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Research Article

Effects of incorporating dragon fruit peel powder into cookies on their nutritional composition, microbial quality, and sensory properties

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Abstract - This study investigates the effects of incorporating dragon fruit peel powder (DPP) into cookies on their nutritional composition, microbial quality, and sensory properties. Two formulations were prepared: a control (DPP0) and a formulation with 5% DPP (DPP5). Nutritional analysis revealed significant improvements in ash (2.42±0.03% in DPP5 and 2.15±0.02% in DPP0), crude protein (7.69±0.14% in DPP5 and 6.75±0.02% in DPP0), crude fiber (0.82±0.08% in DPP5 and 0.09±0.02% in DPP0), and crude fat (27.63±0.04% in DPP5 and 26.63±0.02% in DPP0). Moisture content slightly decreased (4.50±0.14% in DPP5 and 4.78±0.21% in DPP0), and carbohydrate content was lower in DPP5 (56.94±0.03%) compared to DPP0 (59.60±0.19%). Over a 30-day storage period, the DPP5 cookies consistently showed lower microbial loads, starting from 0.5×10^2 CFU/g at day 5 to 1.9×10^3 CFU/g at day 30, compared to DPP0, which ranged from 0.8×10^2 CFU/g to 2.2×10^3 CFU/g over the same period. Sensory evaluation indicated a significant preference for DPP5 cookies, with mean scores for color (8.40±0.67), texture (8.28±0.55), odor (8.50±0.82), flavor (8.50±0.75), and overall acceptance (8.03±0.70), all surpassing those of the DPP0 cookies, which scored 7.25±0.63, 7.13±0.46, 7.05±0.68, 7.20±0.69, and 6.90±0.78, respectively. These results suggest that Dragon fruit peel powder enhances the nutritional composition, microbial stability, and sensory appeal of cookies, making it a valuable ingredient for functional food development.

Keywords: Dragon fruit, peel, powder, cookies, development

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1. Introduction

Cookies are extensively consumed as industrially manufactured food items in Bangladesh. They often consist of refined flour, sugar, hydrogenated fats, and other components, including additives and emulsifiers (Nurfirdausi et al., 2023). Manufacturers enrich cookies with various cereals such as finger millet, gram flour, soy flour, and others, which significantly enhance their nutritional content due to the high dietary fiber in these cereals (Agrahar-Murugkar et al., 2018; Butt et al., 2007; Chakraborty & Chakraborty, 2022; Ghoshal & Kaushik, 2020; Šoronja-Simović et al., 2017). Bangladesh's current market size of biscuits and cookies is around $597-717 million, with well-established brands commanding 40-50% of the overall market share (Wing, 2019). In the first half of fiscal year (FY) 2018-2019, the net export profits from biscuits and cookies reached $80.41 million, almost double the $43.09 million earned in the previous year. Experts project that this figure will quadruple in the coming years (Wing, 2019). They also predict a 15% biscuit and cookies market growth rate over the next 10-15 years, surpassing the government's GDP growth objective by 5% (Wing, 2019). Consumers universally embrace and devour cookies, making them a viable means of enhancing nutritious intake (Giese & Stabauer, 2022). Due to their inexpensive price, convenience, shelf-stability, and nutritious content, these snack items have gained popularity among young and older individuals (Sielicka-Różyńska et al., 2021).

Dragon fruit, scientifically known as *Hylocereus undatus*, belongs to the Cactaceae family and is native to Mexico, Central and South America (Al-Mekhlafi et al., 2021). The fruit has a visually appealing color and a soft, quickly melting pulp containing black edible seeds. Due to its high nutritional value, it attracts producers from various regions of Bangladesh. It is a non-climacteric fruit with red surface color and green color scales, with white flesh inside containing many little black seeds (Li et al., 2016). Its high fiber content, vitamin C, minerals, and phytoalbumins give it nutraceutical characteristics, which are widely esteemed for their antioxidant effects (Nishikito et al., 2023). Dragon fruits are primarily accessible from August to November and offer various health advantages, such as reducing blood glucose levels in individuals with type 2 diabetes (Poolsup et al., 2017). The fruit also has nutritional benefits, including vitamin C and dietary fiber (Rebecca et al., 2010). Farmers can easily preserve the fruit at ambient temperature and use its pulp to create other processed items. The crop is resilient, thriving in any climate conducive to blooming and fruiting, as well as in well-drained soil conditions. Typically, these plants produce fruit quickly and have few issues with diseases and pests (Balendres & Bengoa, 2019).

