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Research Article

Development and Stabilization of Value-Added Functional Drink Using Melon By-Product Agricultural Waste

Saba Namet,[1] Moazzam Rafiq Khan,[1] Rana Muhammad Aadil,[1] and Muhammad Anjum Zia[2]

[1]*National Institute of Food Science and Technology, University of Agriculture, Faisalabad 38000, Pakistan*
[2]*Department of Biochemistry, University of Agriculture, Faisalabad 38000, Pakistan*

Correspondence should be addressed to Moazzam Rafiq Khan; mrkhan_ft@yahoo.com
and Rana Muhammad Aadil; muhammad.aadil@uaf.edu.pk

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Melon (*Cucumis melo L.*) is a widely grown horticulture crop in many parts of the world widely known for its nutritive properties. Processing of melon leads to the production of a wide range of natural end-user products and produces a significant quantity of underutilized by-products about 35%, which are made up of 3–7% of seeds and 25–44% of peels. The objective of the present research is the development of a value-added drink to effectively utilize melon by-products which are considered an excellent source of antioxidants and bioactive compounds using varying concentrations of peel and seed powder (5 and 10%) and their extracts (1 and 3%) alongside control treatment for comparison purpose. The prepared value-added drinks were stored for 3 months at $4 \pm 1^{\circ}C$ and analyzed at 15-day intervals for physicochemical characteristics, bioactive components, antioxidant indices, and sensorial evaluation. A significant ($p < 0.05$) decrease in pH and an increase in acidity were noticed while total soluble sugars decreased slightly in all treatments throughout storage. In comparison to other drinks, value-added drink (T_6) prepared by incorporating 3% melon peel extract preserved total phenolic contents (1.80 ± 0.07 mg GAE/g), total flavonoid contents (0.53 ± 0.003 mg QE/g), DPPH ($53.23 \pm 0.07\%$), and FRAP (3.85 ± 0.08 μM $FeSO_4$/g) at the end of storage and was effective in maintaining quality attribute, better retention of bioactive compounds, and longer shelf life due to higher antioxidant potential. In terms of sensorial scores, T_4 (10% melon seed powder) was more acceptable and was effective in maintaining physicochemical attributes throughout storage. The conversion of such waste in developing innovative functional foods could maximize profit, reduce environmental issues, and improve the sustainability of food by incorporating food waste into the food chain. Such research investigation is aimed at allaying growing concerns about food waste by reusing rejected food by-products.

1. Introduction

Melon or *Cucumis melo* L. is a member of the Cucurbitaceae family and is one of the most popular fruits grown in tropical regions of the world. Its consumption has been linked to both nutritional and bioactive advantages [1]. Its production was greater than 40 MT annually in the world according to FAO [2]. Between 8 and 20 million tonnes of nonedible portions (peels and seeds) is generated from commercial melon processing sources each year, which is a significant global waste stream [3], about 35% which is made up of 3–7% of seeds and 25–44% of peels [4]. This waste adds to growing disposal concerns while also indicating a loss of biomass, essential minerals, and phytochemicals. Agroindustrial waste management is regarded as the biggest challenge for developing economies due to its negative effects on the environment. Due to their phytochemical enriched profile and potential health benefits, these have recently gained attention [5]. It is necessary to value these by-products to develop some functional products, which can reduce the waste overabundance of increasing populations [6–8]. From this perspective, this organic material might be an inexpensive source for developing novel foods, ingredients, or products that reduce waste and adverse environmental effects. Due

to their abundance in bioactive chemicals, including fatty acids, carotenoids, and polyphenols, these waste by-products could be valorized [9–11]. Additionally, melon by-products exhibit a range of biological properties, comprising antioxidant, antidiabetic, anti-inflammatory, antiangiogenic, antiulcer, and antibacterial activities. These properties are entirely supported by the presence of bioactive components in melon by-products. These by-products can be viewed as viable candidates for innovative functional food development helping to advance sustainability throughout the food chain [12]. The demand for nutrient-dense foods and functional foods for a variety of uses (colorants, food enrichments, fortifiers, natural antioxidants, and food preservatives) increases globally by consumers. This demand can be met by the food industry focusing on extracting bioactive compounds from waste generated by food processing with potential advantageous properties [13]. The importance of developing functional foods and beverages is growing as a result of the increased market focus on foods and beverages with improved consumer health features [14–16]. The development of food products by utilizing melon seed and peel as an ingredient is highly desired for nutritional, economic, and environmental reasons [17]. Considerable research work is being done on agricultural waste valorization due to its positive effects on the environment and diverse phytochemistry [18]. These by-products need processing before consumption. Therefore, the development of products is a challenging task. The present research work proposed its use as a shelf-stable value-added drink. The prepared novel drink was analyzed for its physicochemical parameters, phytochemicals, antioxidant indices, and sensorial evaluation during storage of 3 months. The value-added drink can pave the way to reinforce economic growth and commercialization as a cheap source of nutrients to overcome challenges faced by the growing population.

2. Materials and Methods

Fresh melons of two different varieties, i.e., T-96 and White Ball, were procured from the local market of Faisalabad. These were inspected carefully, and healthy fruits were selected. These were washed with tap water and peeled, and then, the seeds were separated and dried by blotting paper. The peels were sliced uniformly to facilitate the drying operation.

2.1. Development of Melon Peel and Seed Powder. Melon peel and seeds were placed on trays in a cabinet dryer operating at $50 \pm 5^{\circ}$C at an air velocity of 1.0 m/s for 4-8 hours until constant weight. The samples were spread uniformly on a stainless steel tray to attain 0.5 cm thickness which was dried using vertical electrothermal blowing air flux. After drying, the peels and seeds were converted into a fine powder using a domestic blender (Braun AG Frankfurt, Germany) as defined by da Cunha et al. [19]. To avoid rehydration, the powder was kept in polyethylene bags at ambient temperature.

2.2. Preparation of Extracts. In a 15 mL Falcon tube, a 500 mg powdered sample was weighed. Then, ethanol-water (50 : 50 *v*/*v*) was added to peel and seed powder samples. These were homogenized well for a minute. The prepared sample mixtures were placed in an orbital shaker (Remi IS 24 BL) for 60 minutes at a speed of 200 rpm and centrifuge (5804-R Eppendorf AG, Hamburg, Germany) at $1200 \times g$ 15-minute period (4°C). The supernatant was collected and filtered using a 0.45 μm filter. At 40°C, the solvent was recovered by using rotary evaporator (EYELA, N-N series, Japan), and then, the prepared extracts were kept at -20°C until further research.

2.3. Product Development. Melon by-product-based value-added drink was prepared by the addition of the following ingredients including water 1 L, sugar 13%, citric acid 0.3-0.4%, CMC 0.20%, sodium benzoate 0.1%, and food grade color 0.001% while control treatment (without the addition of by-products) was prepared for comparison. The addition of melon peel powder (MPP), melon seed powder (MSP), melon peel extract (MPE), and melon seed extract (MSE) at different levels, i.e., T_0: standard drink, T_1: drink containing 5% MPP, T_2: drink containing 10% MPP, T_3: drink containing 5% MSP, T_4: drink containing 10% MSP, T_5: drink containing 1% MPE, T_6: drink containing 3% MPE, T_7: drink containing 1% MSE, and T_8: drink containing 3% MSE, was done. The prepared drink was stored for 90 days at $4 \pm 1^{\circ}$C and analyzed for selected parameters after 15-day intervals.

