

DEVELOPMENT AND CHARACTERIZATION OF FUNCTIONAL DATE BARS FORTIFIED WITH APPLE PEEL POWDER

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ABSTRACT

Apple (*Malus domestica* L.) is widely consumed, highly nutritious, and generates over 26 million tons of dry matter residue annually, primarily from peel disposal. Apple peels are rich in antioxidants, flavonoids, phenolics, and dietary fiber. Thus, the present study utilized apple peel powder (APP) in the development of date bars, assessing its impact on the physicochemical, nutritional, and sensory properties of the bars. The treatment plan included: T₀ (control / 100 g date paste (DP)), T₁ (98 g DP + 2 g APP), T₂ (96 g DP + 4 g APP), T₃ (94 g DP + 6 g APP), T₄ (92 g DP + 8 g APP) and T₅ (90 g DP + 10 g APP). The results showed that the moisture content in date bars decreased from 12.42% to 10.39% upon incorporation of APP. Crude fat slightly increased (3.00% to 5.15%), while crude protein, crude fiber, and ash content significantly improved from (9.25% to 14.16%, 3.00% to 5.15%, and 1.65% to 3.40%, respectively). Total soluble solids ranged from 58.20 to 63.45, with their highest value in the 10% APP-incorporated samples. pH values ranged from 4.12 to 5.54, the highest with 10% APP. Color parameters viz. L*, a*, and b* increased, from 24.34 to 34.13, 7.86 to 9.22, and 9.09 to 13.32, respectively. Total phenolic content (TPC) and antioxidant activity (DPPH) increased, with TPC from 0.81 to 1.44 and DPPH from 22.45 to 31.33. The results of the sensory evaluation showed the T₃ (6% APP samples) to be the highest in color, taste, flavor, texture, and overall acceptability while the other treatments were also liked by the panel.

Keywords: Apple peel powder; Functional Foods; Physicochemical and Nutritional Evaluation; Sensory Attributes

INTRODUCTION

Convenience foods that are ready to eat have become more popular because of changes in the daily routines of most of the world's population (Popkin *et al.*, 2020). These days, people's attention on food is not only on controlling hunger but on eating dietary products that may improve their health or lower the risk of contracting certain diseases (Aja *et al.*, 2023). Fruit-based snack bars are among the best options since they are highly nutritious with natural sugars, vitamins, minerals, and other bio-nutritive components that meet consumers' daily required nutritional needs (Ayad *et al.*, 2020). Fruit bars provide nutrition and health benefits to people of different age groups and generally have a longer shelf life than fresh fruits. It is consumed for pleasure in addition to energy and satisfaction (Aslam *et al.*, 2023; Silva *et al.*, 2018). Fruit bars' exceptional shelf-life, texture, flavor, appealing packaging, and portability are all contributing factors to their growing popularity. Healthy fruit bars would be an enhanced replacement for junk foods which are considered unhealthy (Irshad *et al.*, 2022). Date bars are high-energy snack foods developed from dried date fruits and sometimes incorporated with additional ingredients. They are popular functional snacks for those seeking nutritious snack options (Irshad *et al.*, 2025).

Date palm fruit (*Phoenix dactylifera* L.) has a high nutritional content, making it a superior choice for snack bar production. Though date fruits are considered a high-carbohydrate fruit, supply a substantial quantity of high-quality nutrients like dietary fiber (e.g., β-glucans), unsaturated fatty acids (e.g., oleic, and linoleic acids), and a variety of micronutrients (e.g., riboflavin, niacin, tocopherols, calcium, and potassium). Date fruits are also known to be low in protein, though research has found important essential amino acids such as lysine and histidine that are lacking in most other fruits. Additionally, in date fruits, significant levels of various beneficial phytochemicals, including carotenoids, polyphenols, and phenolic acids, were also found (Hussain *et al.*, 2020; Barakat and Alfheaid, 2023; Amadou, 2016).

