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Valorization of Date Pits into a Functional Coffee Alternative: Compositional, Antioxidant, and Sensory Evaluation

Hiba Naveed[1], Kanza Aziz Awan[1], Zahid Bashir[1*], Waleed Sultan[1], Ahmad Faraz[1], Momina Noor[1], Arzoo Fatima[1]

Abstract

Functional foods, which provide health benefits beyond basic nutrition, have historical roots in ancient dietary traditions. Thus, the incorporation of functional foods into daily diets helps in promoting health and well-being. In this regard, date fruit pits emphasize the unexploited byproduct with significant functional and nutritional properties. Pakistan faces substantial post-harvest losses. Date fruit pits are often wasted despite their nutritional and bioactive moieties. This research explores date pits as a sustainable coffee substitute while minimizing food waste. Three formulations were analyzed: (T_0) 100% black coffee, (T_1) 100% date pit coffee, and (T_2) 70% black coffee and 30% date pit coffee blend. Results show that T_0 had the highest ash content (3.99±0.01), and T_2 had the highest pH (9.11±0.03) and moisture content (8.84±0.01). Date pit coffee proposes acceptable sensory attributes, a strong antioxidant profile, low calorie content, and distinguishable health and environmental sustainability benefits. These outcomes uphold its potential as an eco-friendly, functional, caffeine-free coffee substitute, an imperative need for waste reduction and elevating sustainable food system practices.

Keywords: Functional Food, Date Pits, Waste Reduction, Caffeine-Free, Antioxidants.

1. Introduction

Approximately 8 million tons of date fruit are globally produced each year. Normally, the seeds of the fruit account for about 10-15% of the fruit's weight and are often discarded as waste. Date pit coffee is an eco-friendly solution for the functional food industry that substitutes conventional coffee with a caffeine-free version. An increase in demand for both functional and sustainable food supply has resulted in the boom of coffee substitutes with new health and environmental advantages (Awan, Yaqoob, et al., 2025; Naveed et al., 2024). Traditional coffee manufacturing is resource-consuming, with high water usage and environmental effects linked with widespread cultivation. Coffee drinking has spread globally, with huge demand for alternatives with health benefits that tackle issues of sustainability (Samoggia & Riedel, 2019). Within these options, date pit coffee has been validated to be a sustainable alternative as a result of its functional potential and environmental advantages. Date pits, a secondary product of the date fruit, are generally discarded, contributing to agricultural waste (Munir et al., 2024).

The health-promoting effects are attributed to the nutritional content of date pits and other minerals like potassium and

[1]Department of Food and Nutritional Sciences, Faculty of Science and Technology, University of Central Punjab,
[*]Corresponding author's E-mail: zbsdk26@gmail.com
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magnesium (Attia et al., 2021). Phenolic compounds, flavonoids, and other antioxidants found in date pits have been reported to have potential restorative, anti-inflammatory, and antioxidant properties, paralleling some of the benefits traditionally associated with coffee consumption (Awan, 2017; Awan, Butt, et al., 2025). Additionally, date pit coffee is caffeine-free, making it suitable for individuals sensitive to caffeine or those seeking alternatives without the stimulant effects (Awan, Butt, Sharif, & Hussain, 2018). Although coffee is common worldwide, overconsumption of caffeine poses serious health risks, such as heart disease, stomach ulcers, and a negative impact on the nervous system. The major research gaps exist in the development and quality assessment of coffee substitutes made from date pits. Although date pits are nutritious, little research has been done on how they can be converted into a coffee substitute, particularly in terms of sensory attributes such as taste, aroma, and mouthfeel. Furthermore, there is a considerable lack of comprehensive hedonic response and consumer acceptability studies, which is crucial to understand the market potential of such products among several population subgroups (Mahmud, Shellie, & Keast, 2020). Additionally, the optimal processing parameters, including roasting, grinding, and brewing methods that would best replicate the flavor profile of traditional coffee, remain insufficiently explored and optimized. While the functional benefits of date pits, like their antioxidant assay and dietary fiber content, have been identified, their specific health impacts when consumed as a beverage have yet to be clinically validated. Safety aspects such as the presence of anti-nutritional factors, contaminants, or microbial risks following processing have also not been properly investigated (Tahmouzi et al., 2024). However, limited studies have been carried out on the roasted date pit product shelf life and storage stability, which raises questions regarding their quality maintenance over time. Closing these gaps is essential for proper development, quality control, and commercialization of date-pit coffee products.

