Heliyon 9 (2023) e15912

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Nutritional probing and storage stability of papaya jam supplemented with date pit powder

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ARTICLE INFO

Keywords:
Papaya
Jam
Nutraceutical
Date pit powder
Supplementation
Storage

ABSTRACT

Jam Quality is a factor robustly influenced by storage conditions. The current research aimed to develop papaya jam with improved nutritional attributes, rheological profile, and shelf-life utilizing date pit powder as a functional ingredient. The effect of date pit powder on the formulated product's physicochemical, microbial, and organoleptic properties was analyzed. Results revealed that overall mineral profile (0.35–1.11%), crude fiber (0.56–2.01%), pH (3.51–3.70%), and antioxidant properties (22.97–30.67%) were significantly increased while water activity reduced (0.77–0.73). Moreover, date pit powder improved the color scores like a*(10.10–10.67), b* (8.13–8.78), L* (25.56–28.09), and textural attributes (Cohesiveness: 0.83–0.90; Firmness: 6.82–6.93) of functional papaya jam. Microbial count reduced from 3.60×10^5-3.06×10^5 cfu/ml by adding date pit powder and staying within the acceptable limit (4.13×10^5-3.60×10^5 cfu/ml) during 2-month storage at refrigeration. Organoleptic evaluation depicted that samples treated with date pit powder scored better than the control, and a sample with 75% pectin replacement was considered best.

1. Introduction

Papaya (*Carica papaya*) belongs to the family Caricaceae containing 04 genera with 31 species native to America and equatorial Africa [1]. *Carica papaya Linn* is India's most widely cultivated and renowned specie [2]. In 2018, 60% of global papaya production was instigated from Asia, 29% from Latin America, and 10% from Africa. India is regarded as the largest producer of Papaya around the

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https://doi.org/10.1016/j.heliyon.2023.e15912
Received 8 December 2022; Received in revised form 16 April 2023; Accepted 26 April 2023
Available online 4 May 2023

globe, having a yield share of 48%, whereas Mexico is the chief exporter of Papaya with a global share of 55%. The predominant importers of Papaya are the United States of America and the European Union, with an estimated 70% and 15% stake, respectively [3].

Papaya is a tropical fruit with exceptional nutritive constituents such as dietary fibres, minerals, polysaccharides, proteins, and vitamins with a diverse range of bioactive phytochemicals such as enzymes (Papain and Chymopapain), flavonoids, glycosides, and phytosterols [4–6]. Moreover, various parts of ripe and unripe papaya fruit exhibit extraordinary medicinal properties such as anti-amoebic, anti-fungal, anti-microbial [6], anti-malarial [7], anti-fertility [8], anthelmintic [9], immunomodulatory [10], and hepatoprotective effect [11]. Papaya is consumed in multiple ways (raw and processed) around the globe, for example, immature green Papaya as a vegetable, papaya snacks, papaya milkshakes, papaya medicine, papaya juice, pie, jams, and jellies [12].

Jam is an intermediate moisture food prepared by cooking fruit pulp with acid, pectin, sugar, and other ingredients like colors, flavors, and preservatives until it achieves a thick consistency [13]. Fruit jams have become more popular because of their utilization as a cost-effective 'Ready to serve' breakfast item enriched with essential nutrients [14]. Preservation of raw fruits was restricted because of the deprivation of facilities; thus, perishable fruits are preserved in the form of Jams and jellies. Fruit processing reduces post-harvest losses and contributes to a sound economy by generating for the food processing industry and farmers [15]. However, food processing is associated with nutrient loss, the addition of synthetic preservatives, and artificial food additives that are responsible for various health conditions. The primary reason to utilize natural food preservatives and additives in processed food products is to treat ailments and to provide nutrients along with calories [16].

Date palm (*Phoenix dactylifera*) is widely consumed around the globe in various forms. Still, it is trendy among Muslims because of its consumption during the sacred month of Ramadan [17]. Date pulp is used to manufacture a variety of processed products (honey, juice, syrups, jams, paste), value-added products (chocolates covered with nuts), fermented products (wine, liquor, vinegar), and by-products (sodas, biscuits, cakes, butter) [18]. However, date seeds or pits are commonly discarded as a constituent of no worth [19]. On the other hand, date pits can be used to manufacture various value-added products such as natural food additives [20], coffee substitutes [21], nutraceuticals [22], and natural gelling agent in the pharmaceutical and cosmetic industry [23,24]. These therapeutic and functional properties of date pit are associated with its exceptional nutritional and bioactive compounds, among them most prominent are dietary fibers [25] antioxidants [26], and pectins [27].

The literature of [28], reported that brews prepared from date pit powder were acceptable in terms of their sensory, quality, and microbiological attributes under predicted shelf life. Another study conducted by Ref. [29] suggested that physicochemical, quality, and sensory attributes of date seed powders and brews varied under various processing conditions. The study of [27], showed that date seed powder could be used as an adequate pectin substitute in the preparation of strawberry jam. A study performed by Ref. [30], reported the supplementation of date pit powder in ketchup as a fibre source along with improved quality and sensory characteristics. In the context of the present scenario, the current study was focused on the nutritional probing and storage stability assessment of papaya Jam supplemented with date pit powder as a pectin substitute. Furthermore, the physiochemical, microbiological, and organoleptic characteristics of papaya jam supplemented with date pit were also evaluated to predict storage stability.

2. Materials and methods

2.1. Materials

Ripe Papaya fruit, Pits of date palm fruit, and sugar were taken from a Local market in Lahore, Pakistan. All Chemicals and solvents used in this experiment were of analytical grade purchased from Descon oxychem Ltd. (Lahore, Pakistan) and ICI Pakistan Ltd. (Karachi, Pakistan).

2.2. Date pit powder (DPP) preparation

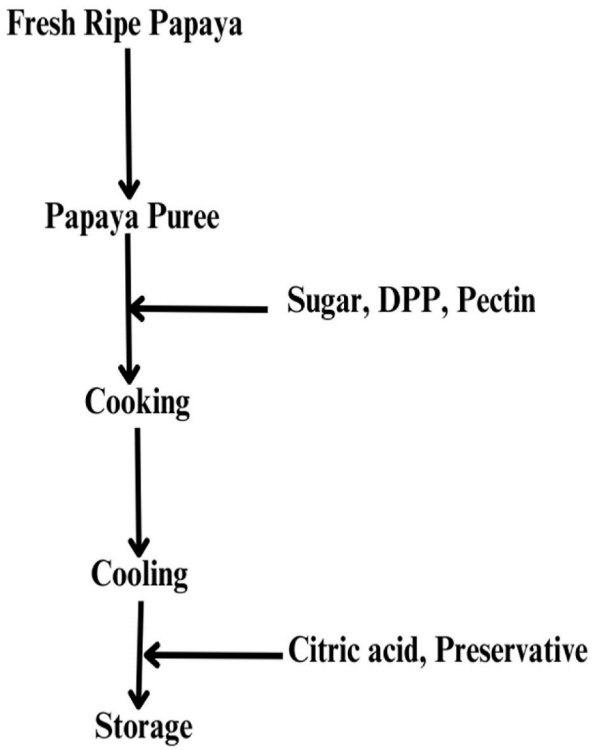
The Mazafati cultivar of dates were procured from a local supermarket, and pits were removed from date flesh manually using a knife. Afterward, pits were washed and boiled at 80–90 °C for 10 min to remove any succulent date material and then soaked in warm water for softening. After soaking, pits were dried in a forced air-drying oven DOF-230 E (Bievopeak, Japan) at 50 °C for 30 h. Dried Pits were ground in mill grinder (Brand: Electronica Venetta, Treviso, Italy) and sifted using a 40-mesh sieve to obtain a fine powder with uniform particle size.

2.3. Physicochemical analysis of date pit powder

Proximate analysis was performed using the standard methods of [31]. Proximate parameters considered were moisture, ash, fat, and crude fiber. Antioxidant analysis was performed by assessing DPPH radical scavenging activity by the method described by Ref. [32] with slight modifications. Extracts were prepared using 10 ml of 50% methanol solution. A blank was used to measure control absorption using 3.9 ml DPPH solution (0.039 mg/ml) and 100 μl sample extracts were combined. Samples were kept in the dark for 1 h, and absorbance was recorded at 517 nm. All samples were run in triplicates, and results were recorded in percentage of antioxidant potential.