Food waste has been utilized as an ingredient in the production of food bars due to its functional and nutritional value, development costs, and agro-industrial applications (Pérez-Marroquín *et al.*, 2023). The waste from fruit peels produced by agro-industries is being utilized by many researchers to develop value-added food products. Fruit peels

can be utilized to develop new functional food products, such as fruit bars. It can offer extra calories and essential nutrients, such as fiber, protein, lipids, vitamins, and minerals (Gupta *et al.*, 2020), and contains substantial levels of polyphenols, dietary fiber, polyunsaturated fatty acids, proteins, essential amino acids, and potassium. The fruit peel also shows good prebiotic potential due to a significant amount of non-digestible fiber. Fruit peels have been shown to possess a wide range of polyphenols with antioxidant attributes that keep lipids from peroxidizing, extending the product's shelf life (Gupta *et al.*, 2023). Generally, fruit waste, particularly fruit peel, contains more polyphenols than fruit pulp. Studies revealed fruit peels to have a higher capability for antioxidants than fruit pulp. Fruit peels also contain higher phenolic compounds than pulp, including flavonoids, carotenoids, anthocyanins, and phenolic acids (Suleria *et al.*, 2020).

Apple (*Malus domestica* L.) fruit and its products are an excellent source of natural antioxidants in our diet, contributing up to 22% of all dietary phenolics. In many fruit industries, apple peel is considered a waste product, but it is a notable source of nutrients and phytochemicals, especially polyphenols which can scavenge free radicals (Saeed *et al.*, 2023). Industries are constantly looking for novel ingredients that can improve nutritional quality and add value to the finished products because of the severe competition in the consumer market (Awuchi *et al.*, 2023; Ruiz-Ojeda *et al.*, 2019). Due to the positive health benefits of apple peel powder, it possibly will be great to produce fruit bars with increased health benefits and minimum processing. However, incorporating apple peel powder in date bars could be a lucrative idea for nutritional snack food development. Therefore, the present study was carried out to investigate the aptness of apple peel powder for use in date fruit bars through physicochemical, nutritional, and sensory analysis.

MATERIALS AND METHODS

Procurement of apple

The apples were purchased from the local market of Quetta City, Pakistan. The best shape, size, uniformity, and color were used to choose apples. It was also ensured that the apples were not physically damaged and that no fungal infection or abrasion had occurred. Then these freshly purchased apples were transferred to the NIFSAT laboratory at the University for further processing.

Washing and peeling apples

First and foremost, the apples were thoroughly washed with tap water to remove any dust particles or foreign substances. The apples were dried and peeled after washing.

Apple peel powder preparation

After being rinsed with tap water, the apple peels were separated from the pulp and chopped into little pieces. The peels were submerged in a 0.5 percent citric acid solution for 20 minutes to prevent browning, after which they were washed and dried at room temperature for 6 days. Dried peels were ground into powder in a mixer and separated with a mesh size of 0.50 mm to manufacture apple peel powder. Dried powder was stored in sterile brown vials at room temperature by following the method of Eshak (2016) for future analysis.

Date bars preparation

The date bar samples were developed by following the method of Irshad *et al.* (2022) with minor modifications. The date fruits were cleaned and dried before being used. After removing the seeds, the dates were steamed for 5 minutes to make them soft. Steamed dates were minced into a paste using the meat-mincing technique. All the ingredients, including the apple peel powder, were blended with the date paste using a mixer after the raw materials had been prepared. Following that, the material was transferred to the cutting table and bar sheeting. The sheeting was done with a stainless-steel roller, and the sheet was cut into bars shaped with a width of 2.5 cm and a length of 7 cm with the help of cutters. Before being held at room temperature, each bar was wrapped in aluminum foil.

Table 1. Treatment plan used for the preparation of apple peel powder enriched date bars

Treatments	Date paste (g)	Apple peel powder (g)
T ₀	100	0
T ₁	98	2
T ₂	96	4
T ₃	94	6
T ₄	92	8
T ₅	90	10

Proximate analysis of apple peel powder and date bars

The proximate analysis of apple peel powder and date bar samples *i.e.*, moisture content, crude fat, crude protein, crude fiber, ash content, pH value, and TSS (°Brix) were carried out according to the standard methods outlined in AOAC (2016).

Color analysis of apple peel powder incorporated date bars

A colorimeter was used for color analysis. The different colors of food items were stated as L^* value of lightness, a^* value for redness or greenness, and the b^* value for yellowness and blueness. The color of the sample was dignified in the dried state as well as in the fresh state to measure the chroma, the hue angle, and the total color difference by using the hunter L^* a^* and b^* values. The color which refers to brightness is measured by L^* , which is the level of whiteness of color, and it falls between the range of 0 for dark or black color to 100 for light or white color. The color a^* measures the level of chromaticity red while it is positive. The green is negative, and it lies between -60 to 60. The b^* measures the chromaticity yellow as soon as it is positive and blue when it is negative. Its ranges fall between -60 to 60. Placed a small amount of date bar sample in the glass dish and put it on the colorimeter and started it. It gave the value of L^* , a^* , and b^* by following the method of Vu *et al.* (2017).

