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Effect of chitosan-gelatin edible coating containing orange peel extract on quality properties and shelf life of Kabakab dates

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ABSTRACT

Dates are nutritionally rich and commercially important. Various solutions have been implemented to increase the shelf life of the product, allowing it to be available to consumers for a longer period. This study aims to use a chitosan-gelatin edible coating containing natural orange peel extract on stored dates at 4 and 25 °C for 90 days. Physical and chemical tests (weight loss, pH, acidity, moisture, reducing sugars, soluble solids, and texture) and sensory evaluations were conducted to assess the treatments over the storage period. The lowest weight loss occurred in the sample treated with the chitosan-gelatin coating containing orange peel extract on day 90 at both temperatures. Results indicated that with increased storage time and temperature, pH and moisture decreased while acidity, soluble solids, reducing sugars, and texture increased significantly. Additionally, a decrease in sensory attributes was observed with increased storage time and temperature, with samples treated with chitosan-gelatin coating containing 4 and 10 mg/ml orange peel extract showing the highest preference in sensory properties for the dates. Based on the findings, the chitosan-gelatin edible coating containing orange peel extract can be introduced as the best formulation for increasing the shelf life of dates for up to 90 days.

1-Introduction

In the majority of hot and dry climates, date palms (Phoenix dactylifera L.) are regarded as one of the most significant and productive livelihood crops. In the Middle East, date fruit is a major economic commodity. Although this fruit has a relatively low protein content, it is known to be a rich source of carbs, simple sugars, minerals, elements like potassium, iron, and phosphorus, vitamins, and a high proportion of dietary fiber [1].

Nowadays, in food packaging, edible films and coatings have, in many cases, fully replaced traditional synthetic or thermoplastic polymer films. These include applications on food products such as confectionery, fresh fruits and vegetables, certain meat products, poultry, fish, frozen, and dried products [2]. The use of edible coatings and wraps to extend the shelf life and enhance the quality of fresh and frozen foods has gained significant attention in recent years [3]. Edible coatings or films improve the appearance of fruits, delay ripening and color changes, and perform functions such as carrying antimicrobial and anti-browning agents, preventing moisture and oxygen ingress, thereby slowing oxidation reactions and improving the quality and shelf life of food products [4]. In recent years, soy protein, gelatin, casein, collagen, chitosan, whey protein, and cellulose-based films have been among the most widely used edible films or coatings [5]. Furthermore, it has been shown that cold storage delays the ripening of fruits and extends the shelf life of dates compared to storage under ambient conditions [6].

Among the most popular edible films or coatings in recent years are those made of soy protein, gelatin, casein, collagen, chitosan, whey protein, and cellulose [5]. Additionally, it has been demonstrated that, in contrast to ambient storage, cold storage prolongs the shelf life of dates and slows the ripening of fruits [6]. Chitosan possesses properties such as non-toxicity, biocompatibility, biodegradability, and antimicrobial activity, which have increased its use compared to many biopolymers [7]. Additionally, chitosan provides numerous health benefits, including antioxidant properties [8], anti-diabetic effects [9], effective weight reduction [10], anti-cancer activity [11], cholesterol-lowering effects [12], among others, making it a promising agent for films and edible coatings. Other studies on antimicrobial films based on chitosan report that they enhance food safety and extend the shelf life of food products [13]. Moreover, chitosan is also used as an active packaging material for preserving dairy products [14]. The properties of chitosan can be enhanced when used in combination with other bioactive agents [15]. Despite all these advantages, the use of chitosan as a packaging material faces challenges due to its weak mechanical properties and poor water resistance caused by its hydrophilic nature [16].

Like proteins and polysaccharides [17], gelatin is a functional biopolymer that has strong anti-water vapor qualities [20], biodegradability [19], and the capacity to create appropriate films [18]. Because of its negatively charged amino acids, gelatin easily combines with chitosan and allows for electrostatic interaction with positively charged chitosan [21]. In order to extend the shelf life of food, particularly that which is susceptible to quality alterations as a result of moisture absorption, gelatin films have been employed as environmentally friendly edible packaging materials [22]. The colorful outer layer of orange peel is called epicarp or flavedo, while the soft white central layer is called mesocarp or albedo. Citrus fruit pieces have been utilized to treat and prevent a number of illnesses. Studies have shown that orange juice can be used to treat scurvy [23], lemon and lime juice can prevent kidney stones [24], grapefruit can lower blood pressure [25], citrus flavonoids can effectively modulate liver lipid metabolism [26], orange juice can prevent and moderate inflammatory processes [27], polyphenols in kumquat peel can effectively act as antioxidants [28], and grapefruit juice can have protective effects against genotoxicity [29].

Addressing the issues surrounding dates is crucial because of their significance for food security, their industrial uses, their contribution to the economy and way of life of date-growing regions, and their advantageous export qualities. In order to assess the use of an edible chitosan-gelatin coating containing natural orange peel extract, this study was carried out on Kabkab dates, which are extensively grown in Iran. Additionally, this study intends to improve the quality and shelf life of dates while lowering expenses and environmental pollution by extracting extracts rich in bioactive components from juice factory leftovers.

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2- Materials and Methods

Orange Peel Extract and Powder Preparation

Following a distilled water wash, the oranges' peels were carefully separated, removing the edible portions. After 48 hours of drying at 40°C in an oven, the separated peels were ground into a fine powder in an electric mill and sieved through a 24-mesh screen. A Soxhlet device was used to extract 100 grams of the powdered material with 800 milliliters of methanol over the course of six hours at room temperature, in accordance with suggested procedures. Peel particles were eliminated by filtering the mixture with Whatman No. 2 filter paper. A rotary evaporator was used to treat the filtered extract under vacuum at 60°C until all of the solvent had been eliminated. In a refrigerator, the extracts were kept at 4°C in dark containers [30].

Preparation of Edible Coating

Gelatin powder was dissolved in 1% w/v double-distilled water to create the gelatin coating (GL), which was then left to stand at room temperature for 40 minutes to promote swelling and improved dissolving. After that, the solution was agitated slowly for 45 minutes at 45°C. The chitosan coating (CH) was made by dissolving chitosan powder in 2% w/v double-distilled water with 0.7% acetic acid, then stirring the mixture for two hours at 30°C. The chitosan-gelatin coating (CH-GL) was made by adding 1% w/v gelatin powder to the chitosan solution and stirring it for 45 minutes at 45°C. A plasticizer of 0.75% (v/v) glycerol was added to the coatings to soften and increase their flexibility, and mixing was carried out for ten more minutes.