2.4. Physicochemical Analysis. Titrable acidity (TA), total soluble solids (TSS), and pH of value-added drinks were analyzed according to Aadil et al. [20].

2.5. Total Phenolic Content (TPC) and Total Flavonoid Content (TFC). TPC in prepared drinks was determined spectrophotometrically as defined by Benmeziane et al. [21] with some modifications using the Folin-Ciocalteu reagent, while TFC was determined by the colorimetric method developed by Benmeziane et al. [21] with some modifications as described by Singh et al. [22].

2.6. Free Radical Scavenging Activity by DPPH and FRAP Assay. Free radical scavenging activity of drink sample extracts was determined according to Safdar et al. [23] with some modifications as mentioned by Alothman et al. [24], while FRAP of sample extracts was conducted according to the procedure of Vella et al. [17] with some modifications.

2.7. Sensory Analysis. According to standards outlined by Meilgaard et al. [25], sensory evaluation of prepared drinks was conducted using a 9-point hedonic scale system (9=extremely like and 1=extremely dislike).

2.8. Statistical Analysis. The results were articulated as means ± standard deviation of the independent variables using three replicates. To compare mean values, one-way ANOVA was used and a post hoc LSD test employing a significance level of 5% ($p < 0.05$) was executed to determine significant differences. Results obtained were analyzed

statistically following the procedure of Montgomery [26] by using Statistix software 8.1.

3. Results and Discussions

3.1. Effect of the Treatments and Storage on TA Value of the Value-Added Drink. Table 1 indicates that treatment and storage duration have a significant effect on the TA. With time, mean values for TA were increased because storage time had a considerable impact on TA value. At zero days, the TA values of all treatments differ significantly from each other. These findings agree with previous reports of Anwaar et al. [27] stating that increasing the concentration of mango peel powder increased the acidity value in mango peel drinks. The reason behind the upsurge in acidity is attributed to the presence of ellagic acid in mango peel. A minimum rise in TA values was reported in T_4 having 10% MSP at the end of storage, while the maximum TA value was monitored in T_8 at the end of storage. The results of the present investigation are analogous to the findings of Dhushane and Mahendran [28] concluding that the acidity of watermelon jam increased significantly throughout the storage period of 12 weeks approaching a maximum value of 0.89% in jam having 3.3 g of pectin in its formulation. The reason behind the increase might be due to sugar breakdown into carboxylic acids or might be due to the addition of citric acid in the watermelon jam [28]. Martínez-Flores et al. [29] noticed an upsurge in TA in carrot juice samples over time with values ranging from 0.29% to 0.33% for control samples stored for 2 days while a value of 3.11% was observed after 10 days of storage, while samples subjected to ultrasound treatment had a considerable increase in TA values ranging from 0.30 to 0.81% with time. Similarly, Batool et al. [30] also reported an increase in the TA value of functional drinks prepared by incorporating varying concentrations of watermelon juice and cucumber juice over time. An increase in TA value was reported by Nawaz et al. [31] in an apple peach drink incorporated with lemon peel during storage of 28 days.

3.2. Effect of the Treatments and Storage on TSS of the Value-Added Drink. TSS differs significantly among treatments due to different incorporation levels of peel powder, seed powder, and their extracts as shown in Table 1. TSS content decreased slightly as the storage time increased with the value reported for zero day (2.09 ± 0.26), and this value decreased (2.05 ± 0.26) at the end of storage. The maximum TSS was recorded in T_4 having 10% MSP in its formulation indicating that melon seed had a higher sugar level while the lowest TSS was observed in T_0 at the end of the storage period of 3 months. Our results are in harmony with the findings of Begum and Premakumar [32] who prepared a functional beverage from lemon, amla, and bitter gourd and analyzed it for TSS reporting a decreasing trend from 5.2 to 3.7 at the end of 2 months of storage. The reason behind the reduction might be attributed to chemical reactions taking place in beverage organic elements. Another study conducted by Dhushane and Mahendran [28] on watermelon jam concluded that TSS was significantly increased throughout storage in different formulation maximum values being recorded as 68.17°Brix in formulation having 80 g sugar, while the minimum value (66.10°) was recorded in a formulation having 60 g sugar during 2nd week of storage. This may be attributed to polysaccharide hydrolysis into simpler sugars throughout storage together with the conversion of insoluble portions into soluble ones. Our results are in contradiction with the findings of Dhushane and Mahendran [28] indicating that storage increased TSS content. In the same way, Salaria and Reddy [33] observed an increase in the TSS content of muskmelon nectar stored for 3 months which might be attributed to carbohydrate hydrolysis into simpler constituents leading to an upsurge in total sugars. In another study, Anwaar et al. [27] reported an increase in the TSS of mango peel drinks stored for sixty days from 4.63 to 5.46, which may be due to the disintegration of polysaccharides and oligosaccharides into simpler ones. Nawaz et al. [31] also reported an increase in TSS of apple peach functional drink incorporated with lemon polyphenols among treatments and with time.

3.3. Effect of the Treatments and Storage on the pH Value of the Value-Added Drink. A very important factor in consumer acceptance of any food ingredient is its pH [27]. The pH of value-added drinks is significantly affected by storage duration and treatment. Mean values presented in Table 1 showed that pH decreased as the storage time increased from zero days to the 90th day of storage. The minimum pH value (4.30 ± 0.19) was monitored in T_2 incorporated with 10% MPP while the maximum value of 4.92 ± 0.23 was recorded in T_4 incorporated with 10% MSP at the end of storage. The pH value observed at zero day was 4.83 ± 0.22, and it decreased to 4.23 ± 0.23 at the end of the storage period. Similar results were reported by Batool et al. [30] in a functional drink prepared with watermelon juice and cucumber juice demonstrating that pH value decreased with increasing storage duration. Similarly, Martínez-Flores et al. [29] observed changes in pH, TA, and viscosity values of carrot juice with or without thermos-sonication treatment. The decline in pH might be attributed to the growth of microbes and changes induced by enzymes. Anwaar et al. [27] also noticed a decline in the pH values of mango peel drinks from 3.74 to 3.42 during 60 days of storage. The reason behind the decline is the breakdown of peptide bonds and sugars into acidic components.

Habibi et al. [34] observed changes in the pH values of orange juice subjected to storage. During cold storage, the pH of juice increased gradually for all orange cultivars stored at different temperatures (2°C and 5°C) with the highest value recorded in Moro and while lowest value being found in Sanguinello. These results differ significantly from the present investigation. Salaria and Reddy [33] observed an upsurge in the pH of muskmelon nectar during storage. Sherzad et al. [35] also reported a similar trend in strawberry-blended RTS beverages prepared by using grape, lime, ginger, and muskmelon juices. A similar trend was also noticed in apple peach drinks incorporated with lemon peel polyphenols as stated by Nawaz et al. [31]. Another study

Table 1: Effect of treatment and storage on TA (%), TSS, and pH of the value-added drink.

