) found that the diameter of biscuits decreased with increase in alfalfa seed flour in refined wheat flour-based biscuits.

Color analysis

The amount of muskmelon seed flour added to biscuits significantly ($P \leq 0.05$) affects their color. Specifically,

Table 1. Proximate composition analysis of muskmelon seeds.

Proximate composition	Moisture (%)	Ash (%)	Crude protein (%)	Crude fat (%)	Carbohydrates (%)	Crude fiber (%)	pH	Water activity
Muskmelon seeds	2.60 ± 0.03	4.58 ± 0.010	19.26 ± 0.020	42.95 ± 0.010	12.68 ± 0.026	15.79 ± 0.020	6.53 ± 0.020	0.363 ± 0.002

All values were taken in triplicate and expressed as mean ± standard deviation; $P \leq 0.05$.

the values representing lightness (L^*), redness (a^*), and yellowness (b^*) of biscuits decreased by increasing the incorporated amount of muskmelon seed flour, as shown in Table 3. Change in the color of biscuits is linked to the Maillard reaction, reducing sugars that react with the amino groups of proteins to form glycosylamines. These glycosylamines then undergo further chemical changes to become Amadori compounds. The Amadori compounds subsequently break down into various intermediate substances, ultimately forming brown pigments called melanoidins. These melanoidins are responsible for the characteristic brown color of baked goods (Olombrada *et al.*, 2024). When adding muskmelon seed flour to biscuit dough, it increases the overall protein content, compared to the biscuits made solely with wheat flour (the control). This increased content of protein favored the Maillard reaction which resulted in lowering of L^*, a^*, and b^* values and the biscuits became darker in color (Brigante *et al.*, 2022). Our findings are consistent with those of Zhang *et al.* (2023), who observed a similar reduction in color values in bread crust when the amount of muskmelon seed residues was increased. Thus, the incorporation of muskmelon seed flour increased the nutritional worth of the biscuits by increasing their protein content and affected their color due to occurrence of complex biochemical reactions.

Texture analysis

The hardness of the biscuits got significantly ($P \leq 0.05$) increased by the increasing the amount of muskmelon seed flour and it has a non-significant impact on the cohesiveness of biscuits, as indicated in Table 2. The increased hardness is due to the high fiber content in the muskmelon seeds which results in tougher and less tender texture of the biscuits (Kaur *et al.*, 2019). The flour of muskmelon seeds has high protein content that gave strength to the gluten network and play role in firmness of the biscuits. Substituting muskmelon seed flour for wheat flour reduces the overall starch content, resulting in a firmer texture (Zhang *et al.*, 2023). Also, high fat content in muskmelon seeds typically interferes with gluten formation and produces a crumblier texture, but its effect is relatively minor (Lau *et al.*, 2021).

Our results align with those of Wani *et al.* (2012), in which cookies were prepared by integrating protein isolates of watermelon seeds, and the texture became harder by increasing protein isolates. In another study, bean hulls were crunched to produce flour, which was added to wheat flour to make a high-fiber loaf. The results implicated that the hardness of the bread was increased by increasing the amount of bean husk flour because of more fiber content in them (Ni *et al.*, 2020).

Table 2. Physical and texture analyses of muskmelon seeds-fortified biscuits.

Treatments	Diameter (mm)	Thickness (mm)	Spread ratio	Hardness (N)	Cohesiveness
T_0	457.33 ± 0.45^{a}	53.66 ± 0.68^{c}	8.54 ± 0.43^{a}	18.57 ± 0.03^{e}	0.04 ± 0.01^{d}
T_1	453.33 ± 0.31^{a,b}	61.00 ± 0.42^{b,c}	7.45 ± 0.51^{b}	21.70 ± 0.05^{d}	0.06 ± 0.03^{c}
T_2	448.00 ± 0.95^{a,b,c}	66.33 ± 0.81^{a,b}	6.77 ± 0.61^{b,c}	35.10 ± 0.09^{c}	0.05 ± 0.01^{b}
T_3	443.00 ± 0.26^{b,c}	71.33 ± 0.52^{a}	6.23 ± 0.38^{c}	41.18 ± 0.01^{b}	0.07 ± 0.04^{b}
T_4	440.67 ± 0.58^{c}	73.00 ± 0.36^{a}	6.04 ± 0.49^{c}	47.61 ± 0.02^{a}	0.09 ± 0.01^{a}

T_0 = 100% wheat flour, T_1 = 95% wheat flour and 5% muskmelon seed flour, T_2 = 90% wheat flour and 10% muskmelon seed flour, T_3 = 85% wheat flour and 15% muskmelon seed flour, and T_4 = 80% wheat flour and 20% muskmelon seed flour.
All values were taken in triplicate and expressed as mean ± standard deviation. The values indicated by the same superscripted letters in the same column do not differ significantly from each other; $P \leq 0.05$.

Proximate composition analysis

The proximate composition of muskmelon seeds and biscuits are given in Tables 1 and 3, respectively. As illustrated in Table 3, increasing the amount of muskmelon seed flour significantly ($P \leq 0.05$) enhances the moisture, ash, protein, fiber, and fat while reducing the carbohydrate content of biscuits. The variation in nutritional composition is due to the internal properties of muskmelon seeds. The seeds of muskmelon contain fibers of hydrophilic nature thus they retain more moisture levels in the biscuits and as a result the moisture content of biscuits has been increased (Gómez-García *et al.*, 2020) sustainability of food processing is a major concern coupled to the reduction of waste generation. Fruit and vegetable processing require of modernization to valorize the waste and by-products highly generated, particularly because they are rich in natural beneficial components which are demanded to human health. Melon (Cucumis melo L.. Muskmelon seeds have a more protein content that resulted in an increased protein content of the final product (Zhang *et al.*, 2023).