Dragon fruit has garnered significant interest from cultivators worldwide due to its visually appealing red-purple hue, substantial nutritional content, and commercial value (Ghosh et al., 2023). The dragon fruit farm in Bangladesh is experiencing significant growth because of strong local and export market demand (Nur et al., 2023).

Alternatively, the consumption of dragon fruit peel offers numerous health benefits, primarily due to its rich content of dietary fibers, antioxidants, and bioactive compounds. These components contribute to various therapeutic effects, making dragon fruit peel a valuable addition to the diet. It contains phytoconstituents such as polyphenols and flavonoids, offering antioxidant, anti-inflammatory, and wound healing properties, suggesting potential health benefits from its consumption (Chatterjee et al., 2024). It also offers health benefits by reducing lipid peroxidation, dietary advanced glycation end products, and starch digestibility due to its phytochemicals, fibers, and antioxidant properties (Chumroenvidhayakul et al., 2023). The addition of dragon fruit peel powder to cookies improves antioxidant activity and reduces harmful toxins. Incorporating it in cookies enhances nutritional value without compromising palatability (Chumroenvidhayakul et al., 2023). The dragon fruit peel extract contains antioxidants that can protect the skin from premature aging, indicating potential health benefits when consumed for skin protection and anti-aging effects (Wahdaningsih et al., 2023). The peel of red dragon fruit has high antioxidant activity and can be used as a source of functional components (Cruz et al., 2022). It has numerous health benefits and potential therapeutic applications. Clinical trials have shown improvements in glycemia, lipid profile, and antioxidant status (Nishikito et al., 2023).

Dragon fruit peel, often overlooked, is a nutrient-rich component of the fruit that offers significant health benefits. Research indicates that it is high in fiber, antioxidants, and essential vitamins, making it a valuable addition to diets. Dragon fruit peel contains notable amounts of carbohydrates (up to 4,050 mg), protein (up to 1,264 mg), and fat (up to 730 mg) (Widyawaty & Lestari, 2022). The peel is rich in vitamin C, with content varying between 1.12 and 1.20 mg/100g, and also provides essential minerals like calcium, magnesium, and iron (Nur et al., 2023). The antioxidant capacity of dragon fruit peel is higher than that of its flesh, attributed to its rich anthocyanin and polyphenol content (Widyawaty & Lestari, 2022; Rosiana et al., 2023). This makes it beneficial for combating oxidative stress. Dragon fruit peel can be incorporated into complementary feeding for infants, enhancing nutritional value and antioxidant content (Rosiana et al., 2023). Additionally, it can be used in products like milk pie, improving fiber and vitamin C levels while reducing water content (Rahmah et al., 2022). While dragon fruit peel is nutritious, its utilization in food products remains limited, suggesting a need for greater awareness and innovative applications in the food industry.

During industrial processing, producers often discard dragon fruit peels, constituting approximately 22% of the fruit's total weight (Le, 2022). These discarded peels are rich in several bioactive compounds (Le, 2022). Utilizing by-products from the fruit processing sector represents a significant and innovative advancement for the food industry. By using dragon fruit processing by-products such as the peel, producers can enhance the output of raw materials while reducing the challenges associated with disposing of significant volumes of industrial waste. Additionally, this practice can facilitate the expansion of alternative food production (Jalgaonkar et al., 2022). Several authors have documented the potential of these substances as natural colorants, thickening agents, and moisturizers in cosmetic products (Cheok et al., 2018; Matra et al., 2021; Thaiudom et al., 2021; Tripathi et al., 2023). Dragon fruit peel is safe for human consumption as it provides natural dyes with functional properties, antioxidants, and polyphenols that are benefcial to health, as already mentioned in several studies (Chumroenvidhayakul et al., 2023; Harni et al., 2023; Rahmana Putra et al., 2024; Yuna et al., 2023). Therefore, the research hypothesizes that incorporating dragon fruit peel powder into cookies will enhance their nutritional composition, improve microbial quality, and positively impact sensory properties. The aim is to evaluate the effects of the dragon peel powder on the cookies' nutrient content, shelf life, as well as consumer acceptance. This study seeks to determine whether dragon fruit peel powder can create a healthier, more appealing cookie product.