To enrich the edible coatings with bioactive compounds, 5 and 10 mg/mL of orange peel extract (OPE) were added to each coating, and the solutions were mixed at 25°C until fully dissolved [32]. The final coating solutions, prepared for coating Kabkab dates, are shown in Table 1.

For coating the Kabkab dates, due to their uneven surface, a dipping method was used. The dates were immersed in the prepared solutions for 2 minutes, after which excess coating solution was removed by draining. The coated dates were then dried under laboratory conditions at 25°C for 24 hours and packaged in polyethylene bags. The control treatment was uncoated (distilled water). The treated and control dates were stored at 4°C and 25°C and were subjected to physicochemical and sensory evaluations at 0, 1, 2, and 3 months after storage.

Table 1: Treatments used to coating the Kabkab dates

Row	Coating composition	Sample Code
1	GL (1 %) + OPE (5 mg/ml)	G-E5
2	GL (1 %) + OPE (10 mg/ml)	G-E10
3	CH (2 %) + OPE (5 mg/ml)	CH-E5
4	CH (2 %) + OPE (10 mg/ml)	CH-E10
5	GL (1 %) + CH (2 %) + OPE (5 mg/ml)	G-CH-E5
6	GL (1 %) + CH (2 %) + OPE (10 mg/ml)	G-CH10E
7	Control sample (uncoated)	C

Physicochemical Properties Analysis

pH Evaluation

Using a pH meter (Metrohm 827, Germany) calibrated with buffer solutions of pH 4 and pH 7 and fitted with standard glass electrodes at 25°C, the pH was measured. In order to do this, a blender was used to combine 25 grams of dates with 100 milliliters of distilled water, and the resulting slurry was filtered through filter paper [33].

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Acidity Evaluation

A titration technique using 0.1 N sodium hydroxide (NaOH) was employed to ascertain the acidity (represented as citric acid) of Kabkab dates. Initially, a porcelain mortar was used to grind five grams of each date sample into a paste. After adding 50 milliliters of distilled water, the mixture was shaken for fifteen minutes. A 0.1 N NaOH solution was used for titration until the pH was between 8.4 and 8.6 [33]. Using Equation 1, the dates' acidity was determined.

$$\text{Acidity} = \frac{V \times N \times 0.064}{M} \times 100 \qquad \text{Eq1}$$

In this equation, V represents the volume of sodium hydroxide used in milliliters, N is the normality of the sodium hydroxide solution, and M is the sample weight in grams.

Moisture Measurement

Ten grams of pitted dates were mixed with 10 mL of distilled water and ground into small pieces. For moisture determination, 2–3 grams of the ground samples were weighed and then dried in a vacuum oven (Memmert V049, Germany) at 65–70°C for 48 hours until a constant weight was reached [34].

Total Soluble Solids (Brix) Evaluation

Ten grams of pitted dates were mixed with 10 mL of distilled water and ground into small pieces. The Brix value, or Total Soluble Solids (TSS), for each extract was then measured using a digital refractometer (Atago PL-2, Japan).[٣٤]

Weight Loss

Weight loss was determined by measuring the weight of the dates at 0, 1, 2, and 3 months after storage and calculating the difference in weight at each time point compared to the initial weight of the dates.[٣٥]

Reducing Sugar Measurement

The reducing sugar content in the dates was measured using the Lane-Eynon method [36]. This method is based on the reduction of divalent copper ions from Fehling's solutions A and B by reducing sugars, converting them to monovalent copper ions, resulting in a brick-red precipitate. For this purpose, 4 grams of dates were weighed, and the volume was adjusted to 100 mL. The titration of Fehling's solutions A and B with the sugar solution was performed until a brick-red precipitate formed, using methylene blue as an indicator. The grams of reducing sugars per 100 grams of date sample were calculated using Equation 2.

$$n = \frac{F \times 100 \times 100}{M \times V} \qquad \text{Eq 2}$$

In this equation ,n represents the grams of reducing sugar per 100 grams of date sample F is the Fehling factor , V is the volume of the sugar solution used in titration, and M is the weight of the date sample in grams.

Texture Firmness

The firmness of the texture, after removing the date pit, was measured using a penetrometer device (Lutron FR-5120, Taiwan) with a cylindrical probe of 1.27 cm in diameter. The probe penetrated at a speed of 2 mm per second to a depth of 1.3 cm [36].

Sensory Evaluation

This assessment was conducted by a panel of 10 semi-trained evaluators, comprising 5 men and 5 women. Sensory evaluation focused on flavor (from pleasant to sour), brightness, texture firmness, and overall acceptance, using a 5-point hedonic scale (1, 2, 3, 4, and 5 corresponding to very poor, poor, average, good, and very good, respectively). This evaluation was carried out one day after coating and repeated monthly for up to 3 months.

Statistical Design

All tests were conducted in triplicate. Statistical analysis was performed using SPSS software version 19, and the results were presented as the mean ± standard deviation. To present differences between data, a one-way analysis of variance (ANOVA) was conducted, and Duncan's test at a 5% significance level was used for mean comparisons. Graphs were created using Microsoft Excel 2016.

3-Results and Discussion

Changes in Weight Loss

The physiological weight loss in fruits and vegetables is directly related to water loss and respiration occurring through the skin of the produce. The extent of moisture loss depends on the pressure gradient across tissue surfaces, which is a crucial factor in determining the post-harvest shelf life of fruits and vegetables [37, 38]. This study evaluated the impact of different coating treatments on the weight loss of Kabkab dates stored at 4°C and 25°C over a 90-day period, with results presented in Table 2. The data showed a gradual increase in weight loss across all treatments as storage time extended, primarily due to fruit respiration and moisture evaporation [39]. However, the control sample exhibited the most significant increase in weight loss at both storage temperatures. The lowest weight loss changes at 4°C, except on the first day, occurred on day 3 in dates coated with chitosan-gelatin containing 10 mg/mL (1.70% ± 0.02) and 5 mg/mL (1.78% ± 0.01) orange peel extract. Conversely, the highest weight loss on day 90 was in the control sample at 4°C, with a loss of 9.12% ± 0.07. At 25°C, the lowest weight loss changes, excluding the first day, were observed on day 3 in dates coated with chitosan-gelatin containing 10 mg/mL (3.92% ± 0.03), while the highest weight loss on day 90 was seen in the control sample with a loss of 11.39% ± 0.09. When comparing weight loss variations in date samples treated with various edible coatings containing orange peel extract at the two different temperatures of 4°C and 25°C (Table 2), it was evident that weight loss was higher at 25°C than at 4°C. The lowest weight loss at 4°C after 90 days was 6.49% ± 0.01, and at 25°C it was 7.61% ± 0.06, both for samples coated with the chitosan-gelatin-based edible coating containing orange peel extract. This reduction in weight loss for treated fruits, as compared to the control, is likely due to the coatings acting as semi-permeable barriers against oxygen, carbon dioxide, moisture, and solute transfer, which in turn reduces respiration, water loss, and oxidation reaction rates [40]. Numerous studies support the findings of this study, demonstrating that edible coatings can reduce weight loss in treated fruits by acting as a barrier against water loss, slowing synthesis, and controlling enzymatic activity, which helps in prolonging the storage life of fruits and vegetables [41, 42, 43]. Accordingly, the results indicate that the chitosan-gelatin coating containing orange peel extract effectively limits water transfer by sealing surface pores on Kabkab dates, thereby reducing the percentage of weight loss.