Similarly, the ash content of the biscuits was increased due to the increase in mineral content as muskmelon seeds are a good source of potassium, magnesium, and calcium. The high composition of dietary fibers in muskmelon significantly improved the fiber content of the biscuits, promoted digestive health and gave feeling of fullness (Gómez-García *et al.*, 2020).

Muskmelon seeds have unsaturated fatty acids and other beneficial fats that contributed to the enhanced fat content of the biscuits and improved the flavor and texture. In contrast to all these proximate parameters, the carbohydrate content of the biscuits got decreased by increasing the amount of muskmelon seed flour because wheat content was decreased in the biscuits. Muskmelon seeds have lower carbohydrate content as compared to the wheat flour that resulted in decreased carbohydrate content of the biscuits (Zhang *et al.*, 2022). Similar findings have been given by Kaur *et al.* (2017), in which the cookies were baked by adding flax seed flour in a common recipe for the biscuits. In another research, the addition of protein isolates of watermelon seeds resulted in higher values of protein, fiber, ash, moisture, and fat contents and lower values of carbohydrate content (Wani *et al.*, 2012). Laczkowski *et al.* (2021) prepared cookies by incorporating chia seed flour and reported similar outcomes as that of proximate composition.

Analysis of antioxidants

Increasing muskmelon seed flour in biscuit recipe significantly increased ($P \leq 0.05$) TPC, TFC, and DPPH inhibition values as shown in Table 4. Increase in antioxidant properties is primarily due to the high concentrations of phenolic and flavonoid compounds in muskmelon seeds. These compounds are incorporated in the biscuits when the flour of muskmelon seeds has been added to the biscuit dough and results in increased phenolic content. Polyphenols and flavonoids play an important role in the antioxidant potential of the food products. The antioxidant potential of the food products is usually measured through the DPPH radical scavenging activity which shows the ability of the product to neutralize the harmful radicals. Antioxidants present in the food samples donate hydrogen atoms or electrons to neutralize the DPPH radical that results in conversion of DPPH radical to a non-radical form which is shown by a color change from violet to yellow or colorless (Gómez-García *et al.*, 2020). The increased antioxidant levels in the food contribute to the better health by reducing the oxidative stress in the body (Ismail *et al.*, 2010). Our results agree with those of Wani *et al.* (2012), in which the addition of watermelon seed protein isolate resulted in an increased TPC, TFC, and DPPH inhibition values. In another study,

Table 3. Color and proximate analyses of muskmelon seeds-fortified biscuits.

Treatments	Color			Moisture (%)	Ash (%)	Crude protein (%)	Carbohydrate (%)	Crude fat (%)	Crude fiber (%)
	L*	a*	b*						
T_0	60.54 ± 0.21^{a}	12.35 ± 0.11^{a}	31.21 ± 0.07^{a}	0.43 ± 0.01^{d}	1.13 ± 0.01^{e}	5.69 ± 0.07^{e}	76.37 ± 0.07^{a}	33.18 ± 0.06^{e}	1.58 ± 0.03^{d}
T_1	56.20 ± 0.04^{b}	10.23 ± 0.04^{b}	29.60 ± 0.05^{b}	0.52 ± 0.03^{c}	1.29 ± 0.03^{d}	7.42 ± 0.09^{d}	73.18 ± 0.07^{b}	33.57 ± 0.04^{d}	1.67 ± 0.06^{c}
T_2	52.69 ± 0.06^{c}	8.55 ± 0.06^{c}	27.98 ± 0.05^{c}	0.60 ± 0.08^{b}	1.45 ± 0.05^{c}	10.16 ± 0.06^{c}	68.52 ± 0.05^{c}	34.24 ± 0.04^{c}	1.73 ± 0.05^{bc}
T_3	44.14 ± 0.05^{d}	7.71 ± 0.04^{d}	26.95 ± 0.03^{d}	0.67 ± 0.07^{b}	1.55 ± 0.02^{b}	12.94 ± 0.09^{b}	64.77 ± 0.07^{d}	34.90 ± 0.03^{b}	1.79 ± 0.05^{b}
T_4	38.85 ± 0.04^{e}	6.14 ± 0.06^{e}	24.10 ± 0.04^{e}	0.78 ± 0.02^{a}	1.70 ± 0.05^{a}	16.41 ± 0.08^{a}	60.31 ± 0.03^{e}	35.47± 0.09^{a}	1.88 ± 0.04^{a}

100% wheat flour, T_1 = 95% wheat flour and 5% muskmelon seed flour, T_2 = 90% wheat flour and 10% muskmelon seed flour, T_3 = 85% wheat flour and 15% muskmelon seed flour, and T_4 = 80% wheat flour and 20% muskmelon seed flour.
All values were taken in triplicate and expressed as mean ± standard deviation. The values indicated by the same superscripted letters in the same column do not differ significantly from each other; $P \leq 0.05$.

Dhen *et al.* (2018) produced bread by adding apricot kernels and showed that the values of TPC, TFC, and DPPH inhibition enhanced by increasing the amount of apricot kernel flour.

Scanning electron miscroscopy analysis

The addition of muskmelon seed flours significantly modified the microstructure of the biscuits, as shown in Figure 1. The scans of SEM showed changes in the size and location of pores within the biscuit matrix. The rheological properties of the dough were affected by the addition of muskmelon seed flour that resulted in a distinct porosity pattern. Biscuits showed smaller and more consistently distributed pores than those samples that were prepared by only wheat flour. The surface texture of biscuits was altered, with SEM demonstrating a potentially rougher or more uneven surface due to the presence of coarser particles of muskmelon seed flour. This modified the mouthfeel of the biscuits and overall perception of texture (Jiang *et al.*, 2021). The incorporation of muskmelon seed flour affected the density of the biscuit. SEM images showed a more compact structure, showing that the particles of the muskmelon seed flour are well integrated into the dough, filling the gaps between the protein and starch network. This interaction affected the development of the gluten network, resulting in a distinct structural arrangement compared to conventional biscuits (Jia *et al.*, 2020).

