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EDIBLE COATING OF SOY PROTEIN OR GELATIN AS A CARRIER OF THYME OIL FOR MAINTAINING QUALITY OF 'BARHEE' DATES FRUITS DURING COLD STORAGE

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Abstract

A critical challenge is the preservation of the high quality of Barhi dates for the longest possible period after harvesting and during the marketing process. This study aimed to evaluate the effectiveness of edible coating with soy protein or gelatin at 6, 9 and 12% as a carrier of thyme oil to maintaining fruits quality and extending storage period of Barhi dates during cold storage at 5^0C with 85-90% relative humidity for 4 weeks compared with control fruit (water only) during two successive seasons 2018 and 2019. Fruit quality attributes were studied such as weight loss (%), rutab percentage (%), firmness (Ib/inch^2), total soluble solids (TSS %), total acidity (TA %), ascorbic acid content (vitamin C, mg\100g F.W.), total carotenoids content (TCC,mg\g F.W.), total flavonoid content (TFC, mg\g F.W.) and pectinase enzyme activity (PE,u/gF.W.) during the two seasons under study. Treated fruits with soy protein (6%) resulted the least fruit weight loss and highest fruit volume, length, diameter and ascorbic acid content. Soy protein at 9% as a Carrier of thyme oil treatment gave the lowest level of pectinase enzyme activity and the highest fruit firmness after 28 days of cold storage at 5^0C. Meanwhile, the highest TSS% values were noticed by soy protein at 9% or gelatin at 12% treatments. Coated fruits by gelatin at 6% as a carrier of thyme oil showed the minimum total acidity after 28 days of cold storage. likewise, gelatinat 9% treatment obtained the lowest fruit rutab percentages. Finally, soy protein treatment showed a remarkable superiority in preserving the fruit quality of Barhi dates during cold storage in comparing with gelatin treatment.

Key words: Edible Coating, Soy Protein, Gelatin, Thyme Oil, Date palm, Fruits and cold storage.

Introduction

Date palm (*Phoenix dactylifera* L.) is the most successful and an extremely important subsistence crop in most of the arid hot regions (Awad, 2007). Dates may be considered as an almost ideal food, providing a wide range of essential nutrients and potential health benefits, it's a good source of fiber, carbohydrates, minerals and vitamins (Atia *et al*., 2018) and rich in antioxidant (Vayalil, 2002). The antioxidant properties of date fruits vary depending on the amount of phenolics, vitamins C and E, carotenoids and flavonoids present (Mansouri *et al*., 2005). The total phenolics in fresh and dried dates were 193.7 and 239.5 mg/100 g, respectively (Al-Farsi *et al*., 2005).

All edible cultivars of date pass through five distinct stages of development and ripening. These stages are designated by Arabic terms and used universally: Hababouk, Kimri, Bisir or Khalal, Rutab and Tamer, whole dates are harvested and marketed at three stages of their development; mainly bisir or khalal, rutab and tamer, depending on cultivar characteristics, especially soluble tannin level, climatological conditions and market demand (Awad, 2007). There is a growing demand in the international market for excellent-quality dates of cultivars such as 'Barhee', 'Medjool', 'Deglet Nour', 'Hayany' and 'Zaghloul' (Botes and Zaid, 1999; AL-Qurashi and Awad, 2007).

Barhi is the most popular cultivar worldwide, marketed and consumed fresh at the mature full yellow (Bisir) stage as a crispy apple-like fruit due to low contents of soluble tannins. At the Rutab stage (ripening), fruit become softer and sweeter but their market value decreases sharply as surplus production has to be sold at lower prices. A strategy for producers could be to export dates to foreign markets, but requires application of modern technology to handle and store fruit at the full

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mature stage to delay fruit ripening (Al-Redhaiman, 2005). Few trials have been carried out to maintain Barhi fruit quality during storage of dates, including low temperature (Hegazy *et al*., 2003), coating with polypropylene films (Thompson and Abboodi, 2003), or using polyethylene bags (Attia *et al*., 1997). However, responses of fruit quality to these treatments have been limited.

Edible coatings or films are suitable for fresh and minimally processed fruits to improve appearance, delay ripening and color changes and functions as a carrier of antimicrobials and antibrowning agents, provide a barrier to moisture and oxygen and consequently reduce the oxidation reaction rates (Kester and Fennema, 1986), improve the quality and shelf life of foods (McHugh and Senesi, 2000). In recent years, edible films or coatings included soy protein, gelatin, casein, collagen, chitosan, whey protein and methyl cellulose-based films (Shon *et al*., 2010). On the other side, Al-Obeed (2010) found that cold storage delayed fruit ripening and extend the shelf life of Barhi dates compared with store at ambient condition.