Quality attribute	Treatments	Storage days						
		0	15	30	45	60	75	90
TA (%)	T_0	0.15 ± 0.003^{e}	0.16 ± 0.005^{bc}	0.18 ± 0.003^{wx}	0.19 ± 0.002^{rst}	0.20 ± 0.001^{nop}	0.22 ± 0.004^{i}	0.23 ± 0.003^{g}
	T_1	0.16 ± 0.002^{abc}	0.17 ± 0.003^{yz}	0.19 ± 0.003^{rst}	0.21 ± 0.005^{mno}	0.21 ± 0.005^{jk}	0.23 ± 0.002^{h}	0.24 ± 0.001^{e}
	T_2	0.17 ± 0.004^{za}	0.18 ± 0.002^{vw}	0.20 ± 0.006^{q}	0.21 ± 0.003^{kl}	0.22 ± 0.002^{ij}	0.24 ± 0.001^{ef}	0.26 ± 0.005^{c}
	T_3	0.13 ± 0.001^{f}	0.15 ± 0.003^{e}	0.16 ± 0.001^{cd}	0.17 ± 0.004^{yz}	0.18 ± 0.003^{uv}	0.20 ± 0.005^{qr}	0.21 ± 0.002^{lmn}
	T_4	0.14 ± 0.001^{f}	0.15 ± 0.004^{e}	0.16 ± 0.005^{d}	0.16 ± 0.006^{ab}	0.18 ± 0.003^{vw}	0.19 ± 0.004^{qrst}	0.20 ± 0.002^{op}
	T_5	0.18 ± 0.004^{wx}	0.19 ± 0.002^{st}	0.20 ± 0.003^{p}	0.21 ± 0.001^{kl}	0.22 ± 0.005^{i}	0.24 ± 0.006^{fg}	0.25 ± 0.003^{d}
	T_6	0.18 ± 0.002^{vw}	0.19 ± 0.002^{qrs}	0.21 ± 0.003^{lm}	0.22 ± 0.001^{i}	0.24 ± 0.001^{fg}	0.25 ± 0.004^{d}	0.26 ± 0.003^{c}
	T_7	0.19 ± 0.002^{tu}	0.20 ± 0.001^{p}	0.21 ± 0.001^{k}	0.23 ± 0.003^{h}	0.24 ± 0.002^{e}	0.26 ± 0.005^{c}	0.27 ± 0.003^{b}
	T_8	0.19 ± 0.002^{qrs}	0.21 ± 0.002^{lmn}	0.22 ± 0.003^{i}	0.24 ± 0.001^{ef}	0.26 ± 0.002^{c}	0.28 ± 0.003^{b}	0.29 ± 0.005^{a}
Storage					**			
Treatment					**			
Storage*treatment					**			
Total soluble solids (°Brix)	T_0	1.75 ± 0.01^{b}	1.75 ± 0.02^{b}	1.74 ± 0.02^{b}	1.74 ± 0.06^{bc}	1.73 ± 0.06^{bc}	1.73 ± 0.05^{cd}	1.72 ± 0.01^{d}
	T_1	2.06 ± 0.05^{l}	2.06 ± 0.03^{l}	2.05 ± 0.04^{lm}	2.04 ± 0.01^{mn}	2.04 ± 0.05^{mn}	2.03 ± 0.01^{no}	2.01 ± 0.02^{o}
	T_2	2.32 ± 0.04^{fg}	2.32 ± 0.01^{efg}	2.31 ± 0.02^{gh}	2.30 ± 0.04^{ghi}	2.29 ± 0.02^{hijk}	2.29 ± 0.02^{jk}	2.28 ± 0.01^{k}
	T_3	2.34 ± 0.02^{e}	2.33 ± 0.02^{ef}	2.33 ± 0.03^{efg}	2.32 ± 0.03^{gh}	2.31 ± 0.02^{hij}	2.31 ± 0.02^{ijk}	2.29 ± 0.01^{jk}
	T_4	2.62 ± 0.01^{a}	2.61 ± 0.05^{a}	2.61 ± 0.05^{a}	2.60 ± 0.04^{ab}	2.59 ± 0.04^{bc}	2.58 ± 0.03^{cd}	2.57 ± 0.03^{d}
	T_5	1.95 ± 0.04^{pq}	1.95 ± 0.04^{pq}	1.95 ± 0.04^{pq}	1.94 ± 0.02^{qr}	1.94 ± 0.02^{qr}	1.93 ± 0.01^{rstu}	1.92 ± 0.01^{stuv}
	T_6	1.94 ± 0.02^{qrs}	1.94 ± 0.02^{qr}	1.93 ± 0.01^{qrst}	1.93 ± 0.01^{stuv}	1.92 ± 0.02^{vwx}	1.92 ± 0.02^{wxy}	1.91 ± 0.01^{xyz}
	T_7	1.97 ± 0.03^{p}	1.97 ± 0.03^{p}	1.96 ± 0.02^{pq}	1.95 ± 0.01^{qr}	1.95 ± 0.01^{rstu}	1.94 ± 0.02^{stuv}	1.93 ± 0.01^{vwx}
	T_8	1.92 ± 0.01^{tuvw}	1.92 ± 0.01^{uvw}	1.91 ± 0.02^{wxy}	1.91 ± 0.02^{xyz}	1.90 ± 0.01^{yz}	1.89 ± 0.04^{za}	1.88 ± 0.04^{a}
Storage					**			
Treatment					**			
Storage*treatment					ns			
pH	T_0	4.65 ± 0.04^{kl}	4.57 ± 0.02^{mn}	4.50 ± 0.03^{o}	4.41 ± 0.02^{qr}	4.29 ± 0.02^{u}	4.18 ± 0.03^{wx}	4.09 ± 0.04^{z}
	T_1	4.61 ± 0.03^{mn}	4.51 ± 0.01^{o}	4.42 ± 0.04^{r}	4.31 ± 0.05^{tu}	4.24 ± 0.01^{v}	4.14 ± 0.04^{xy}	4.02 ± 0.06^{a}
	T_2	4.58 ± 0.02^{mn}	4.49 ± 0.04^{op}	4.38 ± 0.03^{rs}	4.30 ± 0.01^{u}	4.19 ± 0.05^{w}	4.11 ± 0.07^{yz}	4.03 ± 0.04^{a}
	T_3	5.11 ± 0.02^{b}	5.04 ± 0.03^{c}	4.97 ± 0.05^{d}	4.87 ± 0.04^{e}	4.77 ± 0.01^{h}	4.68 ± 0.06^{jk}	4.57 ± 0.02^{n}
	T_4	5.23 ± 0.03^{a}	5.13 ± 0.04^{b}	5.03 ± 0.05^{c}	4.97 ± 0.04^{d}	4.81 ± 0.02^{fg}	4.69 ± 0.03^{jk}	4.58 ± 0.01^{mn}
	T_5	4.71 ± 0.04^{ij}	4.61 ± 0.02^{lm}	4.51 ± 0.05^{o}	4.39 ± 0.06^{r}	4.29 ± 0.04^{u}	4.13 ± 0.05^{xy}	4.01 ± 0.06^{a}
	T_6	4.78 ± 0.03^{gh}	4.69 ± 0.04^{jk}	4.59 ± 0.06^{mn}	4.49 ± 0.01^{op}	4.39 ± 0.05^{r}	4.34 ± 0.04^{st}	4.19 ± 0.02^{w}

Table 1: Continued.