Although coffee is popular worldwide, excessive consumption of caffeine is associated with serious health issues that include arrhythmias, cardiovascular disease, and diabetes. Coffee has furan as a constituent, which at high levels can be carcinogenic or tumorigenic (Zawirska-Wojtasiak et al., 2018). In addition, coffee can suppress gastric acid secretion and lead to gastrointestinal upsets. In conclusion, coffee substitute consumption is a possible measure to prevent the mentioned health impacts. Date pit coffee is certainly a possible substitute (Diaz-Rojas et al., 2019).

This study aims to determine the quality and development of coffee extracted from date pits by examining its physicochemical properties, nutritional value, and sensory panel. Through an extensive quality evaluation, this study hopes to contribute to the larger research domain of sustainable food innovation by proving date pit coffee as a sustainable alternative. Using date pit coffee as a recycling of agricultural waste fits the current trend of implementing sustainable actions and incorporating healthy items into a healthy food system. The study will add to the research on the use of date pits as evidence of the thinking on the conversion of farming waste into useful foods.

2. Materials and Methods

This investigation was performed in the Postgraduate Research Laboratory within the Department of Food and Nutritional Sciences, Faculty of Science and Technology at the University of Central Punjab (UCP), Lahore, and the Pakistan Council of Scientific and Industrial Research (PCSIR), Lahore. Focusing on the preparation and quality analysis of date pit-based coffee. Multiple treatments were devised for the development of date pit coffee as a substitute for traditional coffee. The detailed methodology and procedures are outlined below, as shown in Figure 1.

2.1 Raw Materials

The date pits were procured from the local food points. For comparison, the black coffee of Nestle was bought from the local market of Johar Town, Lahore.

2.2 Chemicals

All chemicals and reagents used in this study were of analytical grade and obtained from Sigma-Aldrich, USA.

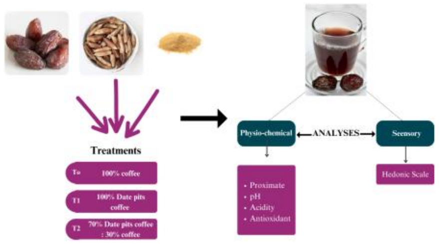

Figure 1. Methodological framework for the valorization of date pits into a functional coffee alternative.

2.3 Development of Date Pit Coffee

The date pits were first rinsed with clean water to remove any dirt or debris. After rinsing, the date pits were left at room temperature (25-30 °C) to dry. The date pits were then roasted in a pan for about 25-30 minutes at a temperature of 180°C (Fikry et al., 2019). This roasting condition (180°C) was chosen to prevent nutritional deterioration and enhance flavor. During roasting, the pits were continuously stirred to avoid burning. After the roasting was done, the date pits were removed and allowed to cool at room temperature. Lastly, the roasted date pits were ground to make a fine coffee powder using the coffee grinder (Model: ZCG495-120V, PSCIR, Pakistan). Different ratios of date pit coffee (%) and coffee (%), e.g., T_0 (100% coffee), T_1 (100% date pit coffee), and T_2, a combination of (30-70%) coffee and date pit coffee, were used. To achieve standardized brewing of these treatments, a ratio of powder to water of 1:15 was used, in which water was kept at 92-96°C. Individual samples were left to steep for an immersion time of 5-7 minutes to extract all bioactive compounds and sensory volatiles before actual sampling was done to analyze utilizing additional physicochemical and antioxidant assays (Muzykiewicz-Szymańska, Nowak, Wira, & Klimowicz, 2021).