2. Materials and methods

2.1 Materials

Dragon fruit was carefully selected from a local market in Mirpur, Dhaka, Bangladesh to ensure the highest quality. The fruit peel was methodically processed as outlined in Section 2.2.1. Essential ingredients, including wheat flour, sugar,

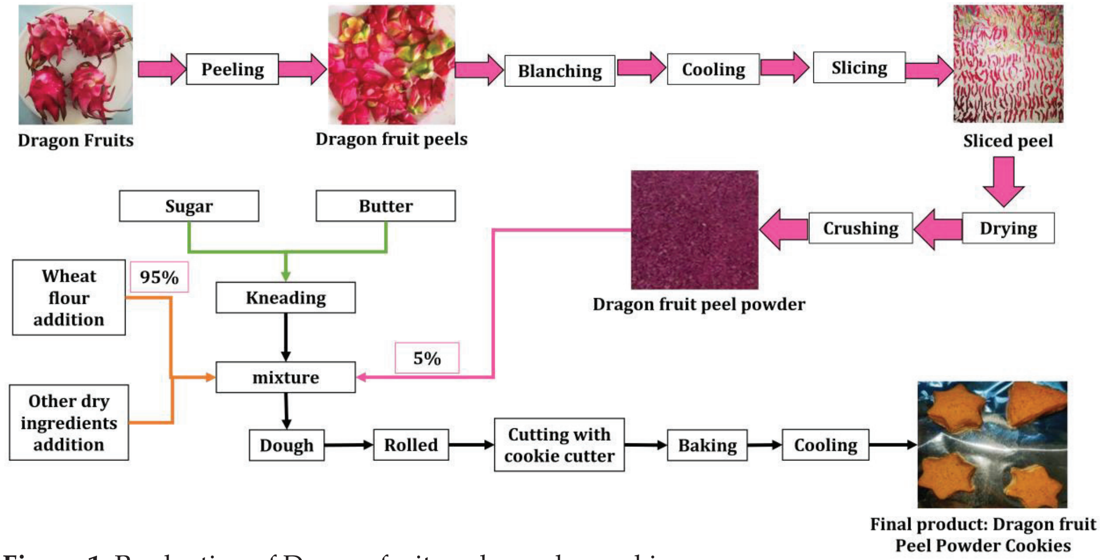


Figure 1. Production of Dragon fruit peel powder cookies.

butter, salt, and vanilla essence were considerately sourced from a trusted local grocery store in Mirpur, Dhaka, Bangladesh. Every single reagent used in the research met rigorous analytical grade standards.

2.2 Methods

2.2.1 Preparation of peel powder

Clean dragon fruit peel was separated from the fruits manually with a sterile knife. Then, the peel was blanched for 2 min at 65°C to prevent enzymatic browning. The peel was then sliced using the slicer before drying in a cabinet dryer at 56°C for 18 hours. The dried peel was then crushed in electric grinder to fine powder and kept in an airtight plastic zip bag container and stored at an ambient temperature of 28 ± 2°C. According to a previous study, Dragon fruit peel powder consists of 21.34% crude fiber, 16.74% ash, 6.66% moisture, 4.35% crude protein, and 1.28% crude fat content (Cacatian, 2022). It contains both soluble and insoluble fibers, with studies indicating water-soluble dietary fiber at 1.33% and insoluble dietary fiber at 1.86% (Rahmah et al., 2024). The total dietary fiber content can be as high as 65.2%, making it an excellent functional ingredient for improving food quality (Chumroenvidhayakul et al., 2023).

2.2.2 Preparation of cookies

The cookies were prepared following the method described by Loza et al. (2017) with minor adjustments (Figure 1). The formulations used to prepare the cookies is detailed in Table 1. For the preparation of DPP5, dragon fruit peel powder was used to replace 5% of the wheat flour. Similar studies incorporating dragon fruit peel powders into baked goods frequently use concentrations of around 5% as it has been found to improve the nutritional quality while preserving product quality (Chumroenvidhayakul et al., 2023; Hong Quan et al., 2024; Muñoz-Murillo et al., 2024). The control cookies (DPP0) were prepared without dragon fruit peel powder. The process involved creaming the butter with sugar until fluffy, followed by the addition of an egg and other dry ingredients (milk powder, salt, DPP, and wheat flour). The dough was kneaded thoroughly for ten minutes and then rolled manually to a thickness of 5 mm using a rolling pin. The sheeted dough was cut using a 3.2 mm diameter cookie cutter. All shaped dough was baked on a greased tray for 15 minutes at 180°C in an electric oven. The cookies were cooled at ambient temperature for 30 minutes before being packed in an airtight plastic container prior to analysis.