The flour of muskmelon seeds is rich in dietary fiber, which can be observed in SEM scans as fibrous structures inside the biscuit matrix. The presence of these fibers can give strength to the structure and contribute to a strong textural property. SEM examination showed variations in the development and stability of air cells within the biscuits. Incorporating muskmelon seed flour can lead to a distinct pattern of air cell distribution, thereby changes the volume and crunchiness of the finally prepared biscuits (Laczkowski *et al.*, 2021).

Fourier transform-infrared analysis

The incorporation of muskmelon seed flour gave significant alterations in composition, starch-protein interaction, functional components, and functional groups of the biscuits, as shown in Figure 2. Adding muskmelon seed flour to biscuits would likely to impact the FTIR spectra of biscuits by modifying their chemical makeup and molecular interactions. FTIR analysis assisted in discovering these alterations by comparing the FTIR spectra of biscuits with and without muskmelon seed flour. Muskmelon seed flour contains proteins, contributing to amide I (about 1,650 cm^{-1}) and amide II (approximately 1,550 cm^{-1})

Table 4. Antioxidant analysis of muskmelon seeds-fortified biscuits.

Treatments	TPC (mg GAE/mL)	TFC (mg CE/g)	% DPPH inhibition
T_0	85.52 ± 0.05[e]	54.84 ± 0.09[e]	48.63 ± 0.04[e]
T_1	110.39 ± 0.06[d]	68.43 ± 0.03[d]	54.17 ± 0.01[d]
T_2	129.64 ± 0.04[c]	85.26 ± 0.08[c]	56.91 ± 0.09[c]
T_3	165.29 ± 0.07[b]	118.73 ± 0.05[b]	61.32 ± 0.07[b]
T_4	210.54 ± 0.04[a]	142.28 ± 0.03[a]	65.54 ± 0.05[a]

T_0 = 100% wheat flour, T_1 = 95% wheat flour and 5% muskmelon seed flour, T_2 = 90% wheat flour and 10% muskmelon seed flour, T_3 = 85% wheat flour and 15% muskmelon seed flour, T_4 = 80% wheat flour and 20% muskmelon seed flour. TPC: total phenolic content; TFC: total flavonoid content; DPPH: 2,2-Diphenyl-1-picrylhydrazyl.
All values were taken in triplicate and expressed as mean ± standard deviation. The values indicated by the same superscripted letters in the same column do not differ significantly from each other; $P \leq 0.05$.

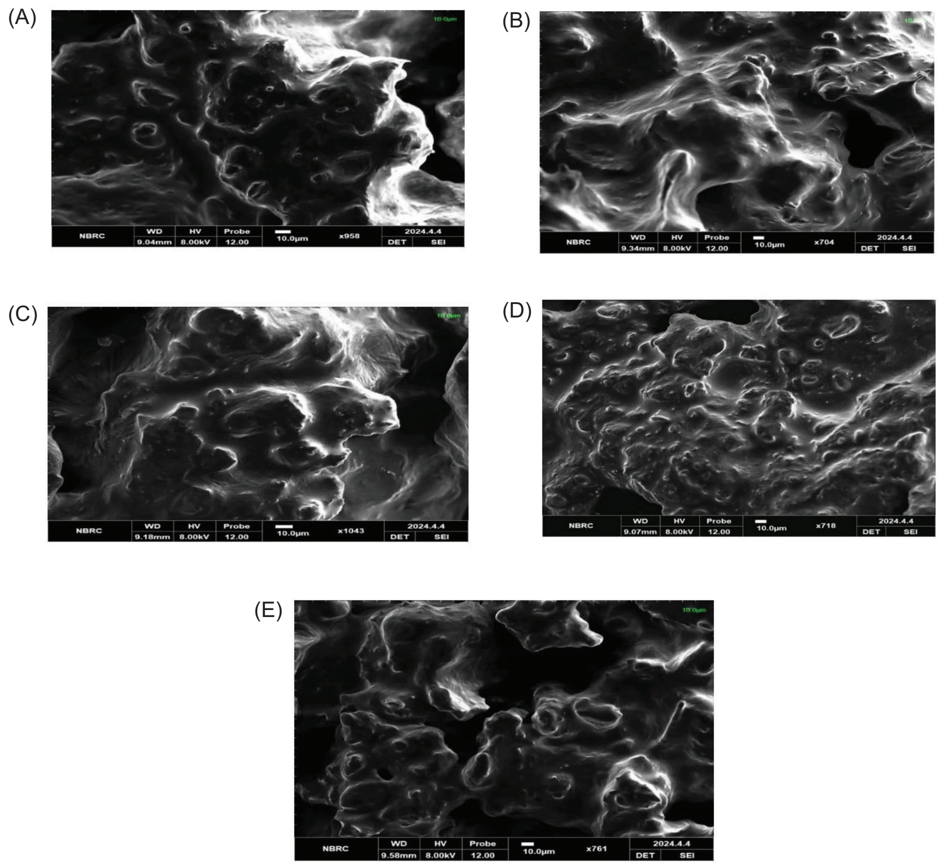

Figure 1. SEM analysis of biscuits with (A) 100% wheat flour, (B) 5% addition of muskmelon seed flour, (C) 10% addition of muskmelon seed flour, (D) 15% addition of muskmelon seed flour, and (E) 20% addition of muskmelon seed flour.