2.4. Papaya jam preparation

Papaya jam samples were prepared by using different concentrations of date pit powder in replacement of concentrations of pectin



Scheme 1. Preparation of Papaya Jam.

used. The papaya jam samples with 0%, 25%, 50%, 75% and 100% pectin replaced by DPP are named T0, T1, T2, T3 and T4, respectively. The remaining recipe was generated by adding ingredients like sugar, citric acid, and sodium benzoate for preservation. Fully ripe fruit was taken, washed out, and trimmed with a knife to discard deteriorated portion. Fruit puree was made by blending fruit chunks with small amount of water. Puree was cooked on low flame with the addition of sugar, pectin and date pit powder following the treatment plan provided. Citric acid and preservatives were added after cooling down the product. The samples were stored at 4 °C until further analysis were performed (Scheme 1). Analysis was performed at a storage interval of 15 days. Initial analysis was performed for fresh samples at day 0 and then at day 15, 30, 45, and 60.

2.5. Physicochemical analysis

The physicochemical composition of all the jam samples was estimated according to the methodology described by Ref. [31]. The nutritional profile was determined by evaluating moisture content, mineral percentage, crude fat, crude fibre, and titratable acidity of the jam. pH was analyzed using digital type pH meter Inolab pH 720, WTW 82362. Brix was measured by using the hand refractometer (Atago N1, Tokyo, Japan). Samples were also evaluated for their water activity according to the methodology described by Ref. [33], using an electronic water activity meter (Model Aqualab, Japan). All the samples were analyzed in triplicates, and the results were recorded in specified units for every parameter.

2.6. DPPH radical scavenging activity

The antioxidant activity of Jam samples enriched with DPP was analyzed using [34], method with slight modifications. Extracts were prepared by combining 20 ml methanol (50%) and 2 g sample solution. They were allowed to be set for three days, and extracts were filtered with Whatman filter paper No.3 until the clear liquid was obtained. A blank was used for measuring control absorption using a 3.9 ml DPPH (2,2-diphenylpicrylhydrazyl) solution. Reaction mixtures were run with 3.9 ml DPPH dye, kept in the dark for 1 h, and absorbance was recorded at 517 nm using spectrophotometer (V-730 UV–Visible Spectrophotometer, SINCO, Japan). All samples were run in triplicates, and results were recorded in percentage.

2.7. Color measurements

The color scores of Papaya Jam samples supplemented with date pit powder were analyzed using Minolta colorimeter CR-300 (Konica Minolta Business Technologies, Inc., Germany), calibrated using a white standard porcelain plate. The scoring of color was obtained in L* (Lightness), a* (redness/greenness) and b* (yellowness/blueness) according to the CIELAB scale. All results were

Table 1
Proximate composition of Date Pit Powder.

Composition	Quantity (%)
Moisture	5.15 ± 0.03
Crude Fat	7.83 ± 0.04
Ash	2.12 ± 0.01
Crude Fiber	10.24 ± 0.02
Antioxidant Activity	45.53 ± 0.05

recorded in triplicates of samples. The total color difference (△E) in samples durning storage was calculated using the CIE formula [35].

$$\Delta E = \sqrt{\left(L_c^* - L_{cp}^*\right)^2 + \left(a_c^* - a_{cp}^*\right)^2 + \left(b_c^* - b_{cp}^*\right)^2}$$

where the abbreviation of color parameters represents c— sample without DPP, and cp—sample with DPP.

2.8. Texture analysis

Texture analysis of Papaya Jam samples supplemented with date pit powder was performed by using Texture analyzer TA. XT plus (Model FRTS) at room temperature. Parameters adjusted for samples of jam were firmness and cohesiveness. Results were recorded in triplicates for all samples.

2.9. Microbiological analysis

Papaya Jam samples were tested for microbial load using the total plate count technique described by Ref. [36], with some modifications. Nutrient agar media was used for plate preparation, and sample dilutions were prepared up to 10^3. The plates were inoculated using the prepared dilution under sterile conditions. The plates were incubated under aerobic conditions at 37 °C for two days, and results were recorded.

2.10. Sensory analysis

According to the method of [37], organoleptic evaluation was performed with some modifications. A 9-point hedonic scale was used in the questionnaire, giving scores from 1 (very dislike) to 9 (very like) to evaluate the papaya jam samples. Five trained panelists evaluated the product at room temperature. Six parameters were recorded for the organoleptic evaluation of papaya jam color, aroma, taste, texture, mouth feel, and overall acceptability. This study was conducted with the approval of the ethical committee of Department of Food Sciences, University of the Punjab Lahore, and all participants provided consent prior to their participation in the study.

2.11. Statistical analysis

The research results were analyzed by applying descriptive statistics (mean, standard deviation etc.). Data were statistically analyzed and compared in the software SPSS version 25.0. Two-way ANOVA and LSD's post hoc analysis were used for multiple comparisons. P value at $p < 0.05$ was considered statistically significant for all results.

3. Results and discussion

3.1. Physicochemical analysis of date pit powder (DPP)

The proximate composition of date pit powder is given in Table 1. Date pit powder revealed prominent physicochemical and oxidative properties. Results of the current study reported that the moisture content in DPP was observed at 5.15%, ash content in DPP was 2.12%, fat content was at 7.83%, crude fiber content was at 10.24%, and antioxidant activity was at 45.53%. The results observed were found in agreement with the study conducted by Ref. [30], that moisture was in the range of 5–10%, fat content was 7–10%, ash was observed at 1–2%, and crude fiber was observed in the range of 10–20%. Results observed for antioxidant activity were in accordance with the study performed by Ref. [38], who reported that the DPPH radical scavenging activity of different date palm cultivars ranged from 29.44% to 62.90%.

Table 2
Proximate composition and microbiological evaluation of papaya jam samples supplemented with date pit powder.