Quality attribute	Treatments	Storage days						
		0	15	30	45	60	75	90
	T_7	4.81 ± 0.05^{fg}	4.71 ± 0.07^{ij}	4.61 ± 0.01^{lm}	4.51 ± 0.03^{o}	4.40 ± 0.04^{r}	4.28 ± 0.05^{u}	4.13 ± 0.06^{y}
	T_8	5.03 ± 0.02^{c}	4.95 ± 0.01^{d}	4.85 ± 0.04^{ef}	4.75 ± 0.05^{hi}	4.66 ± 0.06^{k}	4.59 ± 0.02^{mn}	4.45 ± 0.03^{pq}
Storage					**			
Treatment					**			
Storage*treatment					**			

Data represents means ± S.D. Data were analyzed by ANOVA; means were separated with the LSD test ($p < 0.05$). Mean values carrying different letters are significantly different from one another. * = $p \leq 0.05$; ** = $p \leq 0.01$; ns = $p > 0.05$. ** = highly significant; * = significant; ns = nonsignificant.

conducted by Dhushane and Mahendran [28] on watermelon jam concluded that the pH of all formulated watermelon jams decreased significantly (5%) with increasing storage duration. This decrease was pronounced in products stored at room temperature (30°C). The factor behind the decrease in pH value during storage may be due to acid formation from the sugar added in the formulation. These findings are in line with that of Imtiaz and Iftikhar [36], who observed decreasing trend of pH values of watermelon jam subjected to storage. These findings are in line with the results of the present research work.

3.4. Effect of the Treatments and Storage on TPC and TFC of Value-Added Drink. Mean values representing TPC (mg GAE/g) in Table 2 indicate that TPC value differed significantly among treatments and decreased significantly as the storage time increased from zero days to the 90th day of storage. Phenolic chemicals are important components of plant foods that have a direct impact on sensory qualities such as flavor, color, and astringency. Also, the inclusion of phenolic compounds in the diet of humans has some positive impacts on health due to their chemopreventive actions against cancer and mutation, which are mostly linked to their antioxidant activities [37]. Maximum TPC was observed in treatments incorporated with 3% MPE with the highest value reported in T_6 (2.51 ± 0.01 mg GAE/g). These are in line with the reports of Selahvarzi et al. [38] concluding that increasing the concentration of melon seed powder in a functional energy drink substantially increased the total phenolic content. In another study conducted by Nawaz et al. [31], it was reported that with increasing concentration of polyphenolic content in the form of extract in a functional apple peach drink, the TPC value increased. Similarly, Faki et al. [39] found that increasing the concentration of grape seed extract powder increased the phenolic content of the Ayran drink in comparison to the control drink. Our findings are in line with these results. In T_6, maximum TPC score was noticed (2.09 ± 0.33 mg GAE/g) at the end of storage while the least TPC value was exhibited by T_7 (1.72 ± 0.18 mg GAE/g) at the end of storage. Similar to the present work, Nawaz et al. [31] also reported maximum TPC content (158 mg GAE/100 g) in treatment having a higher concentration of extract, i.e., 3% extracted from the lemon peel in apple peach drink at zero days. However, the total phenolic content decreased as the storage time increased as mentioned by Nawaz et al. [31] with a reduction of 32.65% in apple peach drinks supplemented with polyphenols extracted from lemon peels. Similar results were also reported by Chiusano et al. [40] in grape juice stored for 2 months with a reduction in TPC value from 24.1% to 21.4% when stored at 20°C and 4°C. The same trend was noticed in cantaloupe powder when stored at room temperature for 180 days, and a minimal decrease in total phenolic content was observed according to Tan et al. [41]. The total phenolic content reported on the first day was 288.45 mg GAE/100 g, and it decreased to 279.45 mg GAE/100 g when stored at 25°C, with 50-70% relative humidity at the end of the storage period. Similar results were reported by Henríquez et al. [42] in apple peel powder stored for 120 days at three different temperatures 4°C, 10°C, and 25°C by Udomkun et al. [43] in papaya powder stored at 30°C. Anwaar et al. [27] also reported an upsurge in TPC value with an increased % of mango peel powder in the drink. This value decreased from 84.21 to 61.84 mg GAE per gram during sixty days of storage. The degradation of polyphenol to polyphenol oxidase caused by oxidation is linked to this drop in TPC [44].

On the contrary, Tan et al. [41] noticed an increasing trend for TPC when stored under accelerated conditions at 38°C, at 90% R.H in the case of cantaloupe powder. The initial TPC value was reported as 288.45 mg GAE/100 g which inclined to 419.45 mg GAE/100 g when stored for 180 days. Similar to these findings, Narsing Rao et al. [45] noticed an upsurge in total polyphenols in tomato powder stored for a period and assumed that this phenomenon might be attributed to a reaction between polymeric phenols and the water moiety that results in the production of monomers. Additionally, the microbial growth or the interactions between oxidized polyphenols and the production of new antioxidants in conjunction with storage may be linked to the rise in TPC [29]. Hence, the increase of TPC in the cantaloupe powder along storage under accelerated conditions could be the result of the formation of other compounds during storage [41].

Mean values for TFC (mg QE/g) reported in Table 2 indicate that maximum TFC was observed at zero day while this value decreased as the storage proceeded. Maximum TFC value was observed in T_6 whereas the minimum TFC content was noticed in T_3 at the end of storage. Our results are in line with the findings of research conducted by Ibrahim and El-Masry [46] on TFC in various parts of cantaloupe extracts; the content was found in the range of 1.61-5.23 μg of rutin equivalent per gram. The highest potential was reported in skin extract while seed extract has the lowest value for TFC. Marsiglia et al. [47] also reported a decrease in TFC in jaboticaba peel powder by 34.74% when stored for 180 days. Marsiglia et al. [47] reported a decreasing total phenolic content of jaboticaba peel powder stored for 180 days with a percentage reduction of 24.74% at the end of storage. This decrease is attributed to physical, chemical, enzymatic, and microbiological changes such as polymerization and oxidation reaction of free phenols and glycoside hydrolysis leading to a decline of phenolics with time as reported by Cabral et al. [48].

Tan et al. [41] observed changes in the TFC of cantaloupe powder stored under two different conditions, i.e., ambient storage where the TFC was reduced by 0.36 times and accelerated condition in which an increase in TFC by 1.55 times was noticed with the initial value being recorded as 156.34 mg/100 g. These findings are in line with the current research work. Similar to our findings, Mrmošanin et al. [49] observed that under high-temperature condition, flavonoid content of cocoa powder rapidly degraded.

3.5. Effect of the Treatments and Storage on Antioxidant Potential (DPPH and FRAP) of Value-Added Drink. The stable free radical model used to evaluate the effectiveness of antioxidants is DPPH. Antioxidants are essential to the

Table 2: Effect of treatment and storage on TPC and TFC of the value-added drink.