bands in FTIR spectrum. The intensity and shape of these bands could be altered, reflecting variations in protein concentrations and structure (Baltacıoğlu *et al.*, 2021). Adding muskmelon seed flour, including lipids, could modify the lipid-related absorption bands. Notable locations include the C-H stretching vibrations of about 2,850–2,950 cm^{-1} and the carbonyl (C=O) stretching vibration near 1,740 cm^{-1}. These alterations suggest variations in the lipid composition of biscuits. Changes in carbohydrate concentration and structure, including starch and non-starch polysaccharides, could be noted. The C-O-C and C-OH stretching vibrations (about 1,000–1,200 cm^{-1}) could reveal changes, indicating the inclusion of muskmelon seed flour. Muskmelon seed flour is rich in dietary fiber, which can be represented in FTIR spectra. Peaks linked with cellulosic and hemicellulosic materials, typically around 1,030–1,100 cm^{-1}, might rise in intensity. Water and hydroxyl groups (O-H stretching)

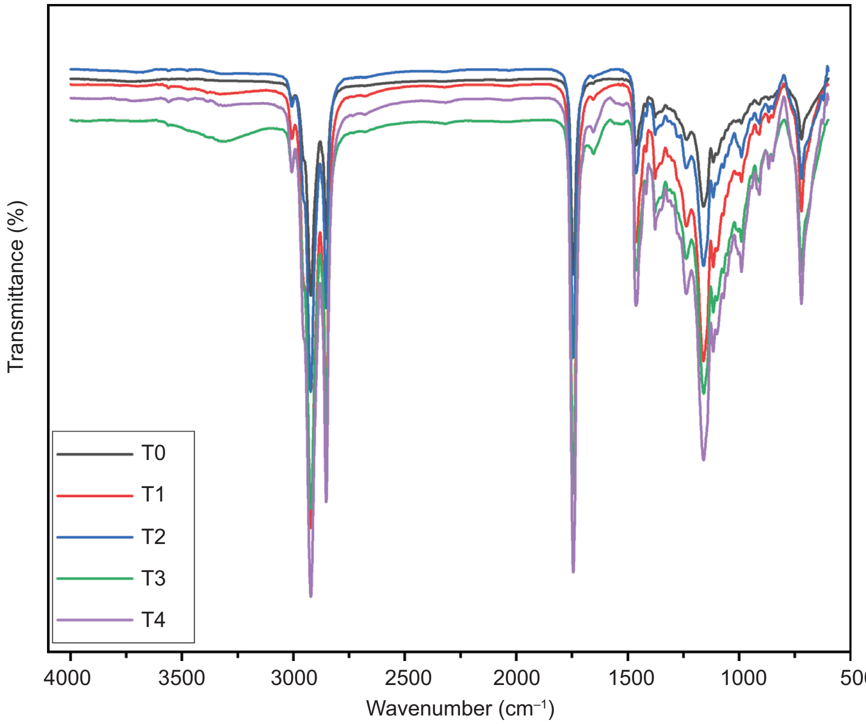

Figure 2. FTIR analysis of biscuits. T_0 = 100% wheat flour, T_1 = 95% wheat flour and 5% muskmelon seed flour, T_2 = 90% wheat flour and 10% muskmelon seed flour, T_3 = 85% wheat flour and 15% muskmelon seed flour, and T_4 = 80% wheat flour and 20% muskmelon seed flour.

may be reflected in variations in broad absorption band around 3,200–3,600 cm^{-1}. Adding muskmelon seed flour could change both moisture content and hydrogen bonding interactions in biscuit matrix (Pattnaik and Mishra, 2022).

Sensory evaluation

The addition of muskmelon seed flour had a significant ($P \leq 0.05$) impact on the sensory properties of biscuits. The scent and sweetness of biscuits were enhanced, while crunchiness and oiliness decreased. The 10% replacement of wheat flour with muskmelon seed flour in a typical biscuit-making recipe achieved better overall appeal, as illustrated in Figure 3. The literature reveals that adding muskmelon seed flour to biscuits increases scent and sweetness because of high fiber content and natural sweetness. Enhancement in aroma was more pronounced when utilizing formulations with higher proportion of muskmelon seed flour, demonstrating a positive association between the amount of muskmelon seed flour and the aroma intensity of biscuits. Moreover, muskmelon seed flour includes natural sugars that contribute to the taste of biscuits. The higher the percentage of muskmelon seed flour used in recipe, the sweeter are the biscuits (Gómez-García *et al.*, 2020).

Earlier, cookies were prepared by including fluted pumpkin seed flour, which showed hardness (texture) and low overall acceptance from blends containing more than 15% pumpkin flour to a crumbly texture, beany taste, and darkening of cookies (Giami *et al.*, 2005). In another study, cookies were prepared by adding bitter gourd protein isolates, and the sensory attributes changed among different treatments as the quantity of protein isolate increased from 5% to 20%. Supplementation of cookies with any component influenced their color, flavor, taste, and texture (Batool *et al.*, 2021).

Conclusion

Muskmelon seeds are an abundant source of proteins, dietary fiber, minerals, vitamins, and antioxidants. Incorporating muskmelon seed flour into biscuits improved their protein content, dietary fiber, TPC, and TFC. Textural analysis demonstrated that biscuits became slightly firmer, which helped them retain their shape after the addition of muskmelon seed flour. SEM revealed increased porosity in biscuits, leading to enhanced nutrient and ingredient absorption within the protein–starch matrix. FTIR analysis showed greater infrared light absorption in samples with higher concentrations of muskmelon seed flour, indicating an