Proximate Composition		Papaya Jam samples				
		Control (T0)	T1	T2	T3	T4
Fat (g/100 g)	0 day	0.27 ± 0.13^{e}	0.46 ± 0.03^{d}	0.64 ± 0.03^{c}	0.83 ± 0.03^{b}	1.05 ± 0.06^{a}
	15 day	0.27 ± 0.13^{e}	0.48 ± 0.03^{d}	0.60 ± 0.03^{c}	0.81 ± 0.03^{b}	1.04 ± 0.06^{a}
	30 day	0.29 ± 0.13^{e}	0.47 ± 0.03^{d}	0.65 ± 0.03^{c}	0.83 ± 0.03^{b}	1.02 ± 0.06^{a}
	45 day	0.29 ± 0.13^{e}	0.46 ± 0.03^{d}	0.64 ± 0.03^{c}	0.82 ± 0.03^{b}	1.03 ± 0.06^{a}
	60 day	0.28 ± 0.13^{e}	0.47 ± 0.03^{d}	0.60 ± 0.03^{c}	0.83 ± 0.03^{b}	1.05 ± 0.06^{a}
Ash (g/100 g)	0 day	0.35 ± 0.01^{d}	0.57 ± 0.15^{cd}	0.71 ± 0.14^{bc}	0.86 ± 0.13^{b}	1.11 ± 0.22^{a}
	15 day	0.37 ± 0.01^{d}	0.58 ± 0.15^{cd}	0.72 ± 0.14^{bc}	0.85 ± 0.13^{b}	1.12 ± 0.22^{a}
	30 day	0.35 ± 0.01^{d}	0.57 ± 0.15^{cd}	0.73 ± 0.14^{bc}	0.84 ± 0.13^{b}	1.13 ± 0.22^{a}
	45 day	0.33 ± 0.01^{d}	0.56 ± 0.15^{cd}	0.71 ± 0.14^{bc}	0.86 ± 0.13^{b}	1.14 ± 0.22^{a}
	60 day	0.34 ± 0.01^{d}	0.55 ± 0.15^{cd}	0.72 ± 0.14^{bc}	0.85 ± 0.03^{b}	1.16 ± 0.22^{a}
Crude Fibre (g/100 g)	0 day	0.56 ± 0.02^{e}	0.85 ± 0.01^{d}	1.31 ± 0.02^{c}	1.67 ± 0.01^{b}	2.01 ± 0.02^{a}
	15 day	0.55 ± 0.02^{e}	0.86 ± 0.01^{d}	1.32 ± 0.02^{c}	1.68 ± 0.01^{b}	2.04 ± 0.02^{a}
	30 day	0.57 ± 0.02^{e}	0.86 ± 0.01^{d}	1.33 ± 0.02^{c}	1.68 ± 0.01^{b}	2.03 ± 0.02^{a}
	45 day	0.57 ± 0.02^{e}	0.88 ± 0.01^{d}	1.31 ± 0.02^{c}	1.67 ± 0.01^{b}	2.02 ± 0.02^{a}
	60 day	0.56 ± 0.02^{e}	0.87 ± 0.01^{d}	1.33 ± 0.02^{c}	1.68 ± 0.01^{b}	2.03 ± 0.02^{a}
Brix°	0 day	65.43 ± 0.05^{jklm}	65.30 ± 0.01^{lmn}	65.20 ± 0.01^{jkl}	65.10 ± 0.01^{no}	$65.00 \pm 0.01^{\circ}$
	15 day	65.83 ± 0.11^{gh}	65.56 ± 0.01^{ijk}	65.40 ± 0.01^{m}	65.33 ± 0.05^{klmn}	65.20 ± 0.01^{mn}
	30 day	66.30 ± 0.02^{de}	66.10 ± 0.06^{fg}	65.93 ± 0.05^{fg}	65.80 ± 0.01^{ghi}	65.50 ± 0.01^{jkl}
	45 day	67.00 ± 0.01^{bc}	66.80 ± 0.01^{c}	66.40 ± 0.01^{d}	66.10 ± 0.06^{ef}	65.60 ± 0.03^{hij}
	60 day	67.90 ± 0.01^{a}	67.10 ± 0.01^{b}	66.80 ± 0.01^{c}	66.30 ± 0.01^{de}	65.90 ± 0.01^{fg}
Water Activity	0 day	0.77 ± 0.05^{ab}	0.76 ± 0.01^{b}	0.75 ± 0.05^{cd}	0.74 ± 0.01^{de}	0.73 ± 0.05^{e}
	15 day	0.76 ± 0.05^{b}	0.75 ± 0.01^{c}	0.76 ± 0.05^{b}	0.73 ± 0.05^{e}	0.76 ± 0.05^{bc}
	30 day	0.76 ± 0.01^{b}	0.75 ± 0.01^{c}	0.77 ± 0.01^{ab}	0.74 ± 0.01^{de}	0.74 ± 0.01^{d}
	45 day	0.78 ± 0.01^{a}	0.76 ± 0.01^{bc}	0.78 ± 0.01^{a}	0.75 ± 0.01^{cd}	0.73 ± 0.01^{e}
	60 day	0.77 ± 0.01^{ab}	0.74 ± 0.01^{d}	0.76 ± 0.01^{bc}	0.73 ± 0.01^{e}	0.72 ± 0.01^{f}
pH	0 day	3.51 ± 0.01^{hi}	3.58 ± 0.01^{e}	3.63 ± 0.01^{c}	3.68 ± 0.01^{b}	3.70 ± 0.01^{a}
	15 day	3.50 ± 0.01^{ij}	3.55 ± 0.01^{f}	3.58 ± 0.05^{e}	3.61 ± 0.01^{d}	3.64 ± 0.05^{c}
	30 day	3.48 ± 0.05^{lm}	3.50 ± 0.01^{hi}	3.51 ± 0.01^{ijk}	3.52 ± 0.005^{gh}	3.53 ± 0.05^{g}
	45 day	$3.45 \pm 0.05^{\circ}$	3.46 ± 0.05^{mn}	3.47 ± 0.05^{lm}	3.48 ± 0.005^{klm}	3.43 ± 0.05^{jkl}
	60 day	3.38 ± 0.05^{s}	3.39 ± 0.05^{rs}	3.40 ± 0.01^{qr}	3.41 ± 0.05^{pq}	3.42 ± 0.05^{p}
Titratable Acidity (%)	0 day	0.34 ± 0.06^{def}	0.33 ± 0.03^{efg}	0.32 ± 0.06^{gh}	0.31 ± 0.04^{hi}	0.30 ± 0.06^{i}
	15 day	0.35 ± 0.06^{bc}	0.34 ± 0.04^{cd}	0.33 ± 0.03^{efg}	0.32 ± 0.06^{gh}	0.31 ± 0.03^{hi}
	30 day	0.35 ± 0.06^{cd}	0.35 ± 0.06^{bc}	0.35 ± 0.06^{bc}	0.32 ± 0.06^{gh}	0.32 ± 0.06^{gh}
	45 day	0.37 ± 0.06^{ab}	0.38 ± 0.06^{a}	0.32 ± 0.06^{gh}	0.33 ± 0.06^{efg}	0.32 ± 0.06^{gh}
	60 day	0.38 ± 0.06^{a}	0.37 ± 0.06^{ab}	0.35 ± 0.03^{bc}	0.34 ± 0.04^{cd}	0.33 ± 0.06^{efg}
Antioxidant activity (%)	0 day	22.95 ± 0.03^{fg}	24.54 ± 0.05^{e}	26.80 ± 0.02^{cd}	28.04 ± 0.03^{b}	30.23 ± 0.02^{a}
	15 day	$22.78 \pm 0.02f^{g}$	24.18 ± 0.06^{f}	26.02 ± 0.03^{cd}	27.99 ± 0.03^{bc}	29.12 ± 0.01^{b}
	30 day	21.63 ± 0.01^{h}	23.20 ± 0.05^{fg}	25.21 ± 0.02^{c}	26.93 ± 0.02^{c}	28.83 ± 0.02^{b}
	45 day	20.87 ± 0.01^{i}	22.03 ± 0.02^{g}	24.01 ± 0.04^{de}	26.13 ± 0.01^{cd}	28.10 ± 0.03^{b}
	60 day	19.48 ± 0.01^{j}	21.28 ± 0.01^{h}	23.19 ± 0.04^{de}	25.16 ± 0.03^{d}	27.96 ± 0.01^{bc}
Total Plate count (CFU x 10^5/ml)	0 day	3.60 ± 0.04^{d}	3.46 ± 0.23^{e}	3.33 ± 0.23^{f}	3.20 ± 0.04^{g}	3.06 ± 0.06^{h}
	15 day	3.73 ± 0.46^{cd}	3.60 ± 0.04^{d}	3.46 ± 0.23^{e}	3.33 ± 0.03^{f}	3.20 ± 0.04^{g}
	30 day	3.86 ± 0.23^{c}	3.73 ± 0.46^{cd}	3.60 ± 0.04^{d}	3.46 ± 0.03^{e}	3.33 ± 0.06^{f}
	45 day	4.00 ± 0.04^{b}	3.86 ± 0.23^{c}	3.73 ± 0.23^{cd}	3.60 ± 0.04^{d}	3.46 ± 0.03^{e}
	60 day	4.13 ± 0.46^{a}	4.00 ± 0.04^{b}	3.86 ± 0.23^{c}	3.73 ± 0.06^{cd}	3.60 ± 0.04^{d}

Mean values ± SD with different letters in a row are significantly different ($p < 0.05$).
Control: Papaya Jam without DPP; T1: Papaya jam with 25% DPP; T2: Papaya jam with 50% DPP; T3: Papaya jam with 75% DPP; T4: Papaya jam with 100% DPP.

3.2. Physicochemical analysis of papaya jam supplemented with DPP

3.2.1. Proximate composition

The proximate composition observed for the Papaya Jam samples supplemented with date pit powder is illustrated in Table 2. Fat content depicted a significant increase ($p < 0.05$) with DPP addition, while on the contrary, storage time displayed a non-significant effect. Fat content for Papaya Jam samples enriched with date pit powder was observed from 0.27% to 1.05%. The Date Pit Powder contains a significant amount of fat, which resulted in an increase in the overall fat content of jam samples supplemented with DPP. The results were in accordance with the study performed by Ref. [39], who utilized date pit powder as a functional ingredient in date bars and reported that in date bars with the supplementation of DPP, crude fat was increased significantly. Another study revealed that during storage of three months, non-significant change ($p > 0.05$) was observed in the crude fat content of Raspberry and peach Jams [40].

Ash content and crude fiber also significantly increased ($p < 0.05$) with DPP addition, while the contrast storage time showed a non-significant effect. Ash content for Papaya Jam samples enriched with date pit powder was observed from 0.35% to 1.11%. The results were in accordance with the study performed by Ref. [39], who reported that samples of date bars with the supplementation of

Table 3
Color parameters of papaya jam samples supplemented by date pit powder.