Table 2: Effect of coating, temperature and storage time on the weight loss of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	**G-E5**	0^{d}	$2.34 \pm 0.03^{cB**}$	4.93 ± 0.07^{bB}	7.11 ± 0.09^{aB}
	G-E10	0^{d}	2.23 ± 0.03^{cC}	4.80 ± 0.05^{bC}	7.02 ± 0.05^{aB}
	CH-E5	0^{d}	2.04 ± 0.04^{cD}	4.31 ± 0.04^{bD}	6.80 ± 0.04^{aC}
	CH-E10	0^{d}	1.97 ± 0.07^{cD}	4.22 ± 0.05^{bDE}	6.88 ± 0.07^{aC}
	G-CH-E5	0^{d}	1.78 ± 0.03^{cE}	4.16 ± 0.04^{bE}	6.49 ± 0.02^{aD}
	G-CH-E10	0^{d}	1.70 ± 0.03^{cE}	4.02 ± 0.06^{bF}	6.52 ± 0.1^{aD}
	C	0^{d}	5.56 ± 0.07^{cA}	7.64 ± 0.13^{bA}	9.12 ± 0.12^{aA}
25	**G-E5**	0^{d}	$4.42 \pm 0.05^{cB**}$	6.81 ± 0.04^{bB}	8.01 ± 0.13^{aBC}
	G-E10	0^{d}	4.40 ± 0.04^{cB}	6.87 ± 0.04^{bB}	8.17 ± 0.06^{aB}
	CH-E5	0^{d}	4.23 ± 0.03^{cC}	6.52 ± 0.12^{bCD}	7.79 ± 0.03^{aDE}
	CH-E10	0^{d}	4.15 ± 0.08^{cC}	6.60 ± 0.17^{bC}	7.91 ± 0.08^{aCD}

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G-CH-E5	0^{d}	4.11 ±0.05^{cC}	6.46 ±0.06^{bCD}	7.72 ±0.12^{aDE}
G-CH-E10	0^{d}	3.92 ±0.05^{cD}	6.37 ±0.06^{bD}	7.61 ±0.11^{aE}
C	0^{d}	6.39 ±0.11^{cA}	9.43 ±0.06^{bA}	11.39 ±0.16^{aA}

*Data are reported as (mean ± standard deviation) in three replicates.
**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract .

pH and Titratable Acidity

Tables 3 and 4 present the changes in pH and titratable acidity over a 90-day period, showing the effects of coatings at 4°C and 25°C. Titratable acidity in stored Kabkab dates exhibited a decreasing trend, while pH showed an increasing trend over time in both the control and treated samples. The smallest pH variation in dates stored at 4°C and 25°C was observed on day one, with initial values ranging between 5.96 and 6.00. On day 90, the lowest pH values were found in dates treated with the chitosan-gelatin coating containing orange peel extract, with pH values of 6.47 ± 0.03 at 4°C and 6.30 ± 0.02 at 25°C. The data indicate that pH values tend to decrease as storage temperature increases, suggesting that time, temperature, and coating type all influence pH changes. In terms of titratable acidity, the lowest acidity at 4°C on day 90 was observed in the control sample, with an acidity of 0.163 ± 0.11, whereas the highest acidity was found in dates coated with the chitosan-gelatin and orange peel extract composite, showing a value of 0.283 ± 0.005 on day 30. The type of edible coating significantly affected acidity changes on days 30, 60, and 90. No significant differences were observed among coated samples containing orange peel extract ($p < 0.05$), though there was a statistically significant difference between these samples and the control ($p < 0.05$). Over time, acidity in the coated dates generally increased at both storage temperatures. This study found that chitosan-gelatin composite coatings with orange peel extract helped stabilize acidity levels in dates. Both coatings with orange peel extract minimized acidity changes more effectively compared to other treatments. The results suggest that these edible coatings have the potential to reduce post-harvest losses in

Kabkab dates by slowing down respiration and decreasing the reliance on organic acids stored in vacuoles as respiratory substrates, thereby delaying the ripening and maturation processes [44].

Table 3: Effect of coating, temperature and storage time on the pH of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	**G-E5**	5.98 ±0.02^{dA**}	6.17 ±0.02^{cB}	6.38 ±0.03^{bB}	6.58 ±0.02^{aB}
	G-E10	5.96 ±0.001^{dA}	6.17 ±0.005^{cB}	6.37 ±0.04^{bB}	6.58 ±0.02^{aB}
	CH-E5	5.98 ±0.02^{dA}	6.13 ±0.01^{cC}	6.35 ±0.04^{bB}	6.53 ±0.03^{aBC}
	CH-E10	5.98 ±0.02^{dA}	6.14 ±0.01^{cC}	6.37 ±0.05^{bB}	6.52 ±0.02^{aCD}
	G-CH-E5	5.97 ±0.03^{dA}	6.10 ±0.01^{cD}	6.39 ±0.01^{bB}	6.53 ±0.04^{aBC}
	G-CH-E10	5.99 ±0.01^{dA}	6.10 ±0.01^{dD}	6.35 ±0.02^{bB}	6.47 ±0.03^{aD}
	C	5.97 ±0.01^{dA}	6.27 ±0.25^{cA}	6.64 ±0.04^{bA}	6.86 ±0.027^{aA}
25	**G-E5**	5.99 ±0.02 cA**	6.08 ±0.02^{cB}	6.20 ±0.06^{bB}	6.43 ±0.05^{aB}