Quality attribute	Treatments	Storage days 0	15	30	45	60	75	90
Total phenolic content (mg GAE/g)	T_1	2.19 ± 0.03^{def}	2.06 ± 0.06^{fghijk}	1.95 ± 0.07^{jklmo}	1.83 ± 0.01^{opqrstu}	1.74 ± 0.07^{tuvwx}	1.64 ± 0.05^{wxyz}	1.54 ± 0.08^{za}
	T_2	2.30 ± 0.07^{bcde}	2.16 ± 0.08^{efgh}	2.02 ± 0.05^{ijklm}	1.91 ± 0.06^{lmnopqr}	1.81 ± 0.04^{pqrstu}	1.71 ± 0.06^{uvwx}	1.62 ± 0.04^{xyz}
	T_3	2.10 ± 0.06^{fghi}	1.98 ± 0.07^{ijklmn}	1.86 ± 0.05^{nopqrst}	1.77 ± 0.07^{stuvw}	1.67 ± 0.05^{vwxyz}	1.57 ± 0.05^{yza}	1.47 ± 0.07^{ab}
	T_4	2.17 ± 0.04^{defg}	2.05 ± 0.03^{ghijkl}	1.94 ± 0.03^{jklmnop}	1.82 ± 0.05^{opqrstu}	1.72 ± 0.09^{tuvwx}	1.63 ± 0.07^{wxyz}	1.55 ± 0.05^{za}
	T_5	2.39 ± 0.08^{ab}	2.27 ± 0.04^{bcde}	2.17 ± 0.04^{efgh}	2.03 ± 0.08^{hijklm}	1.92 ± 0.07^{klmnopq}	1.80 ± 0.07^{pqrstuv}	1.69 ± 0.04^{uvwxy}
	T_6	2.51 ± 0.01^{a}	2.37 ± 0.05^{abc}	2.24 ± 0.07^{cde}	2.19 ± 0.01^{efgh}	2.02 ± 0.01^{ijklm}	1.90 ± 0.04^{mnopqr}	1.80 ± 0.07^{qrstuv}
	T_7	1.95 ± 0.05^{ab}	1.87 ± 0.01^{bc}	1.79 ± 0.05^{cd}	1.73 ± 0.03^{de}	1.66 ± 0.07^{def}	1.59 ± 0.03^{ef}	1.49 ± 0.06^{f}
	T_8	2.31 ± 0.05^{bcd}	2.18 ± 0.07^{defg}	2.07 ± 0.02^{fghij}	1.99 ± 0.06^{ijklmn}	1.88 ± 0.08^{nopqrs}	1.78 ± 0.05^{rstuv}	1.67 ± 0.03^{vwxyz}
Storage					**			
Treatment					**			
Storage*treatment					**			
TFC (mg QE/g)	T_1	0.73 ± 0.001^{d}	0.67 ± 0.005^{g}	0.58 ± 0.003^{k}	0.52 ± 0.006^{n}	0.48 ± 0.004^{q}	0.45 ± 0.005^{t}	0.42 ± 0.001^{v}
	T_2	0.75 ± 0.002^{c}	0.70 ± 0.003^{f}	0.62 ± 0.001^{j}	0.55 ± 0.005^{m}	0.51 ± 0.002^{o}	0.49 ± 0.004^{q}	0.47 ± 0.005^{rs}
	T_3	0.43 ± 0.004^{u}	0.39 ± 0.005^{x}	0.34 ± 0.004^{b}	0.30 ± 0.007^{e}	0.28 ± 0.001^{g}	0.26 ± 0.006^{h}	0.24 ± 0.003^{i}
	T_4	0.45 ± 0.003^{t}	0.41 ± 0.005^{w}	0.36 ± 0.003^{a}	0.33 ± 0.001^{c}	0.32 ± 0.007^{d}	0.31 ± 0.005^{e}	0.29 ± 0.002^{fg}
	T_5	0.78 ± 0.006^{b}	0.71 ± 0.002^{e}	0.63 ± 0.007^{i}	0.56 ± 0.005^{l}	0.52 ± 0.004^{n}	0.50 ± 0.003^{p}	0.49 ± 0.004^{q}
	T_6	0.80 ± 0.005^{a}	0.73 ± 0.001^{d}	0.65 ± 0.003^{h}	0.61 ± 0.007^{j}	0.58 ± 0.002^{k}	0.55 ± 0.001^{m}	0.53 ± 0.003^{n}
	T_7	0.46 ± 0.003^{s}	0.42 ± 0.006^{v}	0.37 ± 0.005^{z}	0.34 ± 0.002^{c}	0.32 ± 0.006^{d}	0.30 ± 0.005^{e}	0.28 ± 0.001^{fg}
	T_8	0.47 ± 0.005^{r}	0.43 ± 0.003^{u}	0.38 ± 0.004^{y}	0.35 ± 0.001^{b}	0.32 ± 0.006^{d}	0.31 ± 0.007^{e}	0.29 ± 0.004^{f}
Storage					**			
Treatment					**			
Storage*treatment					**			

Data represents means ± S.D. Data were analyzed by ANOVA; means were separated with the LSD test ($p < 0.05$). Mean values carrying different letters are significantly different from one another. * = $p \leq 0.05$; ** = $p \leq 0.01$; ns = $p > 0.05$. ** = highly significant; * = significant, ns = nonsignificant.

human body because they defend it during the process of stress metabolism [27]. Mean DPPH values of the value-added drink are affected by storage, and treatment presented in Table 3 displayed a decreasing trend. The highest DPPH ($62.10 \pm 5.96\%$) was exhibited by treatment T_6 incorporated with 3% MPE while the lowest value ($38.27 \pm 3.55\%$) was observed in T_3 supplemented with 5% MSP seed at the end of the storage study. These findings were supported by Al-Sayed and Ahmed [50] stating that incorporating sharlyn MP and watermelon rind in the cake enhanced antioxidant potential and reduced the activity of FFA, peroxides, oxidation, and hydrolysis of lipids when stored for 21 days. The highest values regarding DPPH were monitored at zero day ($56.97 \pm 9.86\%$), and this value decreased ($42.82 \pm 7.36\%$) after 3 months of storage demonstrating that the storage period decreased the antioxidant potential of value-added drink. The results are in line with the reports of Anwaar et al. [27] stating that increasing mango peel powder increased the DPPH value of mango peel drink. The reason behind the upsurge is due to an increase in polyphenol and carotenoid content by increasing % of mango peel powder. The mango peel drink stored for 60 days demonstrated a decline in DPPH value. As a result of temperature and light exposure, oxidation and polyphenol breakdown resulted in a decline in DPPH value. In another study, Selahvarzi et al. [38] incorporated melon seed powder in a functional energy drink demonstrating that increasing the melon seed percentage increased the DPPH value of the prepared drink. Similarly, Faki et al. [39] found that increasing the concentration of grape seed extract powder increased the antioxidant potential of the Ayran drink in comparison to the control drink. Nizori and Lamtiar [51] stated that adding red dragon peel extract to pedada's jam enhanced the antioxidant potential (DPPH). Marsiglia et al. [47] reported that DPPH values decreased in jaboticaba peel powder stored for 180 days. The powder showed strong antioxidant activity for up to 150 days and then decrease. A decrease of 14.30% was reported at the end of storage. The results of the present study are close to these findings showing a considerable decrease in the DPPH value of value-added drinks when stored for 90 days.