Color Parameters		Papaya Jam samples				
		Control (T0)	T1	T2	T3	T4
L*	0 day	25.56 ± 0.06^{f}	26.03 ± 0.04^{e}	26.93 ± 0.04^{d}	27.69 ± 0.15^{c}	28.09 ± 0.07^{a}
	15 day	25.53 ± 0.03^{fg}	26.01 ± 0.01^{e}	26.91 ± 0.01^{d}	27.67 ± 0.02^{c}	28.07 ± 0.05^{ab}
	30 day	25.52 ± 0.01^{fg}	25.96 ± 0.01^{e}	26.89 ± 0.01^{d}	27.65 ± 0.02^{c}	28.06 ± 0.03^{ab}
	45 day	25.50 ± 0.02^{fg}	25.97 ± 0.02^{e}	26.86 ± 0.02^{d}	27.63 ± 0.02^{c}	28.03 ± 0.01^{ab}
	60 day	25.47 ± 0.02^{g}	25.94 ± 0.02^{e}	26.84 ± 0.02^{d}	27.60 ± 0.03^{c}	28.03 ± 0.05^{b}
a*	0 day	10.10 ± 0.01^{j}	10.25 ± 0.01^{g}	10.41 ± 0.05^{e}	10.56 ± 0.01^{c}	10.67 ± 0.01^{a}
	15 day	10.08 ± 0.01^{jk}	10.24 ± 0.05^{g}	10.40 ± 0.05^{e}	10.55 ± 0.01^{c}	10.66 ± 0.01^{ab}
	30 day	10.07 ± 0.01^{jk}	10.24 ± 0.01^{gh}	10.39 ± 0.01^{ef}	10.53 ± 0.01^{c}	10.65 ± 0.01^{b}
	45 day	10.06 ± 0.02^{kl}	10.22 ± 0.01^{hi}	10.39 ± 0.01^{ef}	10.54 ± 0.01^{cd}	10.63 ± 0.01^{b}
	60 day	10.05 ± 0.03^{l}	10.21 ± 0.01^{i}	10.37 ± 0.01^{f}	10.52 ± 0.05^{d}	10.64 ± 0.01^{b}
b*	0 day	8.13 ± 0.02^{j}	8.25 ± 0.01^{g}	8.40 ± 0.01^{e}	8.56 ± 0.02^{c}	8.78 ± 0.02^{a}
	15 day	8.11 ± 0.02^{jk}	8.24 ± 0.01^{gh}	8.38 ± 0.05^{e}	8.50 ± 0.02^{c}	8.76 ± 0.02^{a}
	30 day	8.10 ± 0.01^{k}	8.23 ± 0.05^{gh}	8.37 ± 0.01^{ef}	8.54 ± 0.02^{cd}	8.77 ± 0.02^{a}
	45 day	8.09 ± 0.01^{k}	8.21 ± 0.01^{hi}	$8.36 \pm 0.01e^{f}$	8.53 ± 0.01^{d}	8.75 ± 0.01^{ab}
	60 day	8.10 ± 0.01^{k}	8.22 ± 0.01^{i}	8.35 ± 0.01^{f}	8.52 ± 0.01^{d}	8.73 ± 0.05^{b}
ΔE	0 day	–	–	–	–	–
	15 day	0.041 ± 0.01^{c}	0.024 ± 0.02^{g}	0.030 ± 0.01^{f}	0.064 ± 0.01^{a}	0.030 ± 0.02^{f}
	30 day	0.017 ± 0.02^{h}	0.041 ± 0.01^{c}	0.024 ± 0.02^{g}	0.049 ± 0.02^{b}	0.017 ± 0.03^{h}
	45 day	0.024 ± 0.01^{g}	0.030 ± 0.03^{f}	0.032 ± 0.01^{e}	0.033 ± 0.02^{de}	0.024 ± 0.02^{g}
	60 day	0.044 ± 0.01^{bc}	0.024 ± 0.02^{g}	0.030 ± 0.01^{f}	0.030 ± 0.01^{f}	0.030 ± 0.01^{f}

Mean values ± SD with different letters in a row are significantly different ($p < 0.05$).
Control: Papaya Jam without DPP; T1: Papaya jam with 25% DPP; T2: Papaya jam with 50% DPP; T3: Papaya jam with 75% DPP; T4: Papaya jam with 100% DPP.

DPP and soy protein isolate showed significant enhancement in ash content. Another study revealed that during storage of three months, non-significant change ($p > 0.05$) was observed in the ash content of mixed araca and marola Jam [41]. Crude fiber content for Papaya Jam samples enriched with date pit powder was observed from 0.56% to 2.01%. The results were in accordance with the study performed by Ref. [39], who reported that samples of date bars with the supplementation of DPP and soy protein isolate showed significant enhancement in crude fiber content. Another study revealed that during storage, non-significant change ($p > 0.05$) was observed in the crude fiber content of nutrient bars [42].

The addition of date pit powder in Papaya Jam depicted a significant effect ($p < 0.05$) on the degree of Brix during the treatments and storage. The maximum value of Brix recorded on day 60 in T_0 was 67.90, while the lowest Brix was recorded on 0 days in T_4, which was 65.00. The previous findings of [27], revealed that during six months, the dry matter was increased in formulated Strawberry Jam replacing pectin with DPP because of the solubilization of Jam ingredients. Polysaccharides undergo acid hydrolysis during storage, so soluble sugars are released in the food product, causing an increase in total soluble solids [43]. In ripe and unripe Papaya, a significant increase in Total Soluble Solids (TSS) was observed for 60 days [44].

The addition of date pit powder in Papaya Jam depicted a significant change ($p < 0.05$) in water activity during the treatments. At the same time, the contrast storage time showed a non-significant effect. Water activity for Papaya Jam samples enriched with date pit powder was observed from 0.77 to 0.73%. The results were in accordance with the study performed by Ref. [39], who reported that DPP is a stable food product with low moisture content. Resultantly the treatments of date bars formulated with date pit powder depicted less moisture content and caused the reduction in water activity of samples supplemented with DPP. The previous study conducted by Ref. [45], was in correspondence of the statistical results of the current research that depicted a non-significant ($p > 0.05$) effect of storage on the water activity of guava Jam.

The acid content of Papaya Jam samples supplemented with DPP was revealed in Table 2. The addition of date pit powder in Papaya Jam depicted a significant change ($p < 0.05$) in Titratable acidity during the treatments and storage. Titratable acidity values were observed in the range of 0.34–0.38% for fresh samples and decreased to 0.30–0.33% with the addition of date pit powder. As from the previous findings of [27], it was revealed that titratable acidity was increased in formulated Strawberry Jam replacing pectin with DPP during six months [45]. showed the conversion of pectin to pectic acid and oxidation of reducing sugars was increased during storage. The results were in accordance with the study performed by Ref. [46], who reported that in apricot and apple Jam, acidity was increased from 0.65 to 0.74 during storage of 60 days.

The addition of date pit powder in Papaya Jam depicted a significant effect ($p < 0.05$) on pH during the treatments and storage. pH values were observed in the range of 3.51–3.38 for fresh samples and increased to 3.70–3.42 for T4 sample with maximum concentration of date pit powder. Because of the conversion of sugar into acids, the pH value can be reduced during the storage period [47]. The results were in accordance with the study performed by Ref. [48], who reported that in diet, apple Jam pH was reduced from 4.34 to 3.01 during storage of three months.

3.3. DPPH radical scavenging activity

The antioxidant activity analyzed using DPPH (2,2-diphenylpicrylhydrazyl) radical scavenging activity is presented in Table 2. As

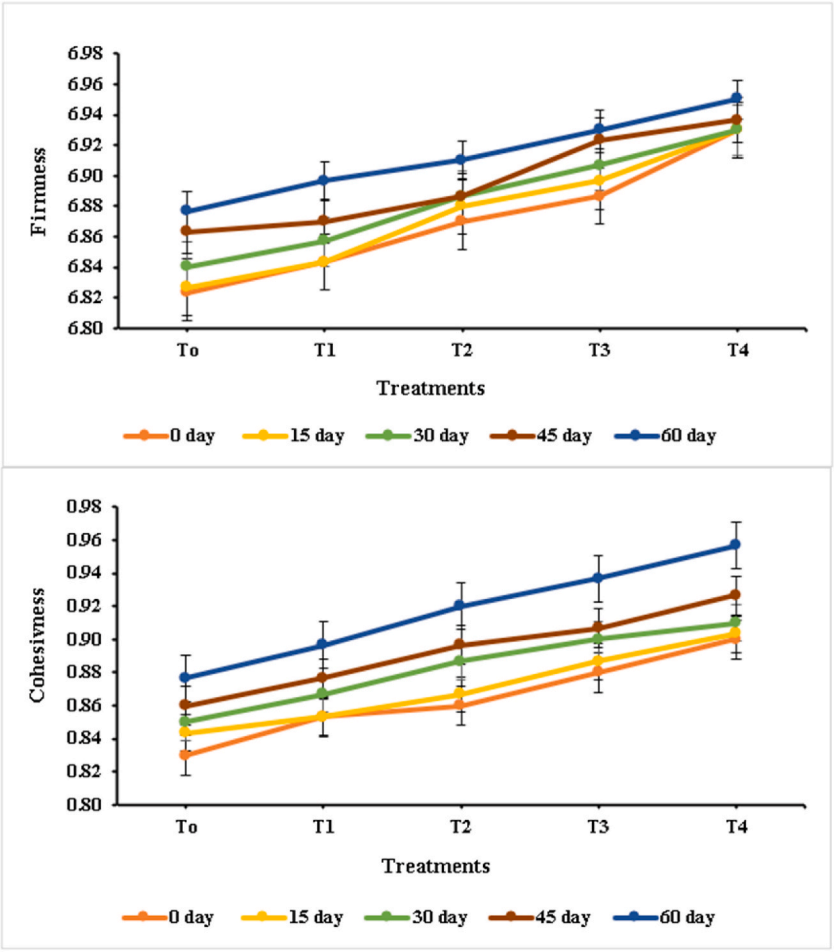


Fig. 1. Texture of papaya jam samples supplemented with date pit powder. Control: Papaya Jam without DPP; T1: Papaya jam with 25% DPP; T2: Papaya jam with 50% DPP; T3: Papaya jam with 75% DPP; T4: Papaya jam with 100% D.