Table 1. Treatment plan for the development of date pit coffee

Treatments	Coffee (%)	Date Pits Coffee (%)
T_0 – 100% traditional coffee	100	-
T_1 – 100% date pit coffee	-	100
T_2 – Blend (30% coffee + 70% date pit coffee)	30	70

2.4 Physicochemical Analyses of the Developed Coffee

To determine the proximate composition of the developed coffee, including moisture, ash, and protein, to evaluate its nutritional profile and quality attributes using the protocol of AOAC (2023). To ensure the credibility of the results, all the analyses were performed in triplicate (n=3).

2.4.1 Moisture Content

In this procedure, 10 g of the sample was subjected to drying in a hot air oven (Model: DO-1-30-02, UCP Lahore, Pakistan), followed by AOAC using the official method No. 1-93401 at a controlled temperature of 105±5°C according to the method of AOAC (2023). The moisture loss percentage was calculated by subtracting the weight of the dried sample from the initial weight, and then expressing this difference as a percentage relative to the initial weight as:

$$\text{Moisture content } (\%) = \frac{(\text{Initial sample weight- Weight of dried sample})}{\text{Initial sample weight}} \times 100$$

2.4.2 Ash Content

A 5 g sample of date pit coffee was carefully placed in a crucible and directly exposed to flame until it was completely charred without any visible fumes as per the procedure of AOAC (2023). Subsequently, the charred sample was ignited in a muffle furnace (Model: MF-1/02, UCP Lahore, Pakistan) by the AOAC method No. 943-05 at a temperature range of 550-600 ℃ for approximately 5-6 hours, until greyish white residues were obtained. The ash percentage was calculated as:

$$\text{Ash content}(\%) = \frac{\text{Weight of Ash}}{\text{Initial sample weight}} \times 100$$

2.4.3 Protein Content

The protein content was analyzed by the AOAC using the official method No. 1-98413. Two grams of the coffee sample was subjected to digestion with concentrated H_2SO_4 using a digestion mixture (K_2SO_4:$FeSO_4$:$CuSO_4$::100:5:10) according to the protocol of AOAC (2023). The digestion process lasted around three to four hours until the color turned light greenish. The digested sample was then transferred to a 250 mL volumetric flask and diluted with distilled water up to the mark. Next, in the distillation apparatus, 10 mL of 40% sodium hydroxide and 10 mL of the digested sample were added. The liberated ammonia was combined with a beaker containing a 4% solution of boric acid and methyl red indicator. This chemical reaction resulted in the formation of ammonium borate, which enabled the determination of the nitrogen content in the sample. The distillate was titrated against a 0.1 N solution of H_2SO_4 until a light golden color emerged. To calculate the crude protein content, the percentage of nitrogen was multiplied by a factor of 5.80.

$$\text{Nitrogen } (\%) = \frac{(\text{Volume of 0.1 N sulphuric acid used} \times 0.0014 \times 250)}{\text{Sample weight} \times \text{Aliquot volume})} \times 100$$

$$\text{Crude protein } (\%) = \text{Nitrogen } (\%) \times 5.80$$

2.4.4 pH

The pH of the date pit coffee sample was determined using a digital pH meter (Model: InoLab 720, Germany) in accordance with the AOAC (2023) guidelines. A small quantity of the sample was carefully placed in the chamber block of the digital pH meter. The meter was then turned on to commence the pH measurement process.

2.4.5 Acidity

The acidity of the date pit coffee sample was determined using a digital acidity meter (Model: QA supplies LLC, USA) following the method of AOAC (2023). Accordingly, 10 g of date pit powder sample was first mixed in 30 mL of distilled water. The resultant solution was then poured on the electronic detector of the digital acidity meter and expressed as % acidity on a citric acid basis.

2.5 Antioxidant Assay of Developed Coffee

The antioxidant assay was assessed using the protocol of Awan et al. (2018) to determine the total phenol content and DPPH (1,1-diphenyl-2-picrylhydrazyl). All measurements were made 3 times (n=3).