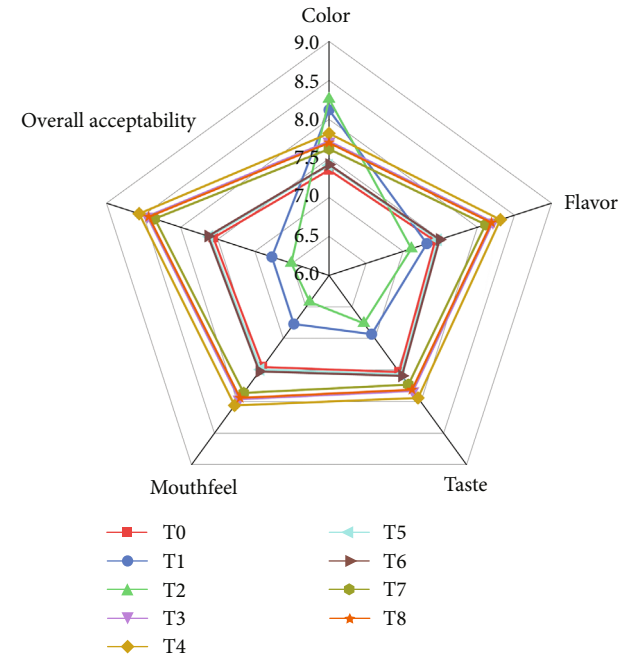
Mean values for FRAP (micrometer of $FeSO_4$ per gram) showed a declining trend with the highest score at zero day, and it decreased as the storage period increased. The highest FRAP values were observed in drinks containing MPE in their formulation with the highest value (4.38 ± 0.43) exhibited in T_6 whereas the lowest value (3.28 ± 0.34) was noticed in a drink containing 5% MSP (T_3) in its formulation. In another study, Morais et al. [52] examined different tropical fruit parts and their processed peels for their antioxidant potential and found FRAP values ranging between 3.54 and 441.83 μmol FeSO4/g dry weight. Dried avocado peel exhibited the highest antioxidant potential. Generally, raw peels exhibit higher antioxidant potential except for passion fruit seeds demonstrating a FRAP value of 119.32 μmol FeSO4/g on a dry weight basis higher than the values reported for all pulp samples. Vella et al. [17] reported the antioxidant potential of cantaloupe by-products measured by FRAP assay and concluded that peel samples possess higher antioxidant potential (12.27 mg AAE/g) in comparison to seed (0.31 mg AAE/g), respectively. In the current study, a decline in antioxidant potential was monitored in treatments over time. Estaji et al. [53] and Kamiloglu et al. [54] described that the possible reason behind this decrease might be due to oxidation and enzyme systems, i.e., PPO and POD, and polyphenolic complex deterioration which are predominantly executing the antioxidant activity. The treatments having a higher percentage of extracts possess higher antioxidant potential throughout storage (T_6 and T_8), but the higher potential was exhibited by melon peel extract. Sah et al. [55] found that yogurt samples supplemented with pineapple peel powder exhibited higher antioxidant activity and stability of phenolic components.

3.6. Effect of the Treatments and Storage on Sensory Evaluation of Value-Added Drink. To evaluate consumer acceptability, sensory evaluation of any food incorporated with bioactive compounds of plant origin is a key step. In this perspective, value-added drinks prepared by MPP, MSP, MPE, and MSE were evaluated using a 9-point hedonic scale for different quality parameters, i.e., color, flavor, taste, mouthfeel, and overall acceptability. Treatment, storage, and their interaction had a significant effect on sensory scores of prepared drinks except for overall acceptability in which the interaction between storage and treatment was nonsignificant. Mean values for all sensory attributes of value-added drink are presented in Figures 1(a)–1(g) demonstrating that maximum scores for color (7.88 ± 0.25) were attained by treatment T_2 while lowest scores (7.15 ± 0.13) were attributed to T_0 at the end of storage. The color value decreased (7.71 ± 0.30 to 7.18 ± 0.15) during 3 months of storage. Color values changed significantly due to treatments having different inclusion levels of powder and extracts. The highest flavor score (8.12 ± 0.12) was monitored in treatment T_4 whereas the lowest score (6.82 ± 0.22) was attained by T_1 at the end of storage. On the other hand, flavor scores declined (7.74 ± 0.43 to 7.31 ± 0.54) throughout storage. Treatment T_4 had the highest taste score (7.67 ± 0.18) while T_2 had the lowest score (6.44 ± 0.21) during 90 days of storage. The maximum taste scores were observed at zero day (7.52 ± 0.39), and this value decreased (6.95 ± 0.45) during storage. Mean values elaborating mouthfeel and overall acceptability of value-added drinks decreased as the storage time increased with a (7.49 ± 0.54) score recorded for mouthfeel at zero day while this value decreased (6.94 ± 0.58) as the time elapsed. The highest scores for mouthfeel were observed in T_4 (7.75 ± 0.20) while the lowest scores were noticed for treatments incorporated with MPP and MPE, i.e., 6.11 ± 0.19 for T_2 at the end of the storage study. The same trend was observed for the overall acceptability of value-added drinks. The highest scores were recorded at zero day of storage (7.76 ± 0.72), and this declined (7.17 ± 0.78) as the storage time increased to 90 days. For treatments, the highest score (8.26 ± 0.19) was recorded for T_4 while the least score (6.17 ± 0.22) was observed for T_2 at the end of the storage study. The treatment having a higher concentration of MPP had lower scores for overall acceptability. This can be

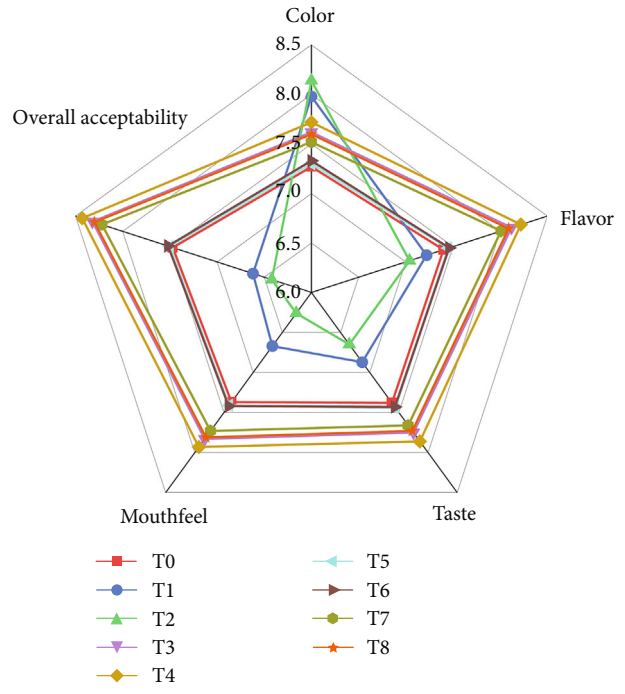
Table 3: Effect of treatment and storage on DPPH and FRAP value of the value-added drink.