predicted the addition of date pit powder significantly improved the antioxidant activity of Papaya Jam samples. A non-significant ($p > 0.05$) change was observed regarding storage days on the antioxidant activity of jam. Compared to the control sample, samples with DPP have significant antioxidants because of the elevated levels of bioactive components found in date palm and pits. Antioxidant activity was observed in the range of 22.95–19.48% for control samples and increased to 30.23–27.96% for samples with a maximum concentration of date pit powder. A study conducted by Ref. [39] found that the DPPH radical scavenging activity in date bars decreased over a 90-day storage period. This reduction is likely due to the breakdown of phenolic compounds, which occurs more rapidly in processed products exposed to high temperatures, as reported by Ref. [49]. During storage, phenolic compounds are easily oxidized and become the reason for the reduction of antioxidants. In Jam processing, cell structure gets disrupted, so phenolic compounds become more prone to non-enzymatic oxidation [50]. Results matched the findings conducted by Ref. [51], on strawberry fruit and jam in that after the processing of fruit, DPPH% inhibition was reduced significantly and in the storage of strawberry jam, non-significant ($p > 0.05$) change was observed.

3.4. Microbiological evaluation

The data presented in Table 2 reveals the impact of date pit powder on the microbial load of Papaya Jam samples. As predicted, the total plate count observed for the control sample was higher than supplemented with DPP. The addition of date pit powder in Papaya Jam depicted a significant change ($p < 0.05$) in Total plate count during the treatments and in the storage but was observed within the acceptable range. However, the increase in the microbial population of samples supplemented with date pit powder was relatively less compared to the control sample, which can be attributed to the low moisture in samples supplemented with DPP and the anti-microbial properties of DPP. Total plate count was observed in the range of $3.60–4.13 \times 10^5$ cfu/ml for fresh samples and decreased to $3.06–3.60 \times 10^5$ cfu/ml on 60 days for control sample. It was observed that DPP has natural antioxidants that make DPP a natural preservative so that it will improve the stability as well as the shelf life of Jams and jellies [52]. Similar findings found that during storage of 60 days at

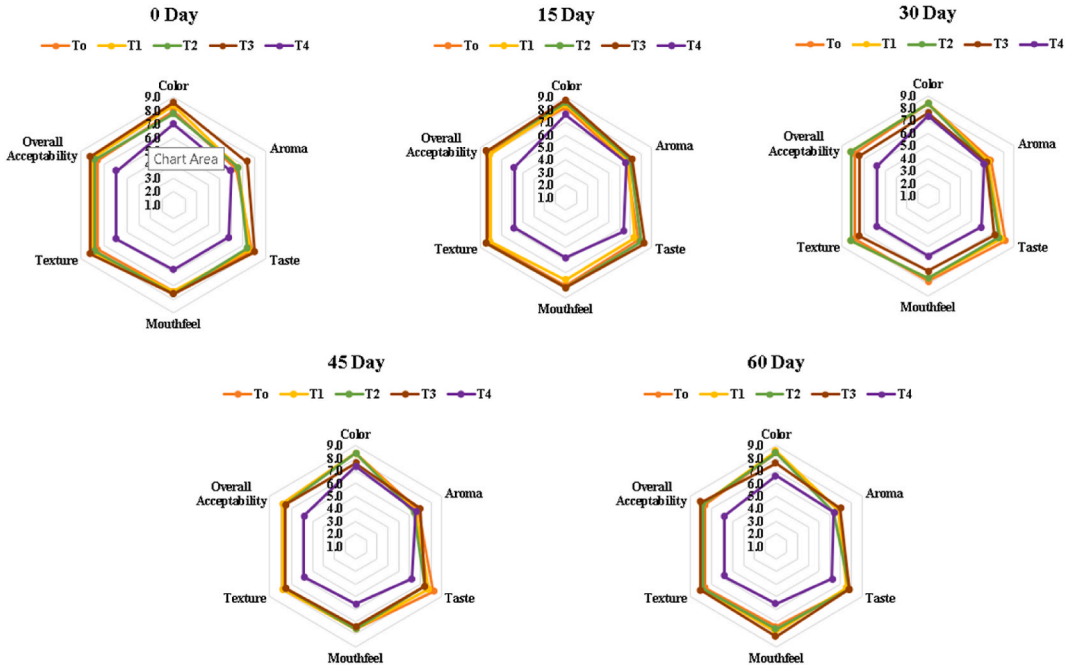


Fig. 2. Sensory Evaluation scores of papaya jam samples supplemented with date pit powder. Control: Papaya Jam without DPP; T1: Papaya jam with 25% DPP; T2: Papaya jam with 50% DPP; T3: Papaya jam with 75% DPP; T4: Papaya jam with 100% DPP.

refrigeration temperature, there was a slight increase of microbial load in ripe papaya jam. However, this microbial load was within acceptable limits [53]. Similar findings conducted by Ref. [39], depicted that in 2 months of storage, there was a significant increase in TPC. However, the increase in the microbial load of samples supplemented with date pit powder remained within acceptable limits.

3.5. Color parameters (L*, a*, b*)

The CIELAB color system was used to record the chromatic data expressing the results as L*, a*, and b*, and the color scores observed are presented in Table 3. Color scores of Papaya Jam samples showed a significant variation with the addition of date pit powder. During storage intervals, a significant reduction ($p < 0.05$) was observed in the L*, resulting in a product with a darker color. The addition of DPP L* value was observed in the range of 25.56–25.47 for fresh samples and increased to 28.09–28.03 for T4. The results of the present study correspond with [30], which depicted that lightness in strawberry jams decreased during storage of 6 months, so the strawberry Jam turned into dark color by adding DPP, which can be due to non-enzymatic browning. Moreover, with the addition of DPP lightness of the jam was increased because the addition of DPP increased the reflectance of the Jam [16]. If all the parameters are in red and yellow quadrants, then the a* and b* values will be positive. A significant reduction ($p < 0.05$) was observed in a*during storage intervals. A* value was observed in the range of 10.10–10.05 for fresh samples and increased to 10.67–10.64 with the addition of100% DPP. The present study's results correspond with [54], that there is a positive correlation between the addition of fiber and the redness of jam. According to Ref. [55], water binding materials act as co-pigment and lead to an increase in a* value. The highest a* value exhibited an excess amount of anthocyanin content that reduced to yellowish content at the end of storage that occurred as by Maillard reaction brown pigment can be produced and anthocyanin degradation [13]. A significant reduction ($p < 0.05$) was observed in b*during storage intervals. The addition of DPP b* value was observed in the range of 8.13–8.10 for fresh samples and increased to 8.78–8.73 on day 60. The present study's results correspond with [56], that yellowness in Aloe Vera-based pineapple Jam was decreased with time because of more processing time and loss of anthocyanin, and jam became dull at the end of storage. Results also matched with [57], that the anthocyanin content of jam was lost in tart cherry Jam, and b* value was reduced during storage, and the processing of jam significantly changed.

3.6. Texture parameters

The texture analysis of Papaya Jam supplemented with date seed powder has two additional parameters: firmness and cohesiveness. Moreover, the scores of the parameters of texture observed are in Fig. 1. The firmness and Cohesiveness of Papaya Jam samples showed a significant variation with the addition of date pit powder. During storage intervals, a significant enhancement ($p < 0.05$) was observed in the Firmness and Cohesiveness. Firmness was observed in the range of 6.82 N–6.87 N for fresh samples and increased to 6.93N–6.95 N for T4, with the addition of DPP [30]. reported similar findings that adding DPP to strawberry jam increased its firmness during storage. The results of this study were consistent with [58], who suggested that replacing pectin with DPP fiber is beneficial