Table 1. Formulation for the production of dragon peel powder composite cookies.

Ingredients (g)	DPP0 (Control)	DPP5
Wheat flour	300	285
Dragon fruit peel powder	–	15
Sugar	100	100
Butter	165	165
Milk powder	10	10
Vanilla essence (mL)	2.5	2.5
Salt	1.5	1.5

Note: DPP, Dragon peel powder; DPP5, wheat flour substituted with 5% dragon fruit peel powder; –, Indicates absence of ingredient.

2.3 Proximate analysis

Proximate analysis was conducted according to AOAC (2016), to determine the nutritional composition of samples, including moisture, ash, fat, protein, crude fiber, and carbohydrate contents.

2.3.1 Determination of moisture content

Determining moisture content involved weighing a sample before and after drying it in an oven at 105°C it reached a constant weight. The sample was cooled in a desiccator and reweighed. The moisture content was then calculated by the weight difference, expressed as a percentage of the original sample weight (AOAC, 2016).

$$Moisture\ content(\%) = \frac{Initial\ Weight - Final\ Weight}{Initial\ Weight} \times 100$$

2.3.2 Determination of ash content

The ash content was determined by incinerating approximately 2 g of the sample in a muffle furnace at 700°C until for 6 hours (AOAC, 2016). The ash content was calculated using the formula:

$$Ash\ content(\%) = \frac{Weightofash}{Weightofsample} \times 100$$

2.3.3 Determination of fat content

The fat content was determined using the Soxhlet extraction method (AOAC, 2016). About 5 g of the sample was used in extraction process with n-hexane for 6 hours. The fat content was calculated using the formula:

$$Fat\ content(\%) = \frac{Weight\ of\ extractedfat}{Weight\ of\ sample} \times 100$$

2.3.4 Determination of protein content

The protein content was determined using the Kjeldahl method (AOAC, 2016). Approximately 2 g of the sample was digested with concentrated sulfuric acid, followed by neutralization and distillation. The nitrogen content was converted to protein content using the factor 6.25. The protein content was calculated using the formulas:

$$\%Nitrogen(N) = \frac{(V_{acid} - V_{blank}) \times N_{acid} \times 14 \times 100}{W \times 1000}$$

Where V_{acid} is the volume of acid used in the titration (ml), V_{blank} is the volume of acid used for the blank titration (ml), N_{acid} is the normality of the titrating acid, 14 is atomic weight of nitrogen (g N/mol), W is the sample weight (g), and 6.25 is the conversion factor.

2.3.5 Determination of crude fiber

The crude fiber content was determined using an acid-base digestion method (AOAC, 2016). Approximately 2 g of the sample was digested with 0.128 M sulfuric acid and 0.313 M sodium hydroxide. The residue was dried, weighed, and incinerated to obtain the crude fiber content, calculated using the formula:

$$Crude\ fiber(\%) = \frac{Weight\ of\ residue - Weigh\ to\ fash}{Weight\ of\ sample} \times 100$$

2.3.6 Determination of carbohydrate content

The carbohydrate content was calculated by difference, subtracting the sum of moisture, ash, protein, fat, and fiber contents from 100% (AOAC, 2016).

$$Carbohydrate\ content(\%) = 100\% - (Moisture + Ash + Protein + Fat + Fiber)$$

2.4 Microbial analysis

The cookie samples were homogenized by crushing in a sterile blender. The homogenized samples were then diluted in sterile test tubes containing phosphate-buffered saline (PBS) solution to create serial dilutions (e.g., 10^{-1}, 10^{-2}, 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}) and vortexed. For microbial analysis, Plate Count Agar (PCA) was used. Plate count agar media were prepared according to the instructions provided by the manufacturer. One mL of a serial diluted sample was transferred into a sterile Petri dish. Afterward, sterile molten agar, maintained at around 45-50°C to avoid killing the microorganisms, is poured into the petri dish containing the sample. The plate is then gently rotated to mix the sample and agar thoroughly, ensuring even distribution of the microorganisms throughout the medium. Once the agar solidifies, the plate is inverted and incubated, at 37°C for 18 hours (Harrigan, 1998). Bacterial counts in colony forming units per gram of sample was calculated using the following formula:

$$Colony\ forming\ units\ pergram(CFU/g) = \frac{(no.of\ colonies\ x\ dilution\ factor)}{volume\ of\ culture\ plated\ in\ gram}$$