Quality attribute	Treatments	Storage days 0	15	30	45	60	75	90
DPPH (%)	T_1	59.43 ± 0.05^{k}	57.07 ± 0.06^{n}	54.10 ± 0.04^{r}	52.36 ± 0.06^{u}	49.09 ± 0.03^{z}	47.46 ± 0.07^{c}	44.48 ± 0.05^{i}
	T_2	63.79 ± 0.07^{f}	61.10 ± 0.05^{i}	57.92 ± 0.07^{m}	56.06 ± 0.06^{p}	52.57 ± 0.04^{t}	50.87 ± 0.06^{w}	48.21 ± 0.03^{b}
	T_3	43.53 ± 0.04^{j}	41.78 ± 0.03^{m}	39.76 ± 0.05^{r}	38.52 ± 0.06^{t}	36.17 ± 0.05^{w}	35.06 ± 0.03^{y}	33.07 ± 0.06^{z}
	T_4	46.75 ± 0.06^{e}	44.87 ± 0.05^{h}	42.63 ± 0.03^{l}	41.32 ± 0.04^{p}	38.79 ± 0.06^{s}	37.55 ± 0.05^{v}	35.19 ± 0.04^{x}
	T_5	69.07 ± 0.06^{b}	66.21 ± 0.05^{d}	62.84 ± 0.06^{g}	60.81 ± 0.05^{j}	57.07 ± 0.07^{n}	55.22 ± 0.03^{q}	51.79 ± 0.04^{v}
	T_6	70.87 ± 0.05^{a}	68.07 ± 0.04^{c}	64.56 ± 0.05^{e}	62.52 ± 0.04^{h}	58.66 ± 0.03^{l}	56.79 ± 0.05^{o}	53.23 ± 0.07^{s}
	T_7	50.54 ± 0.06^{x}	48.51 ± 0.05^{a}	45.98 ± 0.03^{f}	44.49 ± 0.08^{i}	41.67 ± 0.06^{n}	40.25 ± 0.09^{q}	37.71 ± 0.05^{u}
	T_8	51.82 ± 0.05^{v}	49.73 ± 0.03^{y}	47.22 ± 0.05^{d}	45.71 ± 0.04^{g}	42.87 ± 0.05^{k}	41.47 ± 0.06^{o}	38.87 ± 0.09^{s}
Storage					**			
Treatment					**			
Storage*treatment					**			
FRAP (μM $FeSO_4$/g)	T_1	4.23 ± 0.04^{ij}	4.00 ± 0.03^{nop}	3.85 ± 0.04^{tu}	3.58 ± 0.01^{y}	3.37 ± 0.04^{bc}	3.30 ± 0.06^{c}	3.15 ± 0.05^{ef}
	T_2	4.57 ± 0.05^{d}	4.41 ± 0.04^{efg}	4.24 ± 0.03^{ij}	4.11 ± 0.04^{lm}	3.98 ± 0.05^{opqr}	3.95 ± 0.03^{pqrs}	3.81 ± 0.06^{uv}
	T_3	3.78 ± 0.03^{uvw}	3.62 ± 0.04^{y}	3.49 ± 0.04^{za}	3.23 ± 0.04^{d}	3.08 ± 0.03^{fg}	2.96 ± 0.02^{h}	2.81 ± 0.04^{i}
	T_4	4.00 ± 0.08^{opq}	3.79 ± 0.10^{uvw}	3.59 ± 0.09^{y}	3.45 ± 0.04^{a}	3.32 ± 0.03^{c}	3.18 ± 0.04^{de}	3.02 ± 0.03^{gh}
	T_5	4.84 ± 0.07^{b}	4.72 ± 0.03^{c}	4.48 ± 0.04^{e}	4.29 ± 0.07^{hi}	4.12 ± 0.04^{kl}	3.93 ± 0.09^{qrs}	3.76 ± 0.03^{vwx}
	T_6	4.94 ± 0.03^{a}	4.82 ± 0.04^{b}	4.64 ± 0.05^{d}	4.38 ± 0.06^{fg}	4.18 ± 0.03^{jk}	3.99 ± 0.04^{rs}	3.85 ± 0.08^{vwx}
	T_7	4.36 ± 0.03^{gh}	4.23 ± 0.06^{ij}	4.07 ± 0.04^{lmn}	3.91 ± 0.03^{st}	3.73 ± 0.06^{wx}	3.60 ± 0.04^{y}	3.43 ± 0.01^{ab}
	T_8	4.43 ± 0.04^{ef}	4.37 ± 0.02^{fg}	4.21 ± 0.03^{j}	4.04 ± 0.06^{mno}	3.88 ± 0.05^{st}	3.71 ± 0.03^{x}	3.56 ± 0.07^{yz}
Storage					**			
Treatment					**			
Storage*treatment					**			

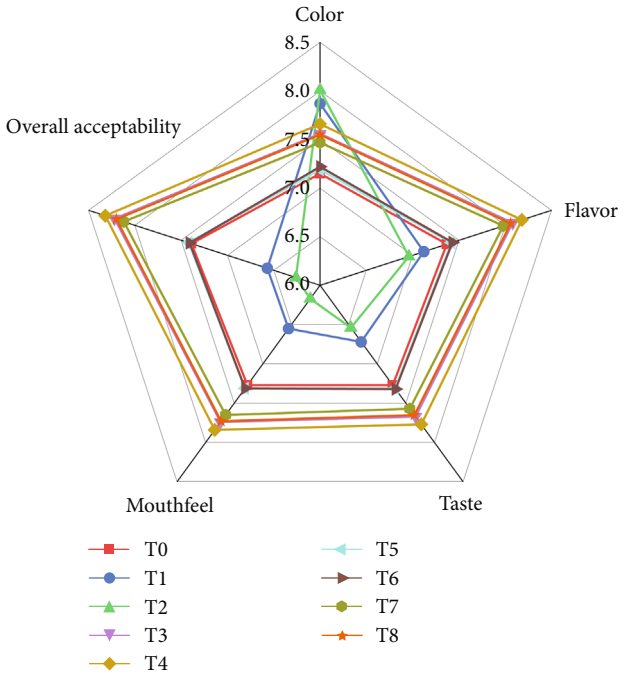
Data represents means ± S.D. Data were analyzed by ANOVA; means were separated with the LSD test ($p < 0.05$). Mean values carrying different letters are significantly different from one another. * = $p \leq 0.05$; ** = $p \leq 0.01$; ns = $p > 0.05$. ** = highly significant; * = significant; ns = nonsignificant.