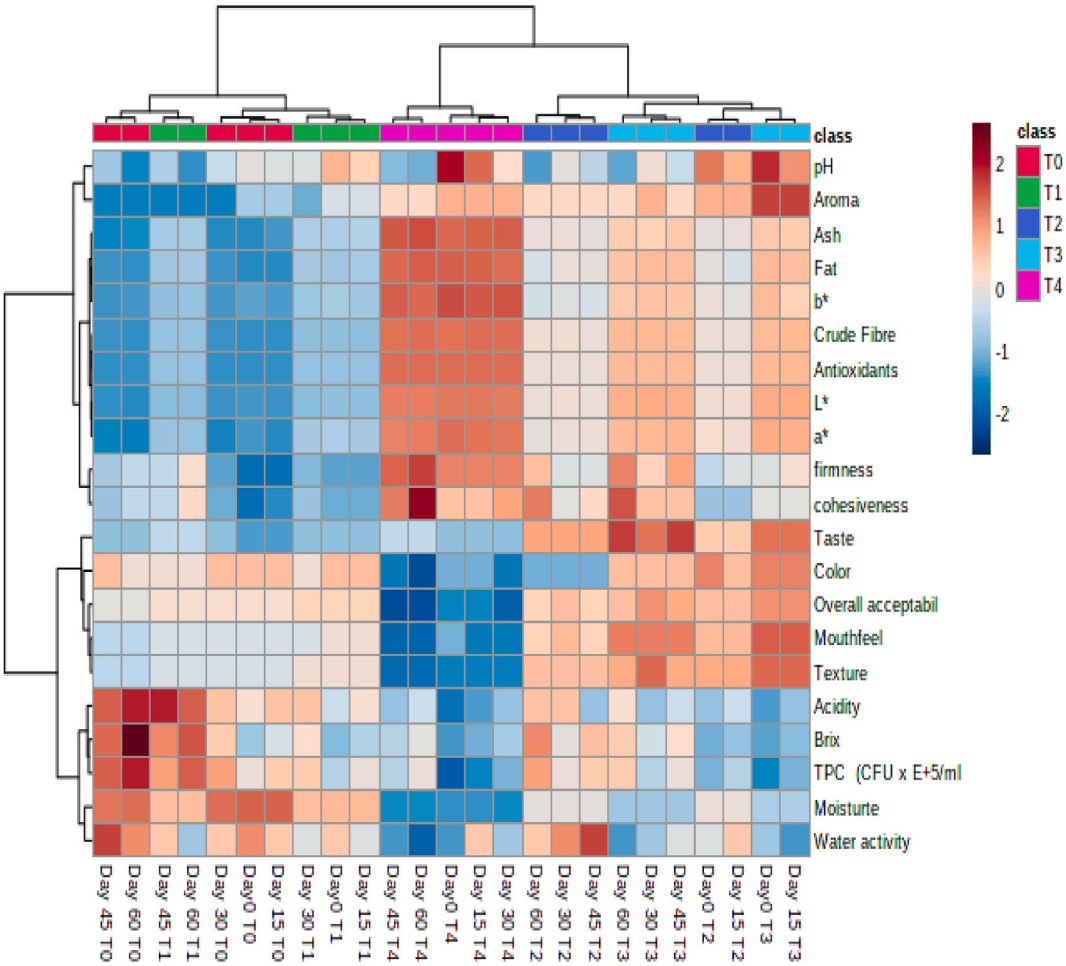


Fig. 3. Heat Map illustrating the correlation of all parameters in date pit powder supplemented papaya jam samples during 60 days of storage.

because it increases active polymeric chains and elasticity in the structure of pectin. Fiber particles act as a lubricant and incorporate into the pectin network of jam. Similar findings found by Ref. [59] that with the addition of mosambi peel powder, the firmness value was increased in jam samples. Cohesiveness observed for the fresh sample was in the range of 0.83N–0.87 N and increased to 0.90N–0.95 N for T4, with the addition of DPP. The results of the present study correspond with [30] that during storage of 6 months, the cohesiveness of strawberry Jam supplemented with DPP was increased with the addition of date seed powder. This happened because DPP fiber matrix has hydration attributes. Similar findings were found by Ref. [16] that the addition of fiber supported a network of pectin formed in a jam.

3.7. Organoleptic evaluation

The sensory attributes of Papaya Jam samples supplemented with date pit powder are provided in Fig. 2. The sensory characteristics of the Jam samples improved significantly ($p < 0.05$) with the increasing concentrations of DPP. On the contrary, the storage time depicted a non-significant ($p > 0.05$) effect on the sensory attributes of Papaya Jam samples indicating that the product was organoleptically acceptable at 60 days. The samples treated with date pit powder were better perceived and scored higher than the control sample. Although all the samples of jam are bright red, the score was enhanced with the supplementation of DPP. Taste, mouthfeel, aroma, and texture were also perceived better for samples supplemented with date pit powder. The increase in taste score might be because of increasing the total soluble solids content, reducing sugars, and the hydrolysis of carbohydrates to simple sugars. Date pit powder helped in giving the jam a characteristic mouthfeel because of its good particle size. Thus, the T3 treatment with 75% replacement of pectin with date pit powder received the highest sensory scores and was perceived as best. The present results were found, like the previous study conducted by Ref. [30], that overall acceptability was higher in the samples of tomato ketchup that were 0.5% and 1% supplemented with date pit powder.

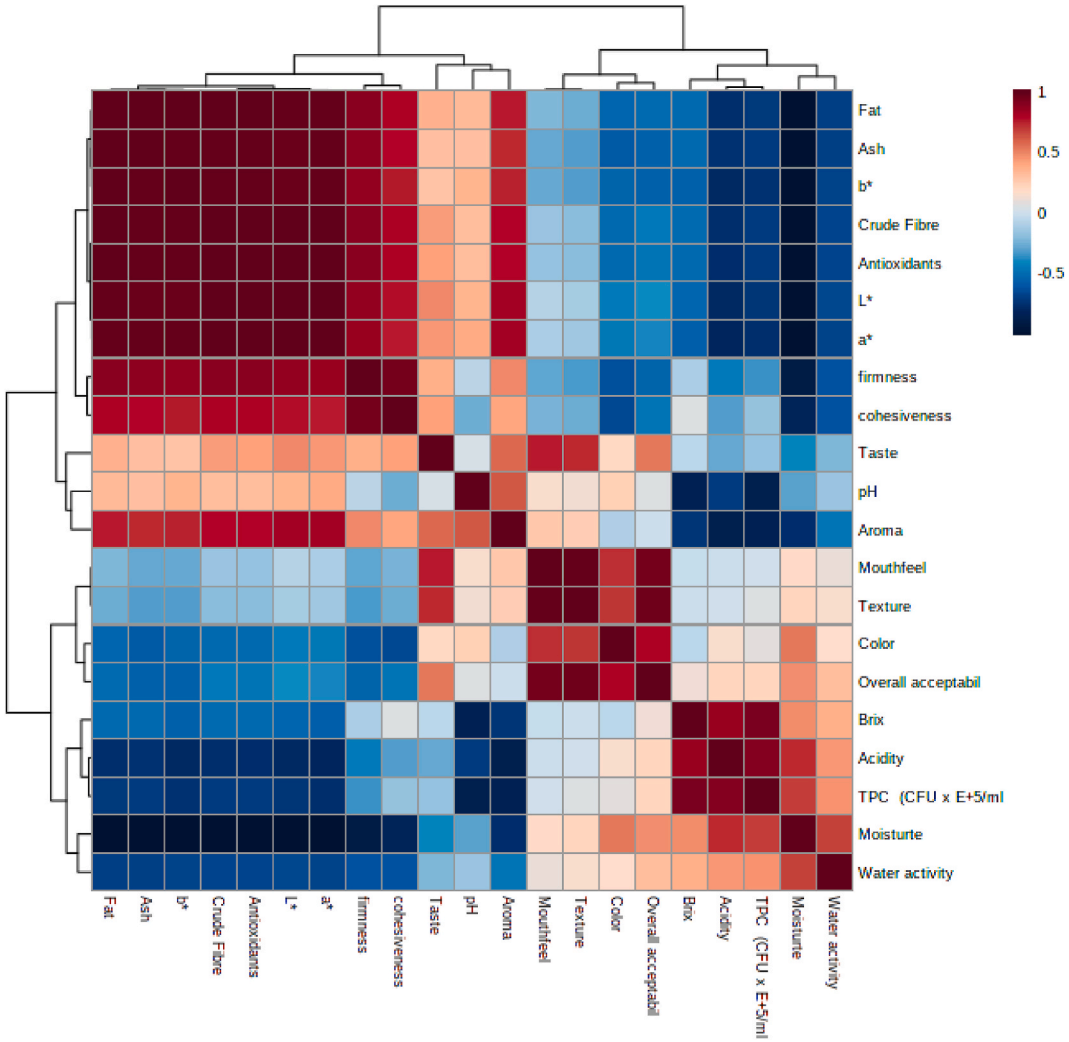


Fig. 4. Correlation among different parameters of date pit powder supplemented papaya jam samples during 60 days of storage.