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G-E10	5.97 ±0.005 dA	6.06 ±0.025 cB	6.21 ±0.01 bB	6.43 ±0.03 aB
CH-E5	5.97 ±0.03 dA	6.07 ±0.02 cB	6.19 ±0.02 bB	6.35 ±0.03 aC
CH-E10	6.00 ±0.01 dA	6.07 ±0.005 cB	6.17 ±0.02 bB	6.33 ±0.028 aC
G-CH-E5	5.98 ±0.011 dA	6.06 ±0.011 cB	6.16 ±0.005 bB	6.30 ±0.02 aC
G-CH-E10	5.98 ±0.02 dA	6.05 ±0.025 cB	6.16 ±0.005 bB	6.32 ±0.025 aC
C	5.97 ±0.017 dA	6.19 ±0.02 cA	6.35 ±0.06 bA	6.62 ±0.04 aA

*Data are reported as (mean ± standard deviation) in three replicates.
**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract.

Table 4: effect of coating, temperature and storage time on the acidity of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	**G-E5**	0.276 ±0.005aA**	0.276 ±0.005aA	0.243 ±0.011bA	0.216 ±0.025bA
	G-E10	0.286 ±0.015aA	0.266 ±0.02aA	0.256 ±0.011aA	0.203 ±0.015bA
	CH-E5	0.286 ±0.011aA	0.276 ±0.005aA	0.256 ±0.01bA	0.20 ±0.01cA
	CH-E10	0.28 ±0.01aA	0.263 ±0.011aA	0.24 ±0.01bA	0.203 ±0.011cA
	G-CH-E5	0.296 ±0.005aA	0.27 ±0.01bA	0.25 ±0.01cA	0.216 ±0.005dA
	G-CH-E10	0.293 ±0.011aA	0.283 ±0.005aA	0.26 ±0.011bA	0.22 ±0.01cA
	C	0.293 ±0.011aA	0.236 ±0.005bB	0.206 ±0.015cB	0.163 ±0.011dB
25	**G-E5**	0.30 ±0.01aA**	0.286 ±0.015abA	0.256 ±0.005bA	0.196 ±0.011cA
	G-E10	0.293 ±0.011aA	0.276 ±0.015aA	0.256 ±0.005bA	0.196 ±0.005cA
	CH-E5	0.286 ±0.005aA	0.273 ±0.005abA	0.26 ±0.02bA	0.203 ±0.011cA
	CH-E10	0.296 ±0.005aA	0.28 ±0.01bA	0.26 ±0.01cA	0.196 ±0.005dA
	G-CH-E5	0.28 ±0.01aA	0.28 ±0.01aA	0.263 ±0.011aA	0.203 ±0.011bA
	G-CH-E10	0.29 ±0.017aA	0.29 ±0.017aA	0.263 ±0.005bA	0.203 ±0.011cA
	C	0.29 ±0.02aA	0.266 ±0.005abA	0.243 ±0.01bB	0.166 ±0.005cB

*Data are reported as (mean ± standard deviation) in three replicates.
**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract.

Changes in Total Soluble Solids (TSS)

Total Soluble Solids (TSS) are an important factor for consumer acceptance of fruits and vegetables. As storage duration increases, the TSS of fruits typically rises, which is attributed to the hydrolysis of complex polysaccharides into simpler sugars and the conversion of pectin and fruit juice concentration [45]. In the present study, the trend of increasing TSS in stored Kabkab dates at 4°C and 25°C over a 90-day period was evaluated (Table 5). The smallest increase in TSS in the Kabkab dates stored at 4°C (72.23 ± 0.05 °Brix) and at 25°C (70.26 ± 0.07 °Brix) was recorded on day 90. TSS increased more rapidly in the control samples compared to the treated dates during the 90-day storage period. The highest increase in TSS was observed in the control Kabkab dates (81.06 ± 0.09 °Brix) at 25°C on day 90. Furthermore, the TSS levels changed more slowly in the chitosan-gelatin coating that included orange peel extract when the effects of the other edible coating types were compared. The findings showed that the control dates had a greater rise in TSS than the coated samples, which might be because to mass transfer and oxidation processes in the fruit [46]. The amount of sugar in fruits affects the amount of soluble solids. As a result, natural enzymes in agricultural goods and microbial growth that may break down substances like starch, cellulose, and pectin can raise the TSS content of fruits by increasing the solubility and breaking down high-molecular-weight components [47, 48]. Reduced metabolic synthesis, water loss, hydrolytic enzyme activity, and the slower conversion of sugars into carbon dioxide and water during storage are probably the causes of the coated Kabkab dates' slower rise in TSS. This is made possible by the coating's protective layer, which also stops microorganisms from growing on the dates' surface. TSS levels are decreased as a result of the decreased conversion of additional carbs into sugars brought on by the slower metabolic activity and respiration rate [49]. These results are consistent with earlier research on various types of dates [40]. Storage period had a substantial impact on TSS levels in a study using seven date types covered with pectin-methylcellulose edible coatings including olive oil. After three months of room temperature storage, TSS rose before progressively falling. These outcomes align with the current study's and previous research's findings, which indicate that acid metabolism leads in the conversion of acid to sugar, which lowers overall acidity and raises TSS during storage [50]. Water loss from the fruit or the conversion of some insoluble substances into soluble ones (such as protopectin to pectin) might potentially be the cause of this rise [40]. Because the coating prevents carbon dioxide and oxygen from entering and leaving the cells, it lowers transpiration and slows the conversion of polysaccharides into soluble solids, which explains the slower increase in TSS seen in coated Kabkab dates. The coated fruits' TSS levels decrease as a result [51].