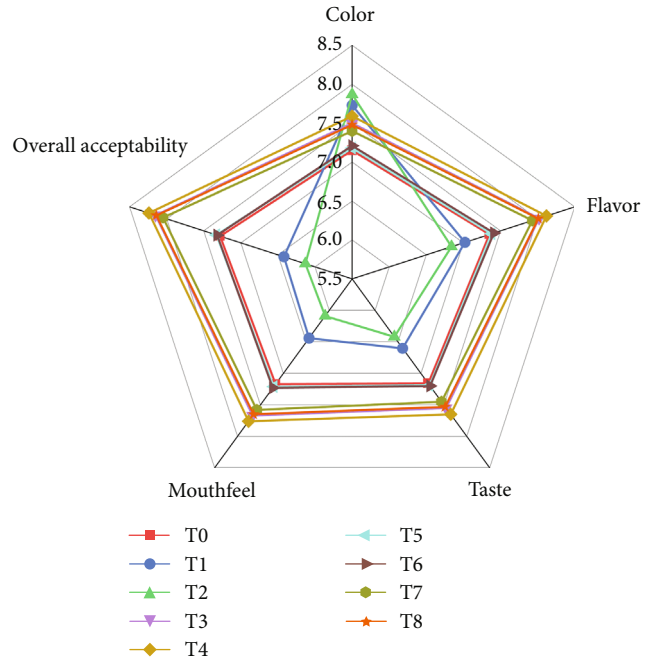
(a) Sensory evaluation at zero day



(b) Sensory evaluation at 15th day

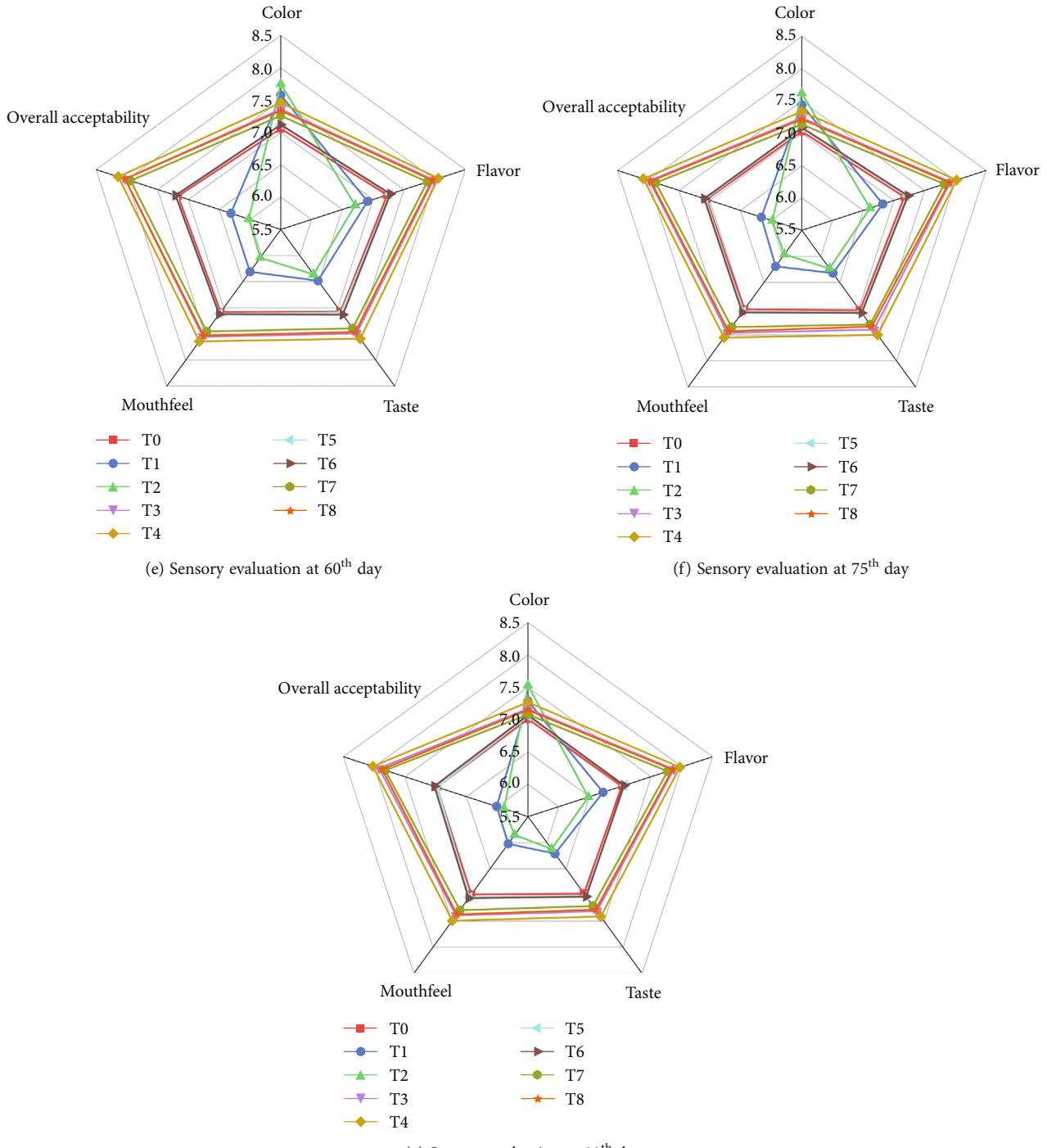


(c) Sensory evaluation at 30th day



(d) Sensory evaluation at 45th day

Figure 1: Continued.



(e) Sensory evaluation at 60th day

(f) Sensory evaluation at 75th day

(g) Sensory evaluation at 90th day

FIGURE 1: (a–g) Sensory evaluation of value-added drink prepared from melon peel powder (MPP), melon seed powder (MSP) and their extracts, melon peel extract (MPE), and melon seed extract (MSE). T_0: standard drink; T_1: drink containing 5% MPP; T_2: drink containing 10% MPP; T_3: drink containing MSP 5%; T_4: drink containing 10% MSP; T_5: drink containing 1% MPE; T_6: drink containing 3% MPE; T_7: drink containing 1% MSE; T_8: drink containing 3% MSE.

elucidated by the fact that increasing the quantity of rind resulted in a decrease in overall acceptability as explained by Mishra et al. [56]. With the increase in storage duration, the organoleptic scores of a product decreased. Sensory scores related to color analysis decreased after the 12th week of storage for watermelon jam prepared with or without pectin extracted from lemon peel. During storage, the Maillard reaction proceeds to a nonenzymatic or enzymatic browning reaction. The decreasing trend is attributed to ascorbic acid oxidation converting it into dehydroascorbic acid and tannin oxidation into gallic acid leading to increased acidity and sourness of formulated jam. A decreasing trend was also

observed for texture scores of prepared watermelon jam during storage. The decrease might be due to the conversion of pectin into its acid counterparts, i.e., pectic acids, and additionally into sugars and other acids, i.e., galacturonic acids. For aroma scores, significant declining scores were recorded in watermelon jams stored for 12 weeks. The decreasing trend might be attributed to volatile aromatic compound loss during storage. For overall acceptability, a declining trend was observed in prepared watermelon stored for 12 weeks due to decreasing scores for appearance and product flavor uniformity [28]. Results of the present study clearly stated a decreasing trend in sensory attributes of all prepared drinks from zero day up to 90 days of storage. Similar results were also reported by Nawaz et al. [31] in the case of an apple-peach drink supplemented with polyphenols from lemon peels. Shubhra et al. [57] observed a decline in sensorial attributes of Kinnow nectar when stored for 6 months. Moazzem et al. [58] also found a decreasing trend in wood apple beverages over 50 days of storage. Mokhtar and Ibrahim [59] also noticed a decreasing trend in the sensory properties of guava nectar subjected to pasteurization when stored for 6 months. These changes were less significant in treatments incorporated with extracts from pomegranate peel and guava leaf in comparison to the control. Sharma et al. [60] described that the possible reasons for the decline in sensory scores are attributed to reactions proceeding including nonenzymatic browning producing brown pigments, volatile compound loss, polysaccharide breakdown, colloidal particle degradation, and complex formation with phenolics and pectin when stored at room temperature. In another study, Anwaar et al. [27] reported a decline in sensory attributes of mango peel drinks with an increasing percentage of peel powder and increased storage duration in the prepared drink. These results are in line with the present work.

4. Conclusion

The application of by-products from fruits and vegetables as functional ingredient source is an emerging domain that has gained much attention representing a possible source to be incorporated in the formulation of functional foods. The present research work demonstrated that 3% melon peel extract in value-added drink presented better stability throughout storage of 90 days in terms of physicochemical, TPC, TFC, DPPH, FRAP, and sensory evaluation. The drinks prepared had a longer shelf life in terms of the stability of bioactive components. In terms of sensory scores, the drinks prepared by the inclusion of melon seed powder or their extracts were more acceptable in comparison to melon peel powder or their extracts. So utilizing melon by-products in drugs and food can improve the food supply and health and reduce environmental impacts together with feeding the malnourished population. Moreover, these functional drinks being rich in nutrients can overcome present-day challenges and help in maintaining a healthy lifestyle through cost-effectiveness.

Data Availability

The data that support the findings of this study are available on request from the corresponding author.

Conflicts of Interest

The authors have declared no conflict of interest.

Authors' Contributions

Saba Namet was responsible for the conceptualization, investigation, methodology, software, methodology, and writing of the original draft. Moazzam Rafiq Khan was responsible for the supervision and wrote, reviewed, and edited the manuscript. Rana Muhammad Aadil was responsible for the data validation and supervision and wrote, reviewed, and edited the manuscript. Muhammad Anjum Zia was responsible for the data validation and wrote, reviewed, and edited the manuscript.

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