3.8. Heat map and hierarchical analysis

For further analysis of parameters relating to storage time and date pit powder concentration heat map was constructed (Fig. 3). The results can be made more instinctive through color comparison as well as data classified by heat map. For diverse parameters, different clusters were detected, signifying the variations between these parameters. Overall, the maximum quantity was detected by the darkest red color for pH of treatment T4 (with 100% DPP replacing pectin) and T3 (with 75% DPP replacing pectin) at 0 days, along with sensory attributes (Aroma, Mouthfeel, and Texture). The control sample showed the maximum quantity of Water activity on the 45th day, while Acidity, Brix, and TPC were on the 60th day of storage. For the parameter of the T4 sample slightly red color was observed, indicating the maximum quantity of Fat, Crude fiber, Antioxidants, Ash, L*, a*, b*, Firmness, and cohesiveness, indicating the maximum concentration of Date Pit powder during the storage of 60 days. Moderate quantities of Taste, Color, Overall acceptability, and texture were observed for sample T3 for 60 days of storage. Neutral Clusters were detected for T2 on all days depicting the lower values of Crude fiber, Antioxidants, Fat, moisture, and Ash. The blue color represents the negative values, and minimum quantities were observed for moisture content, Water activity, taste, color, Mouth feel, texture, and overall acceptability of the T4 sample throughout the storage period of 60 days.

3.9. Correlation

Regression analysis was performed to evaluate the correlation among the results of conducted assays on Papaya Jam samples supplemented with DPP (Fig. 4). A highly significant correlation was found between Fat, Ash, Antioxidant activity, Crude fiber, Firmness, Cohesiveness, L*, a*, and b*. A significant correlation was observed between the sensory characters (Color, Aroma, Taste,

Mouthfeel, Texture and Overall acceptability). For Brix, acidity and TPC also showed a positive correlation. Neutral clusters were found between the parameters of moisture and water activity. Between the sensory parameters, Brix and pH slightly negative correlation was detected. A significant negative correlation was found among Fat, Ash, crude fiber, antioxidant activity, waster activity, Brix, L*, a*, b*, firmness, and cohesiveness. A strong significant negative correlation was observed between the parameters of Acidity, TPC, and moisture content.

4. Conclusion

The current study reported a detailed insight into the effect of date pit powder on papaya jam's physicochemical, microbial, and sensory attributes during a storage time of 2 months. Results observed during this study revealed that supplementation of date pit powder significantly improved the mineral content, crude fiber, total soluble solids, and antioxidant potential of formulated papaya jam. Microbial evaluation illustrated that date pit powder had substantial anti-microbial properties and reduced the total bacterial count to a significant level. Organoleptic evaluation depicted that during a storage time of 2 months, no significant effect was observed on the sensory parameters comprising aroma, texture, taste, color, and overall acceptability. Present research findings supported the practical application of date pit powder in jam, jellies, and confectionery as a potential pectin replacer, nutrient enhancer, and preservative.

Author contribution statement

Shafaq Anwar: Performed the experiments; Wrote the paper.
Anam Saleem, Muhammad Adnan Nasir: Analyzed and interpreted the data.
Ayesha Razzaq, Abrar Hussain, Huzaifa Mehmood: Contributed reagents, materials, analysis tools or data.
Muhammad Rizwan Tariq: Conceived and designed the experiments; Contributed reagents, materials, analysis tools or data.
Shinawar Waseem Ali, Waseem Safdar: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.
Zujaja Umer, Zunaira Basharat: Performed the experiments; Analyzed and interpreted the data.
Umair Ali, Azeem Intisar: Performed the experiments; Contributed reagents, materials, analysis tools or data.
Shahid Masood: Conceived and designed the experiments.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

References

[1] V. Yogiraj, P.K. Goyal, C.S. Chauhan, A. Goyal, B. Vyas, Carica papaya Linn, an overview, International Journal of Herbal Medicine 2 (5) (2014) 1–8. Food chemistry, 145, 23-27.
[2] S. Fauziya, R. Krishnamurthy, Papaya (Carica papaya): source material for anticancer, CIBTech J Pharm Sci 2 (1) (2013) 25–34.
[3] Faostat, Date, the food and agriculture organization of the united nations [Last accessed on 2020 Jun 10], http://www.faostat.fao.org/faostat/en/#data/QC, 2018.
[4] D.E. Adedeji, J. Kayode, M.J. Ayeni, An ethnobotanical study of plant species used for medicine by the Eegun indigenous tribal group of Lagos State, Nigeria, Not. Sci. Biol. 10 (3) (2018) 318–327.
[5] R. Pinnamaneni, Nutritional and medicinal value of papaya (Carica papaya Linn.), World J. Pharm. Pharmaceut. Sci. 6 (8) (2017) 2559–2578.
[6] F. Saeed, M.U. Arshad, I. Pasha, R. Naz, R. Batool, A.A. Khan, B. Shafique, Nutritional & phyto-therapeutic potential of Papaya (Carica papaya Linn.), an overview, Int. J. Food Prop. 17 (7) (2014) 1637–1653.
[7] M.I. Oraebosi, G.M. Good, Carica papaya augments anti-malarial efficacy of artesunate in Plasmodium berghei parasitized mice, Annals of Parasitology 67 (2) (2021) 295–303.
[8] C.O. Nwaehujor, J.O. Ode, M.R. Ekwere, R.I. Udegbunam, Anti-fertility effects of fractions from Carica papaya (Pawpaw) Linn. methanol root extract in male Wistar rats, Arab. J. Chem. 12 (7) (2019) 1563–1568.
[9] L.K. Kanthal, P. Mondal, S. De, S. Jana, S. Aneela, K. Satyavathi, Evaluation of anthelmintic activity of carica papaya latex using pheritima posthuma, International Journal of Life Science &Pharma Research 2 (1) (2012) 10–12.
[10] S. Pandey, P.J. Cabot, P.N. Shaw, A.K. Hewavitharana, Anti-inflammatory &immunomodulatory properties of Carica papaya, J. Immunot. 13 (4) (2016) 590–602.
[11] O. Oseni, E.O. Odesani, O. Oloyede, O. Adebayo, M. Ogundare, Antioxidant &hepatoprotective activities of Carica papaya (Papaw Leaf) &Loranthus bengwensis (cocoa mistletoes) against diclofenac induced hepatotoxicity in rats, Int. J. Life Sci. Sci. Res. 4 (1) (2018) 1974–1982.
[12] U.D. Chavan, Processing of papaya into various products. Fruits and vegetable processing training programmee (15937.61284), https://doi.org/10.13140/RG.2, 2018.
[13] N. Touati, M.P. Tarazona-Díaz, E. Aguayo, H. Louaileche, Effect of storage time &temperature on the physicochemical &sensory characteristics of commercial apricot jam, Food Chem. 145 (2014) 23–27.
[14] D.B. Pinandoyo, S. Siddiqui, M.K. Garg, Physico-chemical analysis of protein fortified papaya jam, Jurnal Al-Azhar Indonesia Seri Sains dan Teknologi 5 (1) (2019) 50–55.
[15] R.U. Khan, S.R. Afridi, M. Ilyas, M. Sohail, H. Abid, Development of strawberry jam and its quality evaluation during storage, Pakistan J. Biochem. Mol. Biol. 45 (1) (2012) 23–25.