2.5.1 Total Phenol Content

To assess the total phenolic content of the coffee samples, the Folin-Ciocalteu reagent-based method was employed, and for comparison, Gallic acid was used as the standard as per the methodology of Yaqoob et al. (2025). For analysis, 0.2 mL of extract of each sample and 0.5 mL of Folin-Ciocalteu phenol reagent (0.2 M/L) were added to test tubes and allowed to stand at room temperature for 5 minutes. Then, 0.4 mL of 0.75% sodium carbonate (Na_2CO_3) was added to the samples and mixed thoroughly. The samples were incubated for 60 minutes at 25°C. The amount of phenolic content under analysis was measured by absorbance at 750 nm in the presence of a microplate reader (Model: ELx-800 BioTek, USA). The final values were expressed in milligrams of Gallic acid equivalents (mg GAE) per 100g as a standard curve. A coefficient of determination (R^2 >0.99) was used to determine the accuracy of this measure. The concentration of the phenolic content was calculated by use of the data of the absorbance in a linear regression standard curve equation:

$$y = mx + c$$

2.5.2 DPPH (1,1-diphenyl-2-picrylhydrazyl)

The methanolic coffee sample was measured by mixing 0.9 mL of freshly prepared solution with 0.1 mL of DPPH (1,1-diphenyl-2-picrylhydrazyl) solution following the method used by Yaqoob et al. (2025). Methanol of the same volume was taken as a control in comparison. The coffee treatments were incubated for 30 minutes at room temperature in the dark. After that, the optical density (OD) was measured at 517nm by using a microplate reader. The following equation was used to calculate the scavenging activity:

$$\text{DPPH activity (\%)} = \text{OD}_{\text{control}} - \frac{\text{OD sample}}{\text{OD}_{\text{control}}} \times 100$$

2.6 Storage Stability Assessment

All the treatments of date pits coffee (Table 1) were stored in an airtight jar at room temperature (25-30ºC) for 15 days using the method of Awan et al. (2017) with modifications. The objective of storage was to study the effect on their quality. The physicochemical and sensory tests of coffee treatments were performed in triplicate (n=3) at intervals of 0 and 15 days.

2.7 Sensory Evaluation

For the sensory evaluation of the three treatments, T_0, T_1 and T_2 (Table 1), a hedonic response approach was employed using a 9-point hedonic scale system. This system, as described by Awan et al. (2017), ranged from 9 (like extremely) to 1 (dislike). The evaluation of date pit coffee was conducted by both students and faculty members from the Department of Food Science & Technology at the University of Central Punjab, Lahore. The sensory attributes assessed included sample appearance, taste, color, aroma, and overall acceptability. To improve reliability, every sample was evaluated in triplicate (n=3). To ensure unbiased evaluations, the serving glasses were cleaned between samples using water at a temperature of 28ºC.

2.8 Statistical Analysis

In order to determine the importance of the data obtained in relation to each parameter, a careful statistical study was done. Statistical Package Version 8.1 was used to analyze a Completely Randomized Design (CRD), a two-way factorial design that would enable a strict and systematic approach to the analysis.

3. Results and Discussion

3.1 Physicochemical Analyses of the Developed Coffee

3.1.1 Moisture Content

The means for the moisture content (%) of date pits coffee at the intervals of 0 and 15 days are shown in Table 2. From the mean results, it is evident that the highest moisture content value among the treatments at 0 days was in T_2 8.84±0.01 followed by T_0 (control treatment) and T_1 (8.82±0.01 and 8.78±0.01, respectively. After storage for 15 days, a slight increase in the moisture content was observed in all treatments. The maximum increase among all treatments was observed in T_2 as 8.86±0.02, followed by T_0 and T_1 at 8.85±0.02 and 8.81±0.01. The

Table 2. Means for proximate analyses (moisture, ash, protein content) of date pits coffee samples