Phytochemical analysis

To determine the Total Phenolics Content (TPC) of apple peel powder incorporated date bars, samples were set by taking 1 gram of the material in a flask, and 10 milliliters of 80% methanol solution were added. Following this, the flask was placed in an ultrasonic bath for 15 minutes. Then the extract was centrifuged at a speed of 5000 rpm for five minutes. Milli pore membrane filter was then used to filter the extract after centrifugation. To determine TPC, 800uL of deionized water, 100uL of Folin-Ciocalteu reagent, and 200uL of an aliquot of the sample were mixed. Following this, 300 uL of 20% w/v sodium carbonate was added to the generated solution, and it was then incubated at $25^{\circ}\text{C}\pm 2$ for two hours in the dark. The UV/vis spectrometer (PG instruments, T80) was used to detect the absorbance at 765 nm. The Gallic acid standard's calibration curve was achieved. The GA equivalent/g was used to represent TPC (Roy *et al.*, 2014).

$$C = c V/m$$

C = total contents of phenolic compounds in mg/g

c = Gallic acid concentration

V = extract volume

m = Extract weight in grams

Antioxidant analysis

DPPH activity was determined according to the method described by Lee *et al.* (2010) with minor modifications. Briefly, 0.1 mL of the sample was added to 3 ml of 4 mg DPPH in methanol solution. The reaction mixtures were incubated for 30 minutes in a dark room and the absorbance read at 510 nm against methanol as a blank. All tests were performed in triplicate, and the DPPH capacity was calculated by applying the following formula.

$$\text{Scavenging radical activity (\%)} = 1 - (A_0/A_b) \times 100$$

A_0 = Sample absorbance

A_b = Blank absorbance

Sensory analysis

Sensory evaluation was done by skilled panelists using a 9-point Hedonic scale for different parameters such as color, flavor, texture, taste, and overall acceptability by adopting the method described by Iwe 2002. Developed apple peel powder incorporated date bars were placed in the transparent plates and labeled randomly. The panelists gave scores randomly after evaluation.

Statistical analysis

The observed results were tabulated in MS Excel and analyzed using the statistical procedure of analysis of variance (ANOVA) while significant differences of mean were further computed by the method as described by Montgomery (2017) using the least significant difference (LSD) at 0.05% probability level.

RESULTS AND DISCUSSION

Proximate analysis of apple peel powder

Proximate analysis of food products gives important and valued information about nutritional composition and helps to access the quality of samples. The observed results for proximate analysis of apple peel powder revealed a moisture content of 12.42%, ash content of 3.40%, crude fiber content of 5.15%, crude fat content of 5.15%, and crude protein content of 14.16% respectively (Table 2). In comparison with a previous study, Saeed *et al.* (2023) observed 7.65% moisture, 2.50% ash, 15.25% crude fiber, 1.18% crude fat, and 2.79% crude protein. These findings underscore the variability in nutritional composition influenced by factors like drying conditions and fruit origin, suggesting the importance of consistent quality assessment in utilizing apple peel powder for various applications.

Table 2. Proximate composition of apple peel powder

Parameters	Mean Values (%)
Moisture	12.42 ± 0.06
Ash	3.40 ± 0.01
Crude Fiber	5.15 ± 0.05
Crude Fat	5.15 ± 0.12
Crude Protein	14.16 ± 0.36