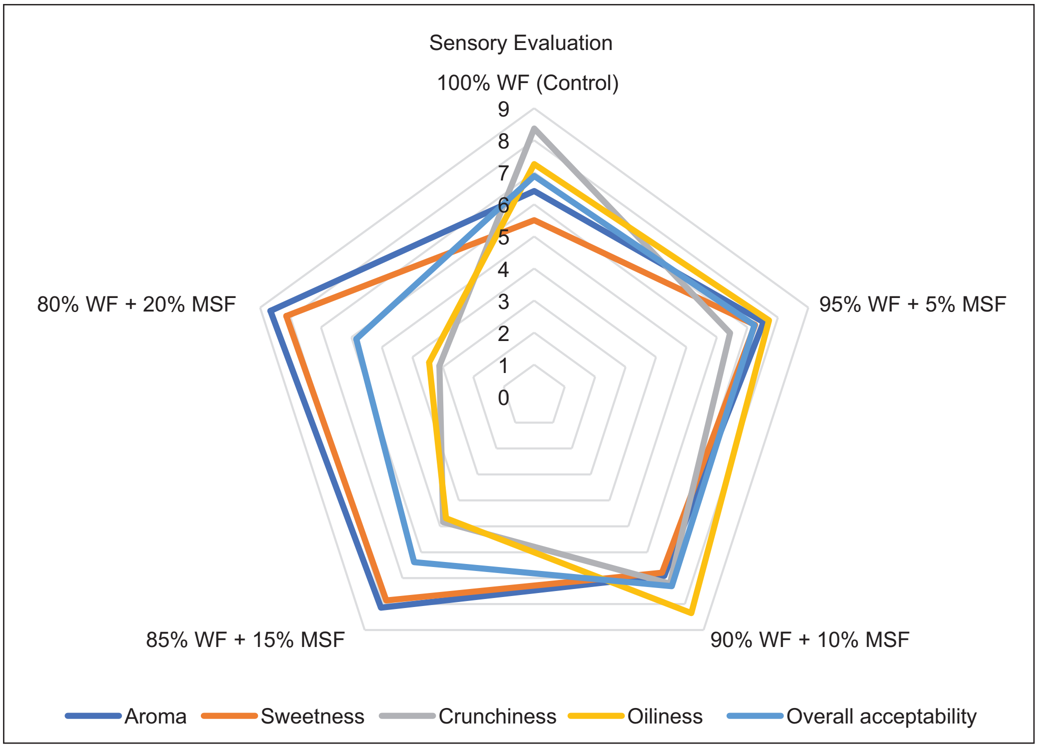

Figure 3. **Sensory analysis of biscuits. T_0 = 100% wheat flour, T_1 = 95% wheat flour and 5% muskmelon seed flour, T_2 = 90% wheat flour and 10% muskmelon seed flour, T_3 = 85% wheat flour and 15% muskmelon seed flour, and T_4 = 80% wheat flour and 20% muskmelon seed flour.**

improvement in nutritional and functional profiles. Sensory evaluation of the muskmelon seed-fortified biscuits indicated their appealing aroma, texture, taste, and flavor. The biscuits with 10% replacement of wheat flour with muskmelon seed flour gained the highest scores in terms of overall acceptability.

For future research, it would be suitable to carry out sensory evaluations by involving both trained and untrained panelists to obtain a more comprehensive understanding of the biscuits' sensorial characteristics. This approach would give a comparison between the perceptions of experts and the general consumers, offering more detailed results into the product's acceptance and potential areas for further improvement. By involving a more diverse panel, the sensory findings across different demographic groups can be enhanced.

Utilization of cucurbit seeds to produce health beneficial and functional foods gives several industrial benefits. Cucurbit seeds are rich source of protein, minerals, vitamins, and healthy fats. Adding them to produce functional foods can improve the nutritional worth of these products and give various health benefits to the consumers. Addition of these seeds into the food products will differentiate the newly developed food products in the market, making them more attractive to health-conscious consumers. These seeds are also considered as waste products of the muskmelon fruit, the food industry can make sustainable use the available resources and an effective food waste management. This approach agrees with the sustainable development goals and can contribute to the concept of circular bioeconomy. Companies that add cucurbit seeds into their food products will increase their sustainability credentials and brand image. This is more important as consumers and businesses will focus on responsible consumption and production.

Author Contributions

Najla Al Masoud: conceptualization, investigation, data curation, writing original draft, writing review and editing, supervision. Syed Ali Hassan: conceptualization, investigation, methodology, data collection, experimentation, writing original draft, writing review and editing. Taghrid S. Alomar: conceptualization, investigation, writing review and editing. Waqar Mujahid: data collection, experimentation, writing review and editing. Rana Muhammad Aadil: conceptualization, investigation, formal analysis, data curation, writing original draft, writing review and editing, supervision. All authors read and agreed to the published version of the manuscript.

Ethical Approval

The sensory evolution was carried out at the National Institute of Food Science and Technology, University of Agriculture, Pakistan with the approval of Institutional Ethical Committee (IEC) (D# 1913/ORIC) as per the standards of Health and Human Protection Services. The panelists were untrained university students who participated voluntarily in this sensory evaluation activity. The samples served were pretested as per safety protocols to minimize the risk of allergy and toxicity.

Conflict of Interest

The authors declared no conflict of interest.

Declaration of AI Statement

During the preparation of this work, the author(s) used AI-based tools to correct the grammatical errors of the manuscript.