Table 5: Effect of coating, temperature and storage time on the soluble solids of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	**G-E5**	66.42 ±0.026 ^{dA**}	69.04 ±0.06 ^{cB}	70.04 ±0.06 ^{bB}	72.05 ±0.07 ^{aB}
	G-E10	66.40 ±0.037 ^{dA}	69.04 ±0.08 ^{cB}	70.06 ±0.06 ^{bB}	72.1 ±0.03 ^{aB}
	CH-E5	66.45 ±0.005 ^{dA}	68.50 ±0.08 ^{cC}	69.76 ±0.16 ^{bC}	70.95 ±0.07 ^{aC}
	CH-E10	66.46 ±0.005 ^{dA}	68.52 ±0.09 ^{cC}	69.74 ±0.09 ^{bC}	70.92 ±0.06 ^{aC}
	G-CH-E5	66.42 ±0.04 ^{dA}	67.8 ±0.14 ^{cD}	68.24 ±0.05 ^{bD}	70.30 ±0.01 ^{aD}
	G-CH-E10	66.43 ±0.04 ^{dA}	67.93 ±0.1 ^{cD}	68.22 ±0.07 ^{bD}	70.26 ±0.07 ^{aD}
	C	66.42 ±0.03 ^{dA}	71.24 ±0.11 ^{cA}	73.76 ±0.075 ^{bA}	77.04 ±0.1 ^{aA}
25	**G-E5**	66.45 ±0.011 ^{dA*}	71.62 ±0.05 ^{cB}	72.33 ±0.06 ^{bB}	73.45 ±0.07 ^{aB}
	G-E10	66.42 ±0.04 ^{dA}	71.71 ±0.06 ^{cB}	72.26 ±0.07 ^{bB}	73.48 ±0.03 ^{aB}
	CH-E5	66.45 ±0.015 ^{dA}	70.23 ±0.04 ^{cC}	70.97 ±0.07 ^{bC}	72.98 ±0.04 ^{aC}

CH-E10	66.45 ±0.00 dA	70.20 ±0.05 cC	70.99 ±0.05 bC	73.01 ±0.04 aC
G-CH-E5	66.43 ±0.043 dA	68.28 ±0.07 cD	70.43 ±0.06 bD	72.24 ±0.07 aD
G-CH-E10	66.44 ±0.036 dA	68.26 ±0.06 cD	70.46 ±0.02 bD	72.23 ±0.05 aD
C	66.43 ±0.047 dA	75.34 ±0.07 cA	77.65 ±0.06 bA	81.06 ±0.09 aA

*Data are reported as (mean ± standard deviation) in three replicates.

**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract.

Moisture Content

The moisture content of dried and semi-dried dates is an important quality parameter, particularly after harvest and for marketing purposes. Edible coatings can act as a physical barrier to moisture loss [51, 52], thereby delaying dehydration and shrinkage of fruits[53]. In the current study, among the coating formulations, the chitosan and chitosan-gelatin coating containing orange peel extract were the most effective treatments in controlling moisture loss after harvest in Kabkab dates (Table 6). Furthermore, the moisture content of the Kabkab dates decreased as the storage time increased. On day 1, the moisture content ranged between 24.48% and 24.52% at both 4°C and 25°C, and by day 90 of storage, this range decreased to 7.80%–14.22% at 4°C and 6.88%–13.88% at 25°C. The lowest moisture content on day 90 was observed in the control samples, with 7.85 ± 0.45% at 4°C and 6.63 ± 0.31% at 25°C. The effect of the chitosan and chitosan-gelatin coating containing orange peel extract showed significant influence in reducing moisture loss during storage. A similar study demonstrated that the moisture content of Bahri dates, both control and coated with an alginate-based edible coating, decreased during a 45-day storage period. However, the non-coated Bahri dates showed a more gradual reduction in moisture content compared to those coated with different edible coatings [54]. In another study investigating the effect of pectin-based edible coatings on various date varieties, the lowest moisture content was found in dates treated with the pectin-based coating. The study also indicated that the moisture content of dates depends on the variety and growing conditions and that edible coatings can act as a physical barrier against moisture loss [55]. Moisture loss and gas exchange in fruits are typically controlled by epidermal layers equipped with protective cells and stomata. The use of edible coatings minimizes the vapor pressure difference between the fruit and the surrounding air, which is typically controlled by the cuticle and epidermal cellular layers [56]. Thus, edible coatings provide an additional layer, sealing the stomata and reducing transpiration, which ultimately leads to moisture retention. Other studies' findings support the current study's, demonstrating that edible coatings' ability to act as a semi-permeable barrier can postpone moisture loss and lower respiration rate because polysaccharides are hygroscopic, making them more effective gas barriers [49,57]. Thus, in comparison to other treatments, Kabkab dates coated with chitosan and chitosan-gelatin with 5 and 10 mg/ml of orange peel extract had the maximum moistness retention. This resulted from the dates developing a surface layer that inhibits moisture loss, lowers respiration rate, and regulates gas exchange. However, in the present investigation, there was a greater loss of moisture in the dates covered with gelatin that included orange peel extract. The dates developed a surface layer that inhibits moisture loss, lowers respiration rate, and regulates gas exchange, which is the cause of this. However, in the present investigation, the dates coated with orange peel extract-containing gelatin had a greater loss of moisture than the other treatments. In low to moderate relative humidity, this implies that gelatin-based coatings have high barrier qualities against the transfer of odors and oxygen. But since they are hygroscopic, they are not very effective at stopping the transmission of water vapor [58]. Gelatin coatings should thus be combined with additional materials to strengthen the protein-

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based films' poor water vapor barrier qualities [48].

Table 6: Effect of coating, temperature and storage time on the moisture content of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	G-E5	24.52 ±0.05aA**	18.71 ±0.17bB	15.88 ±0.63cB	12.98 ±0.78dB
	G-E10	24.51 ±0.07aA	18.79 ±0.08bAB	15.96 ±0.94cB	12.85 ±0.95dB
	CH-E5	24.51 ±0.05aA	19.02 ±0.37bAB	17.05 ±0.38cAB	13.67 ±0.16dAB
	CH-E10	24.52 ±0.06aA	18.89 ±0.33bAB	17.09 ±0.35cAB	13.76 ±0.35dAB
	G-CH-E5	24.51 ±0.03aA	19.48 ±0.79bA	17.77 ±0.4cA	14.22 ±0.33dA
	G-CH-E10	24.5 ±0.02aA	19.50 ±0.36bA	17.72 ±1.41cA	14.14 ±0.57dA
	C	24.5 ±0.02aA	14.59 ±0.16bC	10.74 ±0.63cC	7.8 ±0.35dC
25	G-E5	24.52 ±0.05aA**	14.20 ±0.64bB	13.768 ±0.313bB	11.42 ±0.3cA
	G-E10	24.49 ±0.06aA	14.29 ±0.19bB	13.85 ±0.19bB	11.4 ±1.14cA
	CH-E5	24.52 ±0.06aA	15.55 ±0.16bA	14.89 ±0.16cAB	13.11 ±0.31dA
	CH-E10	24.50 ±0.02aA	15.75 ±0.57bA	14.75 ±0.94bAB	13.08 ±0.28cA
	G-CH-E5	24.48 ±0.01aA	16.11 ±1.48bA	15.88 ±0.77bA	13.88 ±0.52cA
	G-CH-E10	24.51 ±0.03aA	16.27 ±0.17bA	15.71 ±1.64bA	13.82 ±3.18bA
	C	24.51 ±0.05aA	12.8 ±0.65bC	8.80 ±0.31cC	6.8 ±0.31dB

*Data are reported as (mean ± standard deviation) in three replicates.