Proximate analysis of apple peel powder enriched date bars

The results of proximate analysis of date bars incorporated with apple peel powder showed highly significant values as mean moisture content ranged from 10.39 to 12.42% with T₀ showing the highest and T₅ having the lowest values (Table 3). A decrease in the moisture content of date bars was observed with the addition of different proportions of apple peel powder. The most important characteristic of food commodities is moisture, which determines how long food can be stored. Date bars are semisolid confections that don't contain any added water (Akhtar *et al.*, 2014) and are not prone to immediate spoilage. Similarly, Irshad *et al.* (2022) noted a decrease in the moisture content of date bars with the addition of different protein sources to them. The content of crude fat ranged from 3.00 to 5.15% with T₅ having the highest fat content and T₀ having the lowest. The results showed an increased trend in crude fat content with the addition of an increased proportion of apple peel powder. The recorded results relate to the findings of Munir *et al.* (2016) as they observed fat content to be in the range of between 2.45 to 5.13% in date fruit bars fortified with protein sources as different protein sources affected the fat content in these fruit bars. The content of crude protein of apple peel enriched date bars ranged from 9.25 to 14.16% with T₅ having the highest and T₀ with the lowest values. The recorded results showed a significant increase in crude protein content of apple peel powder-enriched date bar treatments compared to control treatments. These results match with the findings of Munir *et al.* (2018) who developed date fruit-based snack bars with the addition of oats to enhance the physiochemical, nutritional, and sensory qualities and found that bars contain crude protein content ranging from 9.7 to 14.3%. In another study by Kavitha *et al.* (2018), it was seen that fruit bars contain protein content ranging from 9.20 to 10.25%. Crude fiber content ranged from 3.00 to 5.15% with T₅ showing the highest and T₀ having the lowest results. The apple peel powder incorporated treatments showed a significant portion of fiber which makes them the perfect fiber-containing confection. Similarly, Irshad *et al.* (2025) recorded fiber content ranging from 2.10 to 8.92% in date bars fortified with different fiber sources. They noted natural fiber sources incorporated treatments to outclass the control treatments in fiber content. Ash content of date bars ranged from 1.65 to 3.40% with T₅ having the highest and T₀ with lowest values. These observed results could be the outcome of the fact that apple peel powder addition in date bars is a more concentrated source of minerals and can be nutritional and beneficial for human health. The date fruit has an adequate amount of ash or minerals, ranging between 1 and 2.5% (Ashraf and Hamidi-Esfahani, 2011) furthermore, the apple peel powder added to date bars also contains enough ash. The pH values of date bars ranged from 4.12 to 4.54 with T₅ having the highest value and T₀ with the lowest value. Similarly, Akhtar *et al.* (2014) also recorded pH values ranging from 4.30 to 5.28 in fruit bars incorporated with apple-date pulp. The total soluble solids (TSS) of date bars ranged from 58.20 to 63.45 °Brix with T₅ having the highest values and T₀ with the lowest values. The addition of apple peel powder affected the total soluble solid concentration of date bars. Similarly, Munir *et al.* (2018) also observed an increase in the TSS of date bars (from 48.0 to 64.2 °Brix) with an increase of oat flour to date bars.

Table 3. Proximate composition of date bars incorporated with apple peel powder

Treatments	Moisture %	Crude Fat %	Crude Protein %	Crude Fiber %	Ash %	pH Value	TSS (°Brix)
T ₀	12.42 ± 0.06 ^a	3.00 ± 0.16 ^f	9.25 ± 0.10 ^f	3.00 ± 0.05 ^f	1.65 ± 0.03 ^d	4.12 ± 0.02 ^d	58.20 ± 0.02 ^e
T ₁	12.00 ± 0.04 ^b	3.21 ± 0.09 ^e	10.00 ± 0.11 ^e	3.21 ± 0.06 ^e	1.91 ± 0.07 ^d	4.16 ± 0.02 ^{cd}	59.93 ± 0.02 ^d
T ₂	11.70 ± 0.02 ^c	3.56 ± 0.08 ^d	11.27 ± 0.40 ^d	3.56 ± 0.06 ^d	2.01 ± 0.02 ^{cd}	4.22 ± 0.03 ^c	60.15 ± 0.02 ^d
T ₃	10.67 ± 0.05 ^d	4.02 ± 0.01 ^c	12.45 ± 0.07 ^c	4.02 ± 0.09 ^c	2.30 ± 0.02 ^c	4.34 ± 0.02 ^b	61.72 ± 0.05 ^c
T ₄	10.63 ± 0.01 ^d	4.83 ± 0.06 ^b	13.63 ± 0.35 ^b	4.83 ± 0.03 ^b	2.76 ± 0.0 ^b	4.48 ± 0.01 ^a	62.59 ± 0.03 ^c
T ₅	10.39 ± 0.04 ^d	5.15 ± 0.12 ^a	14.16 ± 0.36 ^a	5.15 ± 0.05 ^a	3.40 ± 0.01 ^a	4.54 ± 0.02 ^a	63.45 ± 0.09 ^c

Values (Mean ± SE). Mean values followed by different letters in each column differ significantly according to the LSD test at (P ≤ 0.05).