Acknowledgments

The authors were thankful to Princess Nourah bint Abdulrahman University Researchers for Supporting Project No. HCPNU2024R18), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

Funding

We are thankful to Princess Nourah bint Abdulrahman University Researchers for Supporting Project number (HCPNU2024R18), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

References

Ahmad M., Ehsan N., Khan H.A., Hamza A., Azmat R. and Ijaz M.U., 2023a. Ameliorative effects of rhamnetin against polystyrene microplastics-induced nephrotoxicity in rats. Pakistan Veternary Journal 43(3): 623–627. https://doi.org/10.29261/pakvetj/2023.058

Ahmad S., Yousaf M.S., Tahir S.K., Rashid M.A., Majeed K.A., Naseem M., et al. 2023b. Effects of co-supplementation of β-galacto-oligosaccharides and methionine on breast meat quality, meat oxidative stability, and selected meat quality genes in broilers. Pakistan Veterinary Journal 43(3): 428–434. https://doi.org/10.29261/pakvetj/2023.043

Anjum R., Hamid M., Khalil R. and Ajmal A., 2023. Possible effect of ascorbic acid against zinc oxide nanoparticles-induced hepatotoxicity in Swiss albino mice. International Journal of Agriculture and Biosciences 12(3): 193–198. https://doi.org/10.47278/journal.ijab/2023.064

American Association of Cereal Chemists (AACC), 2000. Baking quality of cookie flour. Standard No. 10-50D:2000. In: George, W. (Ed.), Approved methods of the American Association of Cereal Chemists, 10th edition. AACC, St. Paul, MN, pp. 334–346

Association of Official Analytical Chemists (AOAC), 2016. Official methods of analysis. In: Horwitz, W. (Ed.), Association of Official Analytical Chemists International, 20th edition. AOAC Press, Arlington, VA, pp. 131–140

Baltacıoğlu, C., Baltacıoğlu, H., Seyhan, R., Uğur, Ö. and Avcu, O., 2021. Investigation of the effect of oyster mushroom (*Pleurotus ostreatus*) powder on biscuit production and effect on quality criteria by Fourier-transform infrared spectroscopy. Journal of Food Processing and Preservation 45(2): e15174. https://doi.org/10.1111/jfpp.15174

Bangulzai N., Ahmed S.F., Kashif M., Fatima M., Ahmed M. and Mushtaq N., 2022. Antifungal activity of essential oils extracted from different plants against *Penicillium digitatum* causing green mold of citrus. International Journal of Agriculture and Biosciences 11(2): 75–83. https://doi.org/10.47278/journal.ijab/2022.011

Batool, R., Yasmin, I., Munawar, I., Aziz, M., Tehseen, S., Khan, W.A. and Azam, M., 2021. Evaluation of a bitter gourd protein isolate in a cookie formulation. International Journal of Vegetable Science 27(5): 480–495. https://doi.org/10.1080/19315260.2020.1861159

Brigante, F.I., Lucini Mas, A., Erban, A., Fehrle, I., Martinez-Seidel, F., Kopka, J., Wunderlin, D.A. and Baroni, M.V., 2022. Authenticity assessment of commercial bakery products with chia, flax and sesame seeds: application of targeted and untargeted metabolomics results from seeds and lab-scale cookies. Food Control 140:109114. https://doi.org/10.1016/j.foodcont.2022.109114

Chiș, M.S., Păucean, A., Stan, L., Mureșan, V., Vlaic, R.A., Man, S., Biriș-Dorhoi, E.S. and Muste, S., 2018. Lactobacillus plantarum ATCC 8014 in quinoa sourdough adaptability and antioxidant potential. Romanian Biotechnological Letters 23(3): 13581–13591.

Ciurzyńska, A., Cieśluk, P., Barwińska, M., Marczak, W., Ordyniak, A., Lenart, A. and Janowicz, M., 2019. Eating habits and sustainable food production in the development of innovative 'healthy' snacks (running title: Innovative and 'healthy' snacks). Sustainability (Switzerland) 12(24): 10572. https://doi.org/10.3390/su122410572

Derar, D., Ali, A., Almundarij, T.I., Abdel-Moniem, E. and Alhassun, T., 2023. Effect of breed, feed, housing, age and parity on serum trace elements levels in goats. International Journal of Veterinary Science 12(4): 612–614. https://doi.org/10.47278/journal.ijvs/2023.008

Devi, L.M. and Badwaik, L.S., 2022. Influence of temperature, time and alkali concentration on protein extraction from muskmelon seed meal. Indian Chemical Engineer 64(2): 219–226. https://doi.org/10.1080/00194506.2021.1915887

Devi, L.M., Lalnunthari, C. and Badwaik, L.S., 2019. Direct transformation of muskmelon seeds meal into biodegradable films and their characterization. Journal of Polymers and the Environment 27(3): 456–463. https://doi.org/10.1007/s10924-018-1361-x

Dhen, N., Ben Rejeb, I., Boukhris, H., Damergi, C. and Gargouri, M. 2018. Physicochemical and sensory properties of wheat-Apricot kernels composite bread. Food Science and Technology (LWT) 95: 262–267. https://doi.org/10.1016/j.lwt.2018.04.068

Dohouonan, D., Brice, O.E.J., Julien, G.K. and Yao, T., 2022. Effectiveness of *Calotropis procera* (Ait. R. Br.) and *Cassia siamea* (Lamk.) leave powders in the control of Sitophilus zeamais Motschulsky (Coleoptera: Curculionidae). International Journal of Agriculture and Biosciences, 11(2): 84–89.

Elihasridas, Pazla R., Jamarun, N., Yanti, G., Sari, R.W.W. and Ikhlas, Z., 2023. Pre-treatments of Sonneratia alba fruit as the potential feed for ruminants using Aspergillus niger at different fermentation times: Tannin concentration, enzyme activity, and total colonies. International Journal of Veterinary Science 12(5): 755–761. https://doi.org/10.47278/journal.ijvs/2023.021

Fahim, K.M., Ahmed, L.I. and Abdel-Salam, A.B., 2022. Influence of the hygienic status of food contact surfaces and handler's hands on the microbial safety of ready to eat foods. International Journal of Veterinary Science 11(2): 249–256. https://doi.org/10.47278/journal.ijvs/2021.102

Gade, S.R., Meghwal, M., Prabhakar, P.K. and Giuffrè, A.M. 2022. A comparative study on the nutritional, antioxidant, thermal, morphological and diffraction properties of selected cucurbit seeds. Agronomy 12(10): 2242. https://doi.org/10.3390/agronomy12102242

Ghany, F.T.F.A., Morsy, S.H., Hassan, H.M.A. and Samy, A., 2023. Evaluation of olive leaves and pomace extracts in growing rabbit diets on productive performance, nutrient digestibility, carcass characteristics, antioxidant status, and economic efficiency. International Journal of Veterinary Science 12(1): 37–44.