2.5 Sensory Evaluation

Sensory evaluation was conducted to assess the acceptability of the cookies in terms of color, texture, odor, flavor, and overall acceptance (Sidel & Stone, 2006). A panel of 40 untrained evaluators, consisting of both male and female assessors who consumes cookie as regular snack item, willingly participated in the sensory evaluation. The cookies were evaluated using a 9-point hedonic scale (1 = dislike extremely, 9 = like extremely) for attributes such color, texture, odor, flavor, and overall acceptance.

2.6 Statistical Analysis

Statistical analysis was performed using IBM SPSS version 27.0. (IBM Corp., 2020). All the analyses were carried out in triplicates. Data were analyzed using independent sample t-tests to evaluate the significant differences $P < 0.05$ and also Wilcoxon signed-rank test was conducted to see the effects of DPP on microbial load (Armonk, 2020).

3. Results and discussion

The nutritional compositions, microbial load, and sensory quality of Dragon fruit peel powder cookies were assessed, and the findings are shown below:

3.1 Nutritional compositions

The nutritional composition of dragon fruit peel powder (DPP) cookies showed significant variations across different formulations (Table 2). The incorporation of DPP influenced the moisture, ash, crude protein, crude fiber, crude fat, and carbohydrate (CHO) content of the cookies. The moisture content in the control sample (DPP0) was 4.78±0.21%, whereas in the sample with 5% DPP (DPP5), it was slightly lower at 4.50±0.14%. Although this reduction in moisture content was not statistically significant, it could be attributed to the fibrous nature of the dragon fruit peel, which tends to absorb and retain less water compared to the other components in the cookie (Krajewska & Dziki, 2023). Dragon fruit peel powder contains approximately 65.2% dietary fiber (Chumroenvidhayakul et al., 2023). Insoluble fibers, like cellulose and lignin, do not retain water but contribute to the structural integrity of cookies (Din et al., 2024). Higher levels of insoluble fiber can result in drier, firmer, or crisper cookies by reducing overall moisture content (Din et al., 2024; Gruppi et al., 2023; Şahin, 2023). Ash content, which is an indicator of the mineral content in the cookies, increased significantly with the addition of DPP. The ash content in DPP0 was 2.15±0.02%, while in DPP5 it rose to 2.42±0.03% ($P < 0.05$). This increase can be explained by the higher mineral content in dragon fruit peel (Fidrianny et al., 2017), contributing to the nutritional value of the cookies.

Table 2. Nutritional Composition of Dragon fruit peel powder cookies.

Samples	Moisture	Ash	Crude protein	Crude Fiber	Crude Fat	CHO
DPP0	4.78±0.21^{a}	2.15±0.02^{a}	6.75±0.02^{a}	0.09±0.02^{a}	26.63±0.02^{a}	59.60±0.19^{a}
DPP5	4.50±0.14^{a}	2.42±0.03^{b}	7.69±0.14^{b}	0.82±0.08^{b}	27.63±0.04^{b}	56.94±0.03^{b}

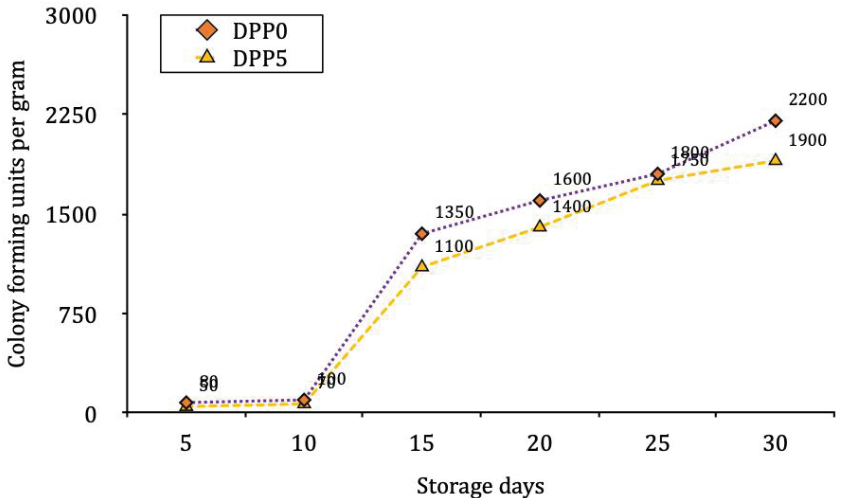
Note: a, b superscript denotes significant differences ($P < 0.05$); CHO, carbohydrates.
The use of superscripts (a, b) in this one sample t-test statistical analysis indicates significant differences between the DPP0 and DPP5, but the order of the letters does not reflect the direction of change.