**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract.

Changes in Reducing Sugar Content

Table 7 shows how the sugar content of Kabkab dates coated with chitosan-gelatin containing orange peel extract changed while they were stored at 4°C and 25°C. After being consumed, the sugars in dates are swiftly transported to the bloodstream, where they may be quickly digested to produce energy for a variety of cellular functions. The date's texture is directly linked to its reducing and non-reducing sugar content, which varies according on the variety. Soft dates with a greater moisture content, for example, often contain very little sugar [59]. Increases in reducing sugars are linked to ripening, while decreases in non-reducing sugars are linked to invertase activity [60].

The results of this study showed that edible coatings based on chitosan and chitosan-gelatin containing 5 and 10 mg/ml of orange peel extract had a significant effect ($p<0.05$) on the reducing sugar content of the Kabkab dates treated at days 30, 60, and 90 of storage. These coatings resulted in lower changes in reducing sugar content compared to the control. The high reducing sugar content in the control samples indicates the prominent and dominant activity of invertase, which significantly reduced the sucrose content in the control samples over the 90-day storage period [61, 62]. According to research on Barhi dates coated with various edible coatings (chitosan, gelatin, and guar gum), the amount of reducing and total sugars

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rose with time for each treatment, but at varying speeds. The control samples showed the largest rise, with total and reducing sugars rising from 31% and 28.2% (at time zero) to 32.2% and 30.8% following five weeks of cold storage [40]. The total and reducing sugars in dates kept at 0°C rose with time, according to another research, which is in line with our results [63]. The slow ripening of the dates, which accompanied the increasing activity of the invertase enzyme, might be the cause of this rise in sugars [40]. In summary, the edible coatings used in this study helped reduce the rate of increase in reducing sugars, likely due to the slower metabolic processes and enzyme activities in coated dates compared to the uncoated control.

Table 7: Effect of coating, temperature and storage time on the reducing sugar (%) of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	**G-E5**	42.22 ±0.03 dA**	43.14 ±0.05 cB	43.95 ±0.06 bB	44.98 ±0.06 aB
	G-E10	42.23 ±0.07 dA	43.16 ±0.08 cB	43.99 ±0.08 bB	44.99 ±0.11 aB
	CH-E5	42.21 ±0.06 dA	42.77 ±0.08 cC	43.15 ±0.06 bC	43.98 ±0.08 aC
	CH-E10	42.26 ±0.06 dA	42.73 ±0.09 cC	43.12 ±0.04 bC	43.87 ±0.13 aCD
	G-CH-E5	42.20 ±0.04 dA	42.84 ±0.06 cC	43.26 ±0.05 bC	43.72 ±0.06 aD
	G-CH-E10	42.21 ±0.04 dA	42.86 ±0.1 cC	43.19 ±0.11 bC	43.84 ±0.12 aCD
	C	42.23 ±0.06 dA	43.67 ±0.11 cA	45.44 ±0.09 bA	47.23 ±0.06 aA
25	**G-E5**	42.20 ±0.04 dA**	43.80 ±0.04 cB	44.27 ±0.08 bB	45.76 ±0.1 aB
	G-E10	42.26 ±0.06 dA	43.84 ±0.04 cB	44.28 ±0.14 bB	45.80 ±0.11 aB
	CH-E5	42.22 ±0.03 dA	43.04 ±0.07 cC	43.63 ±0.15 bC	44.19 ±0.08 aC
	CH-E10	42.19 ±0.05 dA	43.06 ±0.1 cC	43.56 ±0.24 bC	44.24 ±0.1 aC
	G-CH-E5	42.26 ±0.04 dA	42.95 ±0.06 cC	43.52 ±0.21 bC	44.26 ±0.13 aC
	G-CH-E10	42.21 ±0.04 dA	42.94 ±0.06 cC	43.51 ±0.21 bC	44.26 ±0.09 aC
	C	42.23 ±0.07 dA	44.51 ±0.09 cA	46.84 ±0.09 bA	47.77 ±0.13 aA

*Data are reported as (mean ± standard deviation) in three replicates.
**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract.

Changes in Firmness

In this work, two distinct storage temperatures (4°C and 25°C) were used to assess the the firmness variations of Kabkab dates treated with different edible coatings based on chitosan and gelatin containing orange peel extract (Table 8). The dates' hardness rose considerably with time (p<0.05), as was seen. Additionally, the hardness of all date samples increased higher during the storage time when the temperature was raised to 25°C. The chitosan-gelatin coating with orange peel extract was shown to be more successful than other treatments in minimizing changes in the hardness of Kabkab dates when the influence of the kind of edible coating was examined. Depending on the type and ripening stage, several research have produced varying findings about the texture hardness of dates throughout storage. In one study, the hardness of Mazzati dates coated with two different lipid-based edible coatings (glycerol mono-stearate and carnauba wax) was significantly impacted by the temperature and storage duration. The hardness of the dates increased as the temperature and time were raised from 4°C to 25°C; nevertheless, the firmness was lower at 4°C than at 25°C. Additionally, dates with edible coatings were less solid than the control samples. These results are consistent with the current study's findings [36]. The researchers in that study attributed the lower firmness of coated dates to reduced moisture loss during storage, highlighting the role of edible coatings in moisture preservation. According to a similar study on the impact of temperature and storage time on Kabkab dates, stiffness increased as temperature and storage time increased. Over the course of a six-month storage period, the hardness of dates treated with 3% and 5% methylcellulose coatings rose; however, the rise in firmness was less pronounced in the coated samples than in the control. The strengthening of cell walls and the ensuing hardness of cell wall connections were credited with this increase in stiffness during storage [64, 65]. It should be noted that factors such as lipid oxidation, water loss, and pectin hydrolysis are major contributors to the reduction of firmness in fruits and vegetables during storage[41]. In a study on Zaghloul dates treated with edible coatings containing 4% jojoba oil, 10% gum arabic, and 7.5% paraffin oil, it was found that all the coatings affected the firmness of the dates, with the lowest firmness observed in the untreated (control) dates. Additionally, cold storage influenced the firmness, with an overall decrease in firmness over time. However, jojoba oil at 5% and gum arabic at 10% were found to maintain the highest firmness in the dates[66]. Many studies have reported that chitosan-based edible coatings are effective in preserving the firmness of fruits and vegetables[67][68][38][43]. These studies confirm the impact of chitosan and chitosan-gelatin composite coatings on maintaining the texture firmness during storage. In this study, Kabkab dates treated with chitosan-gelatin containing orange peel extract showed higher firmness than untreated dates, which could be due to the dense coating layer that creates a suitable microenvironment around the surface of the dates, thereby reducing changes in pectin and enzymatic degradation of the cell wall.