Giami, S.Y., Achinewhu, S.C. and Ibaakee, C. 2005. The quality and sensory attributes of cookies supplemented with fluted pumpkin (Telfairia occidentalis Hook) seed flour. International Journal of Food Science & Technology 40(6): 613–620.

Gómez-García, R., Campos, D.A., Aguilar, C.N., Madureira, A.R. and Pintado, M. 2020. Valorization of melon fruit (*Cucumis melo* L.) by-products: phytochemical and biofunctional properties with emphasis on recent trends and advances. Trends in Food Science and Technology 99: 507-519. https://doi.org/10.1016/j.tifs.2020.03.033

Hooda, S. and Jood, S. 2005. Organoleptic and nutritional evaluation of wheat biscuits supplemented with untreated and treated fenugreek flour. Food Chemistry 90(3): 427-435. https://doi.org/10.1016/j.foodchem.2004.05.006

Horvat, A., Granato, G., Fogliano, V. and Luning, P.A. 2019. Understanding consumer data use in new product development and the product life cycle in European food firms – an empirical study. Food Quality and Preference, 76: 20-32. https://doi.org/10.1016/j.foodqual.2019.03.008

Ismail, H.I., Chan, K.W., Mariod, A.A. and Ismail, M. 2010. Phenolic content and antioxidant activity of cantaloupe (*Cucumis melo*) methanolic extracts. Food Chemistry 119(2): 643-647. https://doi.org/10.1016/j.foodchem.2009.07.023

Iozon, I., Cernea, M., Buza, V., Miclăuș, V., Lațiu, M.-C.M., Martonos, C., Vlasiuc, I,, Szakacz, A.R. and Ștefănuț, L.C., 2023. Inulin effect on intestinal mucus-secreting cells. Pakistan Veterinary Journal 43(3): 435–441. https://doi.org/10.29261/pakvetj/2023.064

Jia, M., Yu, Q., Chen, J., He, Z., Chen, Y., Xie, J., Nie, S. and Xie, M. 2020. Physical quality and in vitro starch digestibility of biscuits as affected by addition of soluble dietary fiber from defatted rice bran. Food Hydrocolloids 99. https://doi.org/10.1016/j.foodhyd.2019.105349

Jiang, G., Wu, Z., Ameer, K. and Song, C. 2021. Physicochemical, antioxidant, microstructural, and sensory characteristics of biscuits as affected by addition of onion residue. Journal of Food Measurement and Characterization 15(1): 817–825. https://doi.org/10.1007/s11694-020-00681-0

Jukić, M., Lukinac, J., Čuljak, J., Pavlović, M., Šubarić, D. and Koceva Komlenić, D. 2019. Quality evaluation of biscuits produced from composite blends of pumpkin seed oil press cake and wheat flour. International Journal of Food Science & Technology 54(3): 602–609.

Kaur, M., Singh, V. and Kaur, R. 2017. Effect of partial replacement of wheat flour with varying levels of flaxseed flour on physicochemical, antioxidant and sensory characteristics of cookies. Bioactive Carbohydrates and Dietary Fibre 9: 14-20. https://doi.org/10.1016/j.bcdf.2016.12.002

Kaur, P., Sharma, P., Kumar, V., Panghal, A., Kaur, J. and Gat, Y. 2019. Effect of addition of flaxseed flour on phytochemical, physicochemical, nutritional, and textural properties of cookies. Journal of the Saudi Society of Agricultural Sciences 18(4): 372–377. https://doi.org/10.1016/j.jssas.2017.12.004

Khan, M.M., Nawaz, M.S., Saeed, A. and Khan, M.A., 2022. Combining ability estimates of various morphological and quality traits of okra. International Journal of Agriculture and Biosciences 11(3): 148–156. https://doi.org/10.47278/journal.ijab/2022.020

Klunklin, W. and Savage, G. 2018. Effect of substituting purple rice flour for wheat flour on physicochemical characteristics, in vitro digestibility, and sensory evaluation of biscuits. Journal of Food Quality 2018(1): 8052847. https://doi.org/10.1155/2018/8052847

Królak, M., Górska-Warsewicz, H., Madra-Sawicka, M., Rejman, K., Żakowska-Biemans, S., Szlachciuk, J., Czeczotko, M., Kwiatkowski, B., Zaremba, R. and Wojtaszek, M. 2022. Towards sustainable innovation in the bakery sector—An example of fibre-enriched bread. Sustainability (Switzerland) 14(5): 2743. https://doi.org/10.3390/su14052743

Kumar, A., Krishnamoorthy, E., Devi, H.M., Uchoi, D., Tejpal, C.S., Ninan, G. and Zynudheen, A.A. 2018. Influence of sea grapes (*Caulerpa racemosa*) supplementation on physical, functional, and antioxidant properties of semi-sweet biscuits. Journal of Applied Phycology 30(2): 1393-1403. https://doi.org/10.1007/s10811-017-1310-4

Laczkowski, M.S., Baqueta, M.R., de Oliveira, V.M.A.T., Gonçalves, T.R., Gomes, S.T.M., Março, P.H., Matsushita, M.

and Valderrama, P. 2021. Application of chemometric tools in the development and sensory evaluation of gluten-free cracknel biscuits with the addition of chia seeds and turmeric powder. Journal of Food Science and Technology 58(11): 4118–4126. https://doi.org/10.1007/s13197-020-04874-9