There was a notable increase in crude protein content from 6.75±0.02% in DPP0 to 7.69±0.14% in DPP5 ($P < 0.05$). This enhancement in protein content may be linked to the protein present in the dragon fruit peel, which complements the existing protein in the cookie ingredients (Jalgaonkar et al., 2022). The crude fiber content gained a substantial rise from 0.09±0.02% in DPP0 to 0.82±0.08% in DPP5 ($P < 0.05$). This increase is significant as dietary fiber is essential for maintaining digestive health, and dragon fruit peel is known to be rich in dietary fiber (Hossain et al., 2021). The higher fiber content in the DPP5 cookies enhances their health benefits, making them a potentially beneficial snack for improving digestive health. Crude fat content showed a slight increase from 26.63±0.02% in DPP0 to 27.63±0.04% in DPP5 ($P < 0.05$). This could be due to the fat content in the dragon fruit peel itself or due to the interaction of DPP with other ingredients, enhancing fat retention (Al-Mekhlafi et al., 2021). The carbohydrate content decreased from 59.60±0.19% in DPP0 to 56.94±0.03% in DPP5 ($P < 0.05$). This reduction can be attributed to the replacement of some carbohydrate-rich ingredients with DPP, which contains lower carbohydrates compared to the base ingredients used in the control sample (Le, 2022).

3.2 Microbial quality

The microbial quality of the cookies was assessed over a storage period of 30 days, and the results indicated a progressive increase in microbial load in both the control and DPP-enriched samples (Figure 2). The cookie samples for microbial analysis were stored at 28±2°C (ambient temperature) with a 60% relative humidity in airtight, food-grade polyethylene packaging. The DPP5 samples consistently showed lower microbial counts compared to DPP0. At the beginning of the storage period (5 days), the microbial load was 0.8×10^2 CFU/g in DPP0 and 0.5×10^2 CFU/g in DPP5. The lower initial microbial load in DPP5 could be attributed to the antimicrobial properties of dragon fruit peel, which has been shown to contain bioactive compounds with antibacterial activity (Temak et al., 2019).

A



B

Storage(days)	Microbial load DPP0	Microbial load DPP5
5	0.8×10^2 CFU/g [a]	0.5×10^2 CFU/g [a]
10	1.0×10^2 CFU/g [a]	0.7×10^2 CFU/g [a]
15	1.35×10^3 CFU/g [a]	1.1×10^3 CFU/g [a]
20	1.6×10^3 CFU/g [a]	1.4×10^3 CFU/g [a]
25	1.8×10^3 CFU/g [a]	1.75×10^3 CFU/g [a]
30	2.2×10^3 CFU/g [b]	1.9×10^3 CFU/g [a]

a, b superscript denotes significant differences ($P < 0.05$)

Figure 2. Microbial quality of dragon fruit peel powder cookies over different storage periods (A, B).

As the storage period progressed, the microbial load increased in both samples, but the DPP5 samples consistently showed a lower microbial load at each time point. For example, at 15 days, DPP0 had a microbial load of 1.35×10^3 CFU/g, while DPP5 had 1.1×10^3 CFU/g. By the end of the storage period (30 days), the microbial load in DPP0 was 2.2×10^3 CFU/g compared to 1.9×10^3 CFU/g in DPP5. The microbial loads for both DPP0 and DPP5 were well within the Bangladesh Standards and Testing Institution (BSTI) limit of 10^4 CFU/g (Abimbola & Olabisi, 2020), even at day 30, where DPP0 reached 2.2×10^3 CFU/g and DPP5 reached 1.9×10^3 CFU/g. This trend suggests that DPP not only enhances the nutritional profile but also contributes to the microbial stability of the cookies, potentially extending their shelf life (Hendra et al., 2019). A Wilcoxon signed-rank test was conducted to determine the effect of incorporating dragon fruit peel powder (DPP5) on microbial load compared to a control (DPP0) over a 30-day storage period. Of the six storage periods, DPP5 (with dragon fruit peel powder) exhibited a general trend of reduced microbial load compared to DPP0. Notably, a statistically significant reduction in microbial load was observed at 30 days (Median = 1250 CFU/g for DPP5 vs. Median = 1400 CFU/g for DPP0; z = 0.0, p = 0.027), as shown in (Figure 2B).