Parameters (%)	Treatments	Storage Days	
		0 day	15 days
Moisture Content	T_0	8.82±0.01	8.85±0.02
	T_1	8.78±0.01	8.81±0.01
	T_2	8.84±0.01	8.86±0.02
Ash Content	T_0	3.99±0.01	3.98±0.02
	T_1	3.98±0.01	3.97±0.01
	T_2	3.97±0.01	3.96±0.01
Protein Content	T_0	4.84±0.03	4.81±0.04
	T_1	4.99±0.02	4.97±0.01
	T_2	5.11±0.01	5.09±0.01

Values represent mean±SD

slight increase in moisture content over the 15-day storage period is likely due to humidity absorption from the surrounding environment. Even in controlled conditions, powdered substances like date pit coffee can absorb moisture from the air, especially if the storage containers are not completely airtight. This minor absorption raises the overall moisture content, as seen in all treatments, with T_2 showing the highest increase, likely due to its initial higher moisture level, making it more prone to further moisture absorption. Analysis showed that there were significant differences between treatments, especially for T_2 ($p < 0.05$). The present findings are aligned with the previous research studies that have explored the moisture content of date pit powder. Hossain et al. (2014) noted that the date

pits from different varieties revealed moisture contents between 3.1 and 12.5%, with some samples falling within the 7 to 9% range, which can be attributed to several factors: date variety, harvest and drying conditions, storage conditions, and processing methods.

3.1.2 Ash Content

The ash content (%) of date pits coffee at the intervals of 0 and 15 days is shown in Table 2. From the mean results, it is evident that the highest ash content (%) across the samples at 0 days was in T_0 (control treatment), 3.99±0.01, followed by T_1 and T_2, 3.98±0.01 and 3.98±0.01, respectively. After storage for 15 days, a slight decrease in the ash content was observed in all treatments, ranging from 3.97±0.01 to 3.98±0.02. Mean values for ash content at 15 days were 3.98±0.02 for T_0, 3.97±0.01 for T_1, and 3.96±0.01 for T_2. The slight decrease in ash content over the 15-day storage period could be due to moisture absorption. During storage, even minimal exposure to air can lead to moisture absorption in the powdered coffee, especially if the storage conditions are not perfectly airtight. This moisture content adds to the weight of the sample without affecting the mineral content, and this is reflected in a small apparent decrease in the percentage of ash content in weight. Statistical comparison indicated significant differences ($p < 0.05$) between T_0 and T_2 at day 15 despite the minimal declines. The results of the current research are relatively in line with Al-Khalili, Al-Habsi, and Rahman (2023), who discovered that date pits are about 4.2% ash on a dry weight basis, reflecting a notable mineral content.

3.1.3 Protein Content

The means of date pit coffee protein content (100%) are shown in Table 2, at the intervals of 0 and 15 days. From the mean results, it is evident that the highest protein content (%) among the treatments at 0 days was in T_2 as 5.11±0.01, followed by T_1 and T_0 (control treatment) as 4.99±0.02 and 4.84±0.03, respectively. After storage for 15 days, a slight decrease in the protein content (%) was observed in all treatments. The maximum decrease among all treatments was noted in T_2 as 5.09±0.01, followed by T_1 and T_0 as 4.97±0.01 and 4.81±0.04, respectively. The slight decrease in protein content after 15 days of storage could be attributed to protein oxidation. During storage, especially in powdered form, proteins are more susceptible to exposure to air and potential oxidation. Despite being minor, the observed declines were statistically significant ($p < 0.05$), with T_2 exhibiting the highest initial protein and, hence, the most significant proportional loss. The findings of this study were also in accordance with the comprehensive analysis of date pits powder by Nwachukwu et al. (2024), who found that the protein content in date pits varies between 4.0 and 5.6%, depending on the variety and maturity of the seeds.