[16] M. Igual, C. Contreras, N. Martínez-Navarrete, Colour &rheological properties of non-conventional grapefruit jams: instrumental &sensory measurement, Lebensmittel-Wissenschaft Und-Technologie -Food Science &Technology 56 (1) (2014) 200–206.
[17] M.A. Sahari, M. Barzegar, R. Radfar, Effect of varieties on the composition of dates (*Phoenix dactylifera L.*)—note, Food Sci. Technol. Int. 13 (4) (2007) 269–275.
[18] R. Salomón-Torres, B. Valdez-Salas, S. Norzagaray-Plasencia, Date palm, source of foods, sweets & beverages, in: The Date Palm Genome, vol. 2, Springer, Cham, 2021, pp. 3–26.
[19] A. Thouri, H. Chahdoura, A. El Arem, A. Omri Hichri, R. Ben Hassin, L. Achour, Effect of solvents extraction on phytochemical components &biological activities of Tunisian date seeds (var. Korkobbi & Arechti), BMC Compl. Alternative Med. 17 (1) (2017) 1–10.
[20] B. Amany Mohamed Mohamed, A.M. Maliha Ali, Production of Mayonnaise from Date Pit Oil, Food and Nutrition Sciences, 2011.
[21] M.M. Mostafa, E. Ali, M. Gamal, M.A. Farag, How do coffee substitutes compare to coffee? A comprehensive review of its quality characteristics, sensory characters, phytochemicals, health benefits &safety, Food Biosci. 43 (2021), 101290.
[22] A. Ahmad, H. Imtiaz, Chemical composition of date pits: potential to extract and characterize the lipid fraction, in: Sustainable Agriculture Reviews, vol. 34, Springer, Cham, 2019, pp. 55–77.
[23] M.I. Waly, N. Guizani, A.A. Alawi, M.S. Rahman, Chemopreventive effect of date pit extract, in: Bioactive Components, Diet &medical Treatment in Cancer Prevention, Springer, Cham, 2018, pp. 105–110.
[24] C.T. Chao, R.R. Krueger, The date palm (*Phoenix dactylifera L.*): overview of biology, uses, and cultivation, Hortscience 42 (5) (2007) 1077–1082.
[25] H.M. Habib, W.H. Ibrahim, Nutritional quality evaluation of eighteen date pit varieties, Int. J. Food Sci. Nutr. 60 (sup1) (2009) 99–111.
[26] M. Metoui, A. Essid, A. Bouzoumita, A. Ferchichi, Chemical composition, antioxidant and antibacterial activity of Tunisian date palm seed, Pol. J. Environ. Stud. 28 (1) (2019).
[27] N.K. Alqahtani, Effects of replacing pectin with date pits powder in strawberry jam formulation, Scientific Journal of King Faisal University, Basic and Applied Sciences 21 (2020) 135–147.
[28] M. Fikry, Y.A. Yusof, A.M. Al-Awaadh, R.A. Rahman, Prediction of the shelf-life of date seeds brew by integration of acceptability and quality indices, J. Food Meas. Char. 14 (3) (2020) 1158–1171.
[29] M. Fikry, Y.A. Yusof, A.M. Al-Awaadh, R.A. Rahman, N.L. Chin, E. Mousa, L.S. Chang, Effect of the roasting conditions on the physicochemical, quality and sensory attributes of coffee-like powder and brew from defatted palm date seeds, Foods 8 (2) (2019) 61.
[30] N. Alqahtani, Physico-chemical &sensorial properties of ketchup enriched with khalas date pits powder, Scientific Journal of King Faisal University 21 (1) (2019) 172–176.
[31] AOAC, Official methods of analysis, in: The Association of Official Analytical Chemists, fifteenth ed., 2000 (Arlington, USA).
[32] A.I. Hussain, F. Anwar, S.T.H. Sherazi, R. Przybylski, Chemical composition, antioxidant & anti-microbial activities of basil (Ocimum basilicum) essential oils depend on seasonal variations, Food Chem. 108 (3) (2008) 986–995.
[33] A. Piga, P. Catzeddu, S. Farris, T. Roggio, A. Sanguinetti, E. Scano, Texture evolution of "Amaretti" cookies during storage, Eur. Food Res. Technol. 221 (3) (2005) 387–391.
[34] B. Matthäus, Antioxidant activity of extracts obtained from residues of different oilseeds, J. Agric. Food Chem. 50 (12) (2002) 3444–3452.
[35] A. Banaś, A. Korus, J. Korus, Texture, color, and sensory features of low-sugar gooseberry jams enriched with plant ingredients with prohealth properties, J. Food Qual. (2018).
[36] M.F. Gliemmo, M.A. Montagnani, L.I. Schelegueda, M.M. González, C.A. Campos, Effect of xantham gum, steviosides, clove, &cinnamon essential oils on the sensory &microbiological quality of a low sugar tomato jam, Food Sci. Technol. Int. 22 (2) (2016) 122–131.
[37] M.C. Meilgaard, G.V. Civille, B.T. Carr, Sensory Evaluation Techniques, fourth ed., CRC Press LLC, New York, 2007.
[38] C. Platat, H.M. Habib, F.D. Al Maqbali, N.N. Jaber, W.H. Ibrahim, Identification of date seeds varieties patterns to optimize nutritional benefits of date seeds, J. Nutr. Food Sci. 8 (2) (2014).
[39] L. Rukh, M. Nadeem, T. Kausar, M.A. Murtaza, M. Luqman, M.B. Shahid, A. Shaukat, Studies on effect of addition of date pit powder &soy protein isolate on physicochemical properties of date bars, Sarhad J. Agric. 37 (4) (2021) 1134–1143.
[40] Valentina Pavlova, Ljubica Karakashova, Viktorija Stamatovska, Naiden Delchev, Ljupka Necinova, Gjore Nakov, Marija Menkinoska, &Tatjana Blazevska, Storage impact on the quality of raspberry &peach jams, Journal of Hygienic Engineering &Design 664 (2013) 25–28.
[41] A. Chaudhary, K. Verma, B.S. Saharan, Probiotic potential of blueberry jam fermented with lactic acid bacteria, Curr. Res. Nutr. Food Sci. 8 (1) (2020) 65.
[42] R. Munshi, A. Kochhar, A. Kaur, Nutrient selection &optimization to formulate a nutrient bar stable on storage &specific to women at risk of osteoporosis, J. Food Sci. Technol. 57 (8) (2020) 3099–3107.
[43] B.P. Bisen, R. Verma, Standardization of recipes on chemical characteristics and storability of guava and papaya mixed fruit bar, Int. J. Chem. Stud. 8 (4) (2020) 824–829.
[44] P. Nafri, A.K. Singh, A. Sharma, I. Sharma, Effect of storage condition on physiochemical &sensory properties of papaya jam, J. Pharmacogn. Phytochem. 10 (2) (2021) 1296–1301.
[45] N. Kanwal, M.A. Randhawa, Z. Iqbal, Influence of processing methods &storage on physico-chemical &antioxidant properties of guava jam, Int. Food Res. J. 24 (5) (2017).
[46] I. Hussain, I. Shakir, Chemical and organoleptic characteristics of jam prepared from indigenous varities of apricot and apple, World J. Dairy Food Sci. 5 (2010) 73–78.
[47] T.U. Rahman, N.T. Amanullah, A. Tahir, A.U. Rahman, A. Khan, 13. Evaluation and preparation of guava jam stored at ambient temperature, Pure &Applied Biology (PAB) 7 (3) (2018) 1064–1073.
[48] A. Muhammad, Y. Durrani, A. Zeb, M. Ayub, J. Ullah, Development of diet jam from apple grown in swat (NWFP), Sarhad J. Agric. 24 (3) (2008) 461–467.
[49] L.K. Beh, Z. Zakaria, B.K. Beh, W.Y. Ho, S.K. Yeap, N.B.M. Alitheen, Comparison of total phenolic content and antioxidant activities of freeze-dried commercial and fresh fruit juices, J. Med. Plants Res. 6 (48) (2012) 5857–5862.
[50] A.L. Kumar, C. Madhumathi, S. Sadarunnisa, K. Srikanth, Standardization of protocol for best blending ratio of papaya cv. Red lady &guava cv. Lalit fruit pulp for preparation of fruit Bar, Plant Archives 17 (1) (2017) 59–68.
[51] T.M. Rababah, M.A. Al-Mahasneh, I. Kilani, W. Yang, M.N. Alhamad, K. Ereifej, M. Al-u'datt, Effect of jam processing & storage on total phenolics, antioxidant activity, &anthocyanins of different fruits, J. Sci. Food Agric. 91 (6) (2011) 1096–1102.
[52] R. Messaoudi, S. Abbeddou, A. Mansouri, A.C. Calokerinos, P. Kefalas, Phenolic profile and antioxidant activity of date-pits of seven Algerian date palm fruit varieties, Int. J. Food Prop. 16 (5) (2013) 1037–1047.
[53] S. Ranganna, Handbook of Analysis & Quality Control for Fruit &Vegetable Products, second ed., Tata McGraw Hills Publishing Co. Ltd., New Delhi, 2014.
[54] C. Phimpharian, A. Jangchud, K. Jangchud, N. Therdthai, W. Prinyawiwatkul, H.K. No, Physicochemical characteristics &sensory optimisation of pineapple leather snack as affected by glucose syrup &pectin concentrations, Int. J. Food Sci. Technol. 46 (5) (2011) 972–981.
[55] V. Emerton, Food Colours, Blackwell Publishing Ltd., Oxford, UK, 2008.
[56] A. Dubey, A. Kumar, P.S. Rao, Development &storage study of reduced calorie aloe vera (*Aloe barbadensis Miller*) based pineapple fruit jam, J. Food Meas. Char. 15 (1) (2021) 961–975.
[57] J. Vukoja, A. Pichler, M. Kopjar, Stability of anthocyanins, phenolics &color of tart cherry jams, Foods 8 (7) (2019) 255.
[58] M. Belović, A. Torbica, I. Pajić-Lijaković, J. Mastilović, Development of low calorie jams with increased content of natural dietary fibre made from tomato pomace, Food Chem. 237 (2017) 1226–1233.
[59] K. Younis, R.U. Islam, K. Jahan, B. Yousuf, A. Ray, Effect of addition of mosambi (Citrus limetta) peel powder on textural & sensory properties of papaya jam, Cogent Food Agric. 1 (1) (2015), 1023675.