Color analysis of apple peel powder incorporated date bars

Color plays a significant role in consumers' decisions about the visual appeal and acceptance of foodstuff. In Table 4, results recorded for color analysis for date bars are depicted. Regarding *L** value (denoting lightness) all the samples of date bars showed a value ranging between 24.34 and 34.13, with T₅ showing the highest and T₀ with the lowest value. For *a** value (a measure of how red or green a color is), all the samples analyzed showed positive values, indicating that samples possess a reddish color. The highest value of 9.22 was held by T₅ apple peel powder incorporated date bars, while the lowest value of 7.86 was held by T₀. Increasing trends were observed in the redness with the addition of apple peel powder with T₅ showing the highest redness. For the *b** value (which indicates how much of a yellow hue an object has), it ranged from 9.09 to 13.32 among all samples, which indicates samples towards a more yellowish color. The highest value was held by T₅ apple peel powder incorporated date bars, while the lowest value was held by T₀. Thus, a positive *L**, *a**, and *b** depicted an inclined change in color by the addition of apple peel powder in date bars. Similarly, Parn *et al.* (2015) developed novel fruit bars that reported similar results and stated that slightly dark saturation or lightness tends to give the date a brownish color, which is a darker shade of orange color. Another study by Kavitha *et al.* (2018) who developed a probiotic millet fruit bar showed a *b** value ranging from 10.28 to 13.96.

Table 4. Color analysis of date bars incorporated with apple peel powder

Treatments	Color <i>L*</i>	Color <i>a*</i>	Color <i>b*</i>
T ₀	24.34 ± 0.04 ^f	7.86 ± 0.05 ^e	9.09 ± 0.04 ^f
T ₁	25.22 ± 0.02 ^e	7.97 ± 0.04 ^e	9.42 ± 0.02 ^e
T ₂	25.95 ± 0.08 ^d	8.19 ± 0.02 ^d	9.77 ± 0.03 ^d
T ₃	28.25 ± 0.02 ^c	8.37 ± 0.01 ^b	10.32 ± 0.02 ^c
T ₄	30.37 ± 0.05 ^b	8.73 ± 0.03 ^c	11.61 ± 0.05 ^b
T ₅	34.13 ± 0.02 ^a	9.22 ± 0.02 ^a	13.32 ± 0.04 ^a

Values (Mean ± SE). Mean values followed by different letters in each column differ significantly according to the LSD test at (P ≤ 0.05).

Phytochemical analysis of apple peel powder incorporated date bars

The total phenolic content of apple peel powder enriched date bars ranged from 0.81 to 1.44 mgGAE/g with T₅ having the highest value of 1.44 followed by T₄ (1.28), T₃ (1.17), T₂ (1.02), T₁ (0.87) and T₀ (0.81 mgGAE/g) respectively (Table 5). Mean comparison between treatments showed that the highest value was held by T₅ and the lowest was held by T₀. The addition of apple peel powder to date bars, which may have a high phenolic content, may be the cause of the rise in phytochemicals and bioactive compounds. Any food source's functional characteristics can be greatly improved by adding bioactive nutrients (Kaushik *et al.*, 2021). Date fruits are rich in phytochemicals, including carotenoids and phenolic compounds. The antioxidant capacity of phytochemicals improves the functionality of food products (Razali *et al.*, 2019). A similar study by Nadeem *et al.*, (2012) on apricot-based date bars also observed similar findings with phenolic contents ranging from 225 to 263 mg/100g.

Antioxidant activity of apple peel powder incorporated date bars

DPPH is an important method used to determine the antioxidant content of food products. It is primarily used to evaluate the antioxidant capability by scavenging free radicals, which values the antioxidant indices. Data regarding the value of DPPH content in apple peel powder-enriched date bars varied in all the treatments. The DPPH content was highest in T₅ (31.33), followed by T₄ (29.33), T₃ (26.41), T₂ (24.44), T₁ (23.78), and T₀ (22.45) respectively. The highest value was held by T₅, and the lowest value was held by the control treatment (T₀) (Table 5). According to Razali *et al.* (2019), different date fruit varieties had an antioxidant capacity of 55-75%. In various investigations

researchers found that nine different date varieties had DPPH inhibitory activities ranging from 22 to 40% (Abdul-Hamid *et al.*, 2020). Other significant classes of phytochemicals with high antioxidant capacities, like carotenoids and phytosterols, are also found in date fruits. Numerous other studies have documented the potent antioxidant capacity of dates grown in various countries, including the US, Kuwait, Oman, Bahrain, and Algeria (Hussain *et al.*, 2020). Similarly, Tanweer *et al.*, (2016) reported results in date fruit bars prepared by ginger supercritical extract ranging from 29.38 to 31.56 DPPH. In another study Omran, (2018) enhanced the nutritional value of oat bars and concluded that the DPPH content in blended apple bars ranged from 23.02 to 29.48 DPPH.