3.1.4 pH Value

The means for the pH values of date pits coffee at the time intervals of 0 and 15 days are presented in Table 3. At day 0, the maximum pH was measured in T_1 (6.78±0.01), then in T_2 (6.73±0.01) and T_0 (6.64±0.03). After 15 days of storage, all treatments recorded a small reduction in pH, with the greatest decrease in T_0 (6.54±0.01), whereas T_1 (6.76±0.01) and T_2 (6.63±0.02) maintained relatively higher stability. The small drop can be explained by the reaction with air and light, yielding minute acidic compounds. However, the capacity of date pits as a buffer constrained the overall change, and the pH stayed in a nearly neutral interval. The change was statistically significant ($p < 0.05$). The current results agree with the research study of Ghnimi et al. (2015), which found a 6-7 pH for date seed coffee as a neutral to slightly acidic pH nature,

Table 3. Means and mean squares of pH and titratable acidity of date pits coffee samples

Attributes	Treatments	Storage Days	
		0 day	15 days
pH	T_0	6.78±0.01	6.77±0.01
	T_1	6.73±0.01	6.72±0.01
	T_2	6.64±0.03	6.64±0.02
Acidity (%)	T_0	1.66±0.04	1.70±0.04
	T_1	1.86±0.04	1.91±0.07
	T_2	2.29±0.16	2.29±0.11

Values represent mean±SD

less bitter than conventional coffee, whose pH range is from 4.85-5.10.

3.1.5 Acidity Content

The means for the acidity content (%) of date pit coffee at the intervals of 0 and 15 days are shown in Table 3. The levels of acidity in the date pit coffee samples, as the concentration of hydrogen ions, were found to increment in order of T_0 and T_2, corresponding with a negative correlation with the measured values of pH. At T_0, the acidity was the lowest at 1.66±0.04, and the highest concentration was in T_2 at 2.29±0.16, indicating that the greater the percentage of date pits, the higher the organic acid release. There was a slight but significant increase in the concentration observed over the 15-day storage period in all treatments. Even so, increases in these will neither affect the standard deviations; hence, it shares a characteristic of good sample stability. This determines the date pit blend as a low-acid substitute that has a consistent chemical composition suitable for sensitive consumers. Research on the acidity content of date pits in coffee is limited. Alhamdan et al. (2021) noted that in most date beverages, the acidity tends to rise over extended storage, due to organic acid development and Maillard reaction products.

3.2 Antioxidant Assay of Developed Coffee

3.2.1 Total Phenol Content

The means for the TPC (mg GAE/100g) of date pits coffee at the intervals of 0 and 15 days are displayed in Figure 2. The highest TPC (mg GAE/100g) value among the treatments at 0 days was in T_1 as 144.13±1.59 mg GAE/100g, followed by T_2 and T_0 (control treatment) as 140.18±0.51 and 129.51±1.31 mg GAE/100g, respectively. After storage for 15 days, a slight decrease was observed in the TPC of all treatments. The maximum decrease was in T_0, at 127.19±1.26 mg GAE/100g, followed by T_2 and T_1, 139.65±0.62 and 140.19±1.19 mg GAE/100g, respectively. The highest decrease was in T_0, possibly because it initially had a higher TPC, making these sensitive compounds more prone to degradation over time. The present results are consistent with Lemine et al. (2014), who reported the TPC (mg GAE/100g) of date pits ranging from 121.55 to 741.63 mg GAE/100g. The TPC value also serves as a key indicator of the date pits coffee's potential for functional food applications.