Table 8: Effect of coating, temperature and storage time on the Hardness of Kabkab dates

Storage Temperature	Edible Coating	Day 1	Day 30	Day 60	Day 90
4	**G-E5**	26.61 ±0.14 cA**	26.87 ±0.17 cB	27.56 ±0.39 bB	28.44 ±0.37 aB
	G-E10	26.6 ±0.37 cA	27.16 ±0.26 bcAB	27.5 ±0.35 bB	28.54 ±0.34 aB
	CH-E5	26.57 ±0.21 cA	26.54 ±0.35 cB	27.6 ±0.32 bB	28.37 ±0.31 aB
	CH-E10	26.41 ±0.2 cA	26.49 ±0.42 cB	27.60 ±0.43 bB	28.7 ±0.27 aB
	G-CH-E5	26.66 ±0.2 cA	26.6 ±0.34 cB	27.47 ±0.25 bB	28.46 ±0.46 aB
	G-CH-E10	26.66 ±0.12 cA	26.58 ±0.32 cB	27.4 ±0.25 bB	28.32 ±0.21 aB
	C	26.58 ±0.27 cA	27.6 ±0.48 bA	28.81 ±0.52 aA	29.57 ±0.42 aA
25	**G-E5**	26.45 ±0.18 dA**	27.16 ±0.21 cB	27.76 ±0.39 bB	28.36 ±0.33 aB
	G-E10	26.45 ±0.18 cA	27.23 ±0.22 bB	27.7 ±0.32 bB	28.41 ±0.324 aB
	CH-E5	26.62 ±0.28 cA	27.06 ±0.065 cB	27.75 ±0.3 bB	28.49 ±0.36 aB
	CH-E10	26.74 ±0.11 cA	27.27 ±0.28 bcB	27.64 ±0.45 bB	28.31 ±0.36 aB
	G-CH-E5	26.49 ±0.13 cA	27.24 ±0.3 bB	27.69 ±0.35 bB	28.39 ±0.4 aB
	G-CH-E10	26.41 ±0.2 cA	27.12 ±0.25 bB	27.81 ±0.31 aB	28.29 ±0.27 aB

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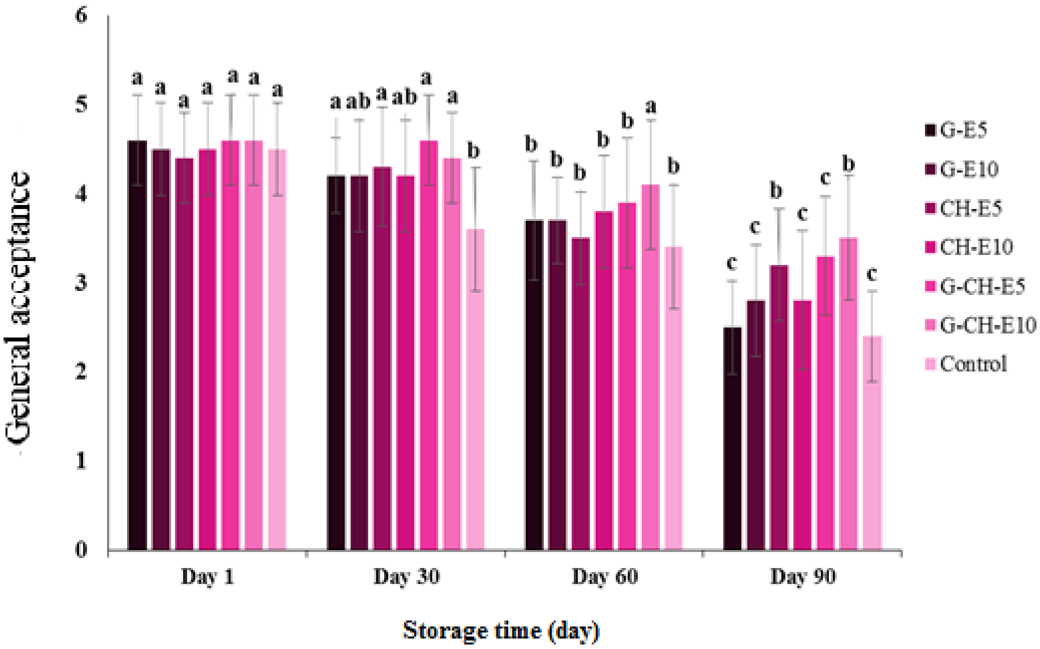
C	26.68 ±0.21 dA	28.41 ±0.38 cA	29.15 ±0.25 bA	29.85 ±0.29 aA

*Data are reported as (mean ± standard deviation) in three replicates.

**The same lowercase letters (a-d) in each row and the same uppercase letters (A-F) in each column indicate no significant difference (P>05.0) between the data based on Duncan's test. (G-E5): gelatin + 5 mg/ml orange peel extract; (10G-E): gelatin + 10 mg/ml orange peel extract; (CH-E5): chitosan + 5 mg/ml orange peel extract; (10CH-E): chitosan+mg/ml 10 orange peel extract; (G-CH-E5): gelatin + chitosan + 5 mg/ml orange peel extract; (10G-CH-E): gelatin + chitosan + 10 mg/ml orange peel extract.