Table 5. Phytochemical and antioxidant activity of apple peel powder incorporated date bars

Treatments	Total phenolics content (mgGAE/g)	DPPH (%)
T ₀	0.81 ± 0.04 ^e	22.45 ± 0.01 ^f
T ₁	0.87 ± 0.02 ^e	23.78 ± 0.01 ^e
T ₂	1.02 ± 0.01 ^d	24.44 ± 0.02 ^d
T ₃	1.17 ± 0.02 ^c	26.41 ± 0.02 ^c
T ₄	1.28 ± 0.01 ^b	29.33 ± 0.01 ^b
T ₅	1.44 ± 0.01 ^a	31.33 ± 0.02 ^a

Values (Mean ± SE). Mean values followed by different letters in each column differ significantly according to the LSD test at (P ≤ 0.05).

Sensory evaluation of apple peel powder incorporated date bars

The results of sensory attributes of apple peel powder incorporated date bars showed significant variations among treatments (Table 6). Overall, treatment T₃ (with 6g apple peel powder) was found to be superior to the rest of the treatments and showed the highest results across all parameters i.e., color (7.20), flavor (7.50), texture (8.20), taste (7.30) and overall acceptability (7.30). It is worthwhile noting that the addition of 6g apple peel powder in date bars was desirable for color. Meanwhile, it could be seen that the addition of 10g apple peel powder in T₅ with a darker color was not desirable. It seems that color, flavor, texture, taste, and overall acceptability were not suitable after the addition of 10g of apple peel powder. Meanwhile T₅ with 10g apple peel powder addition in date bars showed the declining consistency and color, texture, flavor, taste, and overall acceptability of the product. These findings align with previous studies indicating optimal levels for ingredient additions to food products for maximal acceptability, as demonstrated by Haneen *et al.* (2019) and Rafiq *et al.* (2018).

Table 6. Sensory evaluation of date bars incorporated with apple peel powder

Treatments	Color	Flavor	Texture	Taste	Overall acceptability
T ₀	6.50 ± 0.84 ^{ab}	5.90 ± 0.99 ^b	7.20 ± 0.9 ^b	6.10 ± 0.87 ^{bc}	5.90 ± 0.01 ^b
T ₁	6.30 ± 0.48 ^{abc}	5.50 ± 0.84 ^b	6.80 ± 0.63 ^b	6.90 ± 0.99 ^{ab}	6.50 ± 0.08 ^{ab}
T ₂	5.90 ± 0.99 ^{abc}	5.90 ± 0.87 ^b	6.30 ± 0.67 ^b	5.60 ± 0.84 ^{bc}	6.20 ± 0.25 ^b
T ₃	7.20 ± 0.78 ^a	7.50 ± 0.97 ^a	8.20 ± 0.42 ^a	7.30 ± 0.82 ^a	7.30 ± 0.08 ^b
T ₄	5.40 ± 0.89 ^{bc}	6.50 ± 0.84 ^{ab}	6.40 ± 0.84 ^b	5.80 ± 0.91 ^{bc}	6.50 ± 0.08 ^{ab}
T ₅	5.10 ± 0.73 ^c	5.40 ± 0.84 ^b	5.10 ± 0.99 ^c	6.60 ± 0.51 ^{abc}	5.90 ± 0.02 ^b

Values (Mean ± SE). Mean values followed by different letters in each column differ significantly according to the LSD test at (P ≤ 0.05).

CONCLUSION

The incorporation of apple peel powder (APP) into date bars significantly enhanced their nutritional profile and overall quality. APP-enriched date bars demonstrated a decrease in moisture content and an increase in crude fat, protein, fiber, and ash content, indicating an improvement in nutritional value. The total soluble solids and pH values also increased with higher APP proportions, contributing to the overall sweetness and stability of the bars. Color parameters (L^* , a^* , b^*) increased, indicating a more appealing appearance. The enrichment with APP resulted in higher total phenolic content and antioxidant activity, suggesting enhanced health benefits. Sensory evaluation revealed that the sample with 6% APP (T₃) was most preferred in terms of color, flavor, texture, taste, and overall acceptability. These findings suggest that APP can be effectively used to enrich date bars, improving both their nutritional and sensory properties, making them a promising option for health-conscious consumers.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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