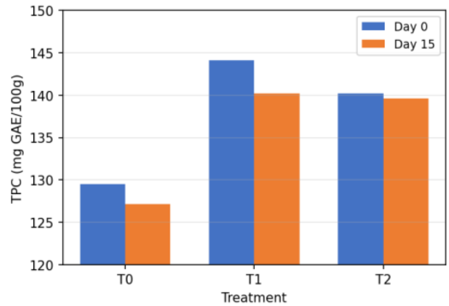

Figure 2. TPC analyses of coffee

3.2.2 DPPH (1,1-diphenyl-2-picrylhydrazyl)

The means for the DPPH (%) of date pits coffee at the intervals of 0 and 15 days are illustrated in Figure 3. The highest DPPH (%) value among the treatments at 0 days was in T_1 as 60.46±0.75, followed by T_2 and T_0 (control treatment) as 58.43±0.45 and 47.94±0.85, respectively. After storage for 15 days, it was observed that there is a slight decrease in DPPH (%) of T_1, T_2, and T_0 as 60.42±0.46, 55.36±0.37, and 43.91±0.31. The current findings align with those of Bijami et al. (2020), who reported the DPPH of date pits ranging from 49.25 to 71.35%. The T_1 had the highest radical scavenging activity of 60.46±0.75. The presence of hydroxycinnamic acids, flavonoids, and tannins gives it this high antioxidant potential. Date pit coffee's phenolic matrix, which contains substances like gallic acid and catechins that donate protons to eliminate free radicals, explains its significant DPPH scavenging action.

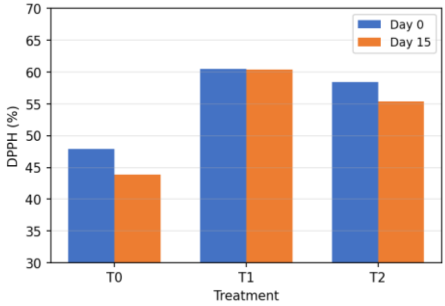

Figure 3. DPPH analyses of coffee

3.3 Sensory Evaluation of Developed Coffee

The sensory evaluation was conducted by a panel of 12 participants using a 9-point hedonic scale. Figure 4 shows the mean hedonic score of the hedonic response to all coffee treatments based on the characteristics of color, taste, flavor, aroma, and overall acceptability. The data were compared through factorial analysis of variance (ANOVA) to identify the primary effect of two variables, Treatment (T_0, T_1, T_2) and Storage Time (Day 0, Day 15), and the interaction of both. The radar graph shows the sensory profile of the products with scores between 6 and 9, with high scores implying a high degree of consumer preference. Sample T_1 (100% date pit coffee) achieved the greatest result in all characteristics, especially in taste and general acceptability, reflecting high consumer appeal. Sample T_0 (conventional coffee) scored lower in most of the traits, particularly aroma, making it the least preferred of the three treatments. Sample T_2 maintained a middle-ground profile with the highest score in colour and aroma. The present findings comply with those made by Babiker et al. (2020), who demonstrated that roasted date pits could be used in the creation of a palatable drink that resembles coffee but has functional health properties.

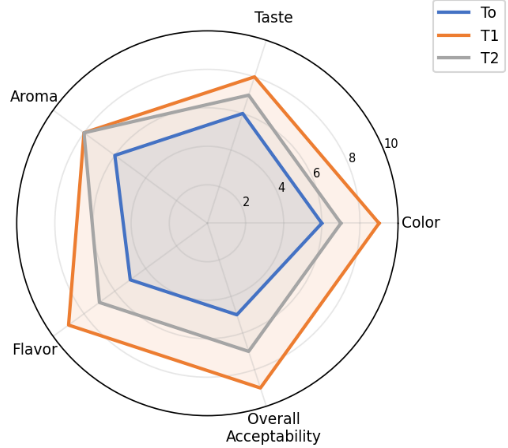

Figure 4. Hedonic response to developed coffee

4. Conclusion & Further Research

This study shows the feasibility of converting date pits into a potential coffee substitute with significant health benefits and powerful antioxidant properties. The 100% T_1 and blended T_2 date pit coffee formulations demonstrated promising sensory qualities in aroma, mouthfeel, and overall acceptability across tested formulations. The caffeine-free aspect and the positive nutritional balance position date pit coffee as a low-calorie and functional beverage appropriate for health-conscious people. Moreover, the innovation will help reduce agricultural waste, which is one of the stated objectives of global sustainability through the upcycling of date pits into value-added products. Although these are promising results, the research still needs more studies to prove the health benefits by means of clinical trials, such as blood sugar control and metabolic effects in the long run. Long shelf-life testing of the product under different storage conditions is also required to test commercial stability. In addition, the process of scaling to pilot and industrial production stages will involve the optimization of processing conditions and a full study of consumer acceptability among various consumer groups.

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5.1 Competing Interests

There are no relevant non-financial or financial interests of the authors.

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