Sensory Evaluation

When compared to untreated (control) dates that were kept at room temperature and in a cold environment, the composite chitosan-gelatin edible covering with orange peel extract successfully maintained higher sensory ratings for overall acceptability and associated sensory metrics in treated Kabkab dates. Regardless of coating type, Kabkab dates stored at 4°C scored higher on sensory evaluations than those stored at 25°C. Figure 1 shows the overall acceptance scores of the dates treated with different edible coatings containing orange peel extract at two different storage temperatures (4°C and 25°C). Based on these results, the evaluators concluded that the dates' overall acceptance declined over time. The decline in overall acceptability was more noticeable in all date samples during the storage duration (p<0.05) as the storage temperature rose to 25°C. These findings are in accordance with the beneficial impact of chitosan on maintaining the quality of Kabkab dates in the current study, which is also in line with research on mangos [69]. In general, the sensory evaluation indicated that the sensory properties of the Kabkab dates were better preserved with edible coatings, and the formation of crystallized sugar and cloudiness in the dates was prevented[69]. Ultimately, based on the overall sensory evaluation results, the chitosan-gelatin coating containing 5 mg/ml and 10 mg/ml of orange peel extract was identified as the best treatment for enhancing the shelf life of Kabkab dates.



a

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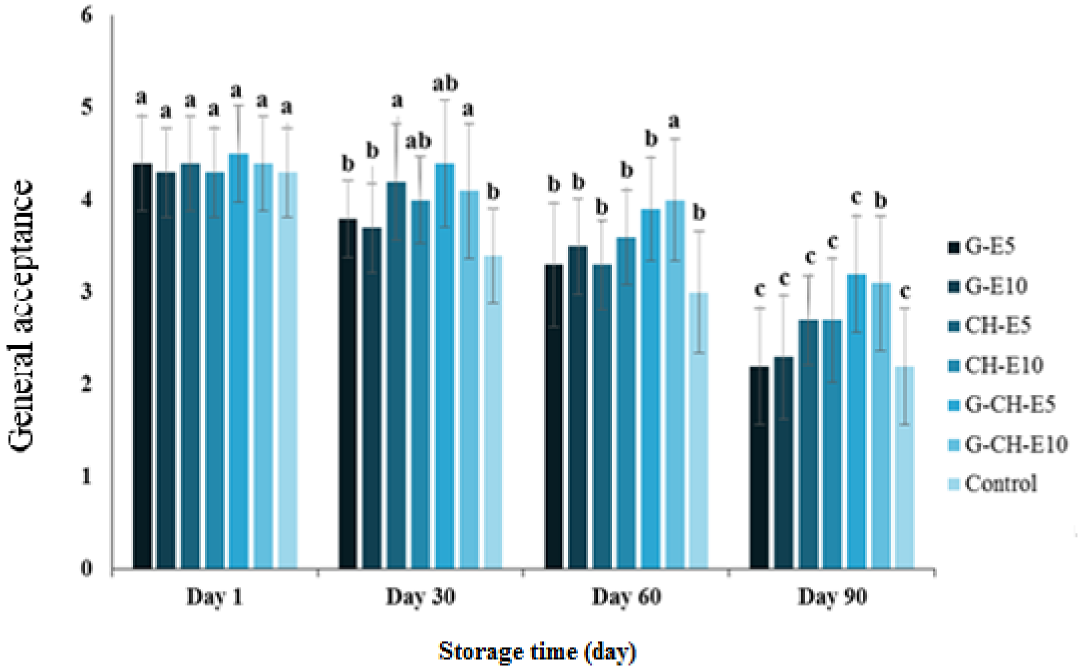

b

Figure 1: Effect of coating, temperature and storage time on the general acceptance of Kabkab dates 4°C (a) and 25°C (b)

4-Conclusion

One of the most extensively grown agricultural products in Iran, especially in the southern Bushehr area, are kabkab dates, which are abundant in minerals and other nutrients. Maintaining the product's quality is crucial because of its strategic value in terms of food, industrial uses, and the agricultural economics of date-growing countries. Thus, the impact of edible coatings made of gelatin, chitosan, and chitosan-gelatin mixed with orange peel extract on the dates' physicochemical and sensory characteristics under various storage settings was assessed in this workGiven the beneficial effects of the orange peel extract-containing chitosan-gelatin coating on the physicochemical and sensory properties of Kabkab dates, this combination may be suggested as an appropriate way to enhance the product's quality and shelf life for a period of three months.

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مقاله علمی_پژوهشی

بررسی تأثیر پوشش خوراکی کیتوزان-ژلاتین حاوی عصاره پوست پرتقال بر خواص کیفی و ماندگاری خرمای کبکاب

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چکیده

خرما از نظر تغذیه‌ای بسیار غنی بوده و از لحاظ تجاری و صادرات نیز از اهمیت بالایی برخوردار است. لذا راهکارهای مختلف در جهت افزایش ماندگاری این محصول اتخاذ شده که می‌تواند آن را در گستره زمانی وسیع‌تر در اختیار مصرف‌کننده‌ها قرار دهد. از این‌رو هدف مطالعه حاضر استفاده از پوشش خوراکی مبتنی بر کیتوزان-ژلاتین حاوی عصاره طبیعی پوست پرتقال بر روی خرما کبکاب ذخیره شده در دو دمای ٤ و ۲۵ درجه سانتی‌گراد به مدت ۹۰ روز بود. در همین راستا با آزمون‌های فیزیکوشیمیایی (افت وزن، pH، اسیدیته، رطوبت، قند احیاء، مواد جامد محلول و سفتی بافت) و حسی (پذیرش کلی)، وضعیت تیمارها طی مدت نگهداری بررسی گردید. بر اساس بررسی‌های صورت گرفته کمترین تغییرات افت وزن در هر دو دمای مورد بررسی (٤ و ۲۵ درجه‌سانتی‌گراد) در نمونه تیمار شده با پوشش خوراکی کیتوزان-ژلاتین حاوی عصاره پوست پرتقال در روز ۹۰ نگهداری بود. نتایج نشان داد که با افزایش زمان و دمای نگهداری، میزان pH و رطوبت کاهش و میزان اسیدیته، مواد جامد محلول، قند احیاء و سفتی بافت افزایش معنی‌داری داشتند (p<۰/۰۵). همچنین با افزایش زمان و دمای نگهداری روند کاهشی در ویژگی‌های حسی وجود داشت و نمونه‌های تیمار شده با پوشش خوراکی بر پایه کیتوزان-ژلاتین حاوی ٤ mg/ml و ۱۰ عصاره پوست پرتقال دارای بالاترین مطلوبیت در ویژگی‌های حسی خرما کبکاب بودند. بر اساس نتایج بررسی‌ها می‌توان پوشش خوراکی کیتوزان-ژلاتین حاوی عصاره پوست پرتقال را به عنوان بهترین فرمولاسیون در جهت افزایش ماندگاری خرما کبکاب تا ۹۰ روز معرفی نمود.