Soy proteins have excellent nutritional and functional properties as well as the ability to form films or coatings (Were *et al*., 1999) and are widely used as low-cost protein additives in processed meats (Liu *et al*., 2000). Soy protein isolate (SPI) was recently found its efficacy as an edible coating to enhance shelf life of apple, potato, carrot (Zhang *et al*., 2005) and storability of strawberry fruits (Amal *et al*., 2010).

Gelatin is a functional biopolymer such as polysaccharides and proteins (Mariod and Adam, 2013), that have a good film forming ability (Gómez-Guillén *et al*., 2007), biodegradability (Jongjareonrak *et al*., 2006) and strong water vapor barrier properties (Artharn *et al*., 2009). Gelatin films have been used as ecofriendly edible packaging materials to preserve the shelf life of foods, especially those sensitive to the quality changes induced by moisture absorption (Alparslan *et al*., 2019). To improve the water vapor barrier properties of the edible films, hydrophobic substances such as fatty acids and essential oils have been added (Nilsuwan *et al*., 2016).

Essential oils have been largely used to preserve the quality of food due to their antimicrobial and antioxidant activities (Aitboulahsen *et al*., 2018). Several researches indicate that the essential oils of various herbal plants are one of the most promising natural compounds safer to develop antifungal and antimicrobial activity against a wide range of postharvest pathogens (Abd El-Moneim *et al*., 2015). Thyme oil is considered as one of the most effective essential oils against a large spectrum of microorganisms (Amal *et al*., 2010).

Therefore, the aim of this study is to evaluate the edible coating films of soy protein and gelatin with thyme oil as a carrier for improving 'Barhi' fruits quality attributes and storage period prolonging during cold storage at 5^0C.

Materials and Methods

Fruits

Date palm (*Phoenix dactylifera* L.) fruits cv. Barhi were harvested at the Khalal stage of maturity during 2018 and 2019 seasons (15 September). Fruits were selected based on their uniformity as possible in color and size and free of any noticeable pathological or mechanical injuries. Fruits were instantly packed and transported to the laboratory of ADS project, Faculty of Agriculture, Cairo University, all fruits washed by tap water and air dried. The initial quality measurements were determined.

Treatments

Dates fruits cv. Barhee were coated with different concentrations of soy protein and gelatin at 6, 9 and 12% with 0.1 % natural thyme oil as a carrier, which were prepared from the oil extraction unit of National Research Centre.

Soy Protein Coating Preparation:

Soy protein coating was prepared according to (Kim *et al*., 2002) by dissolving 6, 9, 12 g of soy protein with 5 g of glycerin in 100 ml distilled water. Solution pH was adjusted to pH 10 using sodium hydroxide (2N), then heated to 75°C for 15 min. Solution was filtrated through a cloth to remove foams and impurities dissolved, then was cooled to (30 - 40°C) and adding1 ml thyme essential oil and used in coating fruits.

Gelatin Coating Preparation

Gelatin coating was prepared according to (Alparslan *et al.,* 2019) by dissolving 6, 9, 12 g of gelatin powder in 100 ml distilled water (at room temperature) and the mixture was stirred until the gelatin completely dissolved and heating to 45 ºC for 15 min, then adding 5 g of glycerin and 1 ml thyme essential oil to the gelatin coating solution and used in coating fruits.

After postharvest coating treatments, fruits were air dried and packed in corrugated cardboard boxes and placed in a cold storage room at 5ºC and 85 - 90% RH for a total storage period of 28 days and compared with the untreated fruits (control). Three replicates for each treatment and sampling time (7 days) were used and each replicate consisted of 15 fruits. Fruit quality measurements were assessed after storage at 5ºC in each sampling date.

Fruit quality assessments

Fruit weight loss (%):Fruits were weighed at the beginning and after an interval of 7 days for a period of 28 days storage. The fruit weight loss percent was calculated by standard procedure as the following equation:

Fruit weight loss % =

$$\frac{wt.of\ 1st\ \text{int}\ erval - wt.of\ 2ed\ \text{int}\ erval}{wt.of\ 1st\ \text{int}\ ervaldx} \times 100$$

Fruit weight (gm.), fruit volume (cm^3), fruit length (cm) and fruit diameter (cm) of each replicate (15 fruits) were evaluated in each sampling date.

Rutab percentage (%): At the sampling of the storage period, the number of rutab fruit was recorded and expressed as a percentage. Fruit that showed softening more than 10% (visually estimated) of its total area was considered rutab/ripe.

Fruit firmness (Ib/inch^2): Fruit firmness was determined using Lefra Texture Analyser (Mod.TA1000). Firmness of 15 fruits from each replicate was measured and the results were calculated as Ib/inch^2 (AOAC., 1990).

Total soluble solids (TSS %): TSS content was estimated in fruit juice using digital hand refractometer (Model Palette, PR-32, Atago) and express in percentage.

Total acidity (TA %) and Ascorbic acid content (vitamin C): Total acidity (expressed as malic acid) was determined by titrating 5ml juice with 0.1N sodium hydroxide using phenolphthalein as an indicator. Ascorbic acid content (VC) was measured using 2, 6 dichlorophenol indophenols' method described by A.O.A.C. (2000).