Lau, K.Q., Sabran, M.R. and Shafie, S.R. 2021. Utilization of vegetable and fruit by-products as functional ingredient and food. Frontiers in Nutrition 8: 661693. https://doi.org/10.3389/fnut.2021.661693

Man, S.M., Stan, L., Păucean, A., Chiș, M.S., Mureșan, V., Socaci, S.A., Pop, A. and Muste, S. 2021. Nutritional, sensory, texture properties and volatile compounds profile of biscuits with roasted flaxseed flour partially substituting for wheat flour. Applied Sciences (Switzerland) 11(11): 4791. https://doi.org/10.3390/app11114791

Mehnaz, S., Abbas, R.Z., Kanchev, K., Rafique, M.N., Aslam, M.A., Bilal, M., Ather, A.S., Zahid, A. and Batool, T., 2023. Natural control perspectives of *Dermanyssus gallinae* in poultry. International Journal of Agriculture and Biosciences 12(3): 136–142. https://doi.org/10.47278/journal.ijab/2023.056

Mehwish Ahmad, U., Manzoor, M., Aleem, K., Shafi, F., Shamoon, F., Rani, A. and Rohail, 2023. A review exploring the incorporation of microalgae to enhance the nutritional profile and health benefits of dairy products. Agrobiological Records 13: 92–100. https://doi.org/10.47278/journal.abr/2023.030

Miller, R.A., Hoseney, R.C. and Morris, C.F. 1997. Effect of formula water content on the spread of sugar-snap cookies. Cereal Chemistry 74(5): 669–671. https://doi.org/10.1094/CCHEM.1997.74.5.669

Mohamed, M.A. and Hassan, H.M.A., 2023. Phytogenic substances as safe growth promoters in poultry nutrition. International Journal of Veterinary Science 12(1): 89–100.

Montgomery, D.C. 2017. Design and analysis of experiments, 10th edition. John Wiley, Hoboken, NJ, 688 p.

Munir, H., Abbas, S. and Sohail, M.T., 2023. Nurturing the crop: recent innovations in vegetable diseases management. Agrobiological Records 13: 101–107. https://doi.org/10.47278/journal.abr/2023.029

Ni, Q., Ranawana, V., Hayes, H.E., Hayward, N.J., Stead, D. and Raikos, V. 2020. Addition of broad bean hull to wheat flour for the development of high-fiber bread: effects on physical and nutritional properties. Foods 9(9): 1192. https://doi.org/10.3390/foods9091192

Olombrada, E., Mesias, M. and Morales, F.J. 2024. Risk/benefits of the use of chia, quinoa, sesame and flax seeds in bakery products. an update review. Food Reviews International 40(4):.1047–1068. https://doi.org/10.1080/87559129.2023.2209794

Pattnaik, M. and Mishra, H.N. 2022. Development and quality evaluation of multivitamin fortified low-fat biscuits. International Journal of Food Science and Technology 57(10): 6531–6539. https://doi.org/10.1111/ijfs.15992

Polyzos, N., Fernandes, Â., Calhelha, R.C., Petrović, J., Soković, M., Ferreira, I.C., Barros, L. and Petropoulos, S.A. 2023. Biochemical composition of pumpkin seeds and seed by-products. Plants 13(17): 2395. https://doi.org/10.3390/plants13172395

Saha, S., Gupta, A., Singh, S.R.K., Bharti, N., Singh, K.P., Mahajan, V. and Gupta, H.S. 2011. Compositional and varietal influence of finger millet flour on rheological properties of dough and quality of biscuit. Food Science and Technology (LWT) 44(3): 616–621. https://doi.org/10.1016/j.lwt.2010.08.009

Ullah, F., Ahmad, S., Wahab, S., Zeb, A., Khattak, M.K., Khan, S. and Kang, M. 2016. Quality evaluation of biscuits supplemented with alfalfa seed flour. Foods 5(4): 68. https://doi.org/10.3390/foods5040068

Wani, A.A., Sogi, D.S., Singh, P., Sharma, P. and Pangal, A. 2012. Dough-handling and cookie-making properties of wheat flour-watermelon protein isolate blends. Food and Bioprocess Technology 5: 1612–1621.. https://doi.org/10.1007/s11947-010-0466-6

Widowati, W., Prahastuti, S., Hidayat, M., Hasiana, S.T., Wahyudianingsih, R., Afifah, E., Kusuma, H.S.W., Rizal, R. and Subangkit, M., 2022. Protective effect of ethanolic extract of jati belanda (*Guazuma ulmifolia* L.) by inhibiting oxidative stress and inflammatory processes in cisplatin-induced nephrotoxicity in rats. Pakistan Veterinary Journal 42(3): 376–382. https://doi.org/10.29261/pakvetj/2022.050

Yang, J., Guan, Y., Chen, J., Su, Y., Zhang, S., Mehmood, K., Saleem, M.U., Shi, D., 2022. Effects of echinacea extract on intestinal metabolomics in immunosuppressive rats. Pakistan Veterinary Journal 42(3): 390–396. https://doi.org/10.29261/pakvetj/2022.041

Zhang, G., Chatzifragkou, A., Charalampopoulos, D. and Rodriguez-Garcia, J., 2023. Effect of defatted melon seed residue on dough development and bread quality. Food Science and Technology (LWT) 183: 114892. https://doi.org/10.1016/j.lwt.2023.114892

Zhang, H., Yuan, Y., Zhu, X., Xu, R., Shen, H., Zhang, Q. and Ge, X. 2022. The effect of different extraction methods on extraction yield, physicochemical properties, and volatile compounds from field muskmelon seed oil. Foods 11(5): 721. https://doi.org/10.3390/foods11050721