3.3 Sensory properties of cookies

The sensory evaluation of the cookies provides understandings into consumer acceptance and preference (Table 3). Sensory attributes such as color, texture, odor, flavor, and overall acceptance were assessed.

Table 3. Sensory score observations of dragon fruit peel powder cookies.

Samples	Sensory Scores	Color	Texture	Odor	Flavor	Overall Acceptance
DPP0	(8) liked very much	14(17.5 %)	7(8.8 %)	10(12.5 %)	14(17.5 %)	10(12.5 %)
	(7) liked moderately	22(27.5 %)	31(38.8 %)	22(27.5 %)	20(25.0 %)	16(20.0 %)
	(6) liked slightly	4(5.0 %)	2(2.5 %)	8(10.0 %)	6(7.5 %)	14(17.5 %)
DPP5	(9) liked extremely	20(25.0 %)	13(16.3 %)	28(35.0 %)	26(32.5 %)	10(12.5 %)
	(8) liked very much	16(20.0 %)	25(31.3 %)	4(5.0 %)	8(10.0 %)	21(26.3 %)
	(7) liked moderately	4(5.0 %)	2(2.5 %)	8(10.0 %)	6(7.5 %)	9(11.3 %)

In terms of color, the DPP5 samples scored significantly higher (8.40±0.67) compared to the DPP0 samples (7.25±0.63) (Table 4), indicating a preference for the enhanced color provided by the dragon fruit peel powder ($P < 0.05$). For texture, the DPP5 cookies were also preferred, with a mean score of 8.28±0.55, significantly higher than the DPP0 cookies, which scored 7.13±0.46 ($P < 0.05$). The fiber content in DPP might have contributed to a more desirable texture (Krajewska & Dziki, 2023). According to several studies, the higher fiber content from dragon fruit peel powder in cookies can enhance texture by forming a pseudoplastic barrier, slowing water movement, and reducing lipid peroxidation, which also improves overall quality of cookies (Chumroenvidhayakul et al., 2023; Piteria et al., 2009; Qalbi et al., 2024). Odor was significantly better in the DPP5 cookies, with a mean score of 8.50±0.82 compared to 7.05±0.68 for DPP0 ($P < 0.05$). This could be due to the aromatic compounds present in dragon fruit peel (Hossain et al., 2021).

Table 4. Sensory mean score of dragon fruit peel powder cookies.

Samples	Color	Texture	Odor	Flavor	Overall Acceptance
DPP0	7.25±0.63[a]	7.13±0.46[a]	7.05±0.68[a]	7.20±0.69[a]	6.90±0.78[a]
DPP5	8.40±0.67[b]	8.28±0.55[b]	8.50±0.82[b]	8.50±0.75[b]	8.03±0.70[b]

Note: a, b superscript denotes significant differences (P < 0.05).

Flavor scores were also higher for the DPP5 cookies, with a mean score of 8.50±0.75 compared to 7.20±0.69 for DPP0 (P < 0.05). The incorporation of DPP likely added a unique flavor profile that was well-received. Overall acceptance was higher for the DPP5 cookies, with a mean score of 8.03±0.70 compared to 6.90±0.78 for DPP0 (P < 0.05). This indicates a general preference for the DPP-enriched cookies, suggesting that the nutritional and sensory benefits of DPP overshadow any potential drawbacks.

4. Conclusion

Incorporating dragon fruit peel powder into cookies not only enhances the nutritional quality by increasing protein, ash, and fiber content but also slightly modifies the moisture and fat content. Furthermore, DPP incorporation improves the microbial quality of the cookies, indicating lower microbial loads over a 30-day storage period. Sensory evaluations indicate that DPP-enriched cookies are generally preferred over the control samples, with significantly higher scores for color, texture, odor, flavor, and overall acceptance. These changes suggest that dragon fruit peel powder can be a valuable addition to cookies, contributing to their nutritional value, extending their shelf life by enhancing microbial stability, and improving consumer acceptance. Further research is recommended to optimize sensory properties and assess consumer acceptance of DPP-fortified cookies on a larger scale.

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