Total carotenoids content (TCC, mg\gm F.W.): Carotenoids content was determined using one gram of flesh fruit with 10 ml methanol. Carotenoids measured calorimetrically at 470 nm. by spectrophoto meter Inst. (Model spectronic 20, Bausch and Lamb Co. USA). The amounts of carotenoids were calculated according to (Lichtenthaler and Wellburn, 1983).

Total flavonoid content (TFC): The TFC was measured by a colorimetric assay developed by (Zhishen *et al*., 1999). Absorbance of the mixture was determined at 510 nm versus prepared water blank. Quercetin was used as standard for the calibration curve. The TFC was expressed as mg quercetin equivalents (QE)/100 g extract.

Pectinase enzyme activity: Sample of 0.5 ml of supernatant enzyme extraction were used and mixed in acetate buffer then incubated at 45°C for l0 min for pectinase. The reaction was stopped with 3 ml of 3, 5-dinitrosalicylic acid reagent, the color was obtained after heating for 10 min. and measured at wavelength of 570 nm and expressed as one unit of pectinase activity liberates 1 Mmol D-galactouronic acid in milliliter per min (Miller, 1959).

Statistical Analysis: The design for this experiment was a completely randomized design (CRD) with three replications. The collected data on various parameters were statistically analyzed using variance (ANOVA) procedure of MSTATC program. Treatments means were compared by Duncan's multiple range tests at 5% level of probability in the average of two seasons of study (Steel and Torrie, 1982).

Results

Fruit physical properties

Fruit weight Loss (%): Weight loss percentage of dates fruitcv. Barhi increased significantly with the prolongation of cold storage period at 5^{0}C for all coating

Table 1: Effect ofsoy protein or gelatin with thyme oil as a carrier on weight loss (%) of "Barhi" date palm fruits stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	0 r	1.38 pq	2.5 n	3.15 ijklm	4.57efgh	0x	2.59v	3.71s	4.36q	5.78k
Soy protein 9% +Thyme oil	0 r	3.12 ijklm	4.4 efghi	5.21cdefg	6.33 cd	0x	2.38w	4.33q	5.61l	6.42h
Soy protein 12%+Thyme oil	0 r	2.15 no	2.93lmn	3.76 hij	5.35 cdef	0x	3.36t	4.14r	4.97n	6.56g
gelatin 6% +Thyme oil	0 r	1.34 pq	3.57 hijkl	4.65 efgh	5.37 cdef	0x	2.55v	4.78o	5.86j	6.58g
gelatin 9%+Thyme oil	0 r	3.63 hijk	5.04 defg	5.68 cde	6.57 c	0x	4.84o	6.25i	6.89f	7.78d
gelatin 12% +Thyme oil	0 r	3.36 ijkl	5.75 cde	7.33 bc	8.39 b	0x	4.57p	6.96f	8.54d	9.6c
Control	0 r	1.76 op	4.26 ghij	8.33 b	10.39 a	0x	2.97u	5.47m	9.67b	11.70a

treatments table 1. However, the all coating treatments significantly reduced the weight loss of Barhi fruits during the storage compared to the control fruits. After 28 days of cold storage, the lowest value of weight loss percentage (4.57 and 5.78%) was obtained in treated fruits with soyprote in at 6% plus thyme oil as a carrier in the first and second seasons, respectively. On the other hand, the highest value of weight loss percentage (10.39 and 11.70%) was obtained in control fruits during the both seasons under study.

Fruit Weight(g): Results in table 2 showed that fruit weight of Barhicv. was significantly increased towards the end of storage period. Soyprote in at 6% plus thyme oil as a carrier treatment recorded the heaviest fruit (11.65 and 10.45gm) after 28 days of cold storage during the two seasons, respectively. While, the control fruit was recorded the lightest fruit (9.28 and 8.66 gm). in both seasons.

Fruit Volume (cm^3): Table 3 illustrated that, all coating treatments record rise in fruit volume values higher than untreated fruit (control) which recorded the less value (10 and 10.12 cm^3) at 28 days of cold storage period. Significant differences were noticed among all coating treatments. The highest values of fruit volume recorded by fruit coated with soy protein at 6% plus thyme oil as a carrier (12.22 and 11.22 cm^3) in both seasons, respectively.

Fruit Length(cm): It is clear from the results that fruit length was reduced gradually and significantly along the storage period table 4. At the end of storage period, the treatment of soy protein at 6% plus thyme oil as a carrier recorded the highest value (2.76 cm) in the first season and treatment of soy protein at 12% plus thyme oil treatment (2.11 cm) in the second season, while the control fruit gave the lowest length of the fruits (1.70 and 1.23 cm) during the two seasons, respectively.

Fruit Diameter (cm): Data in table 5 indicate that, fruit diameter took the same line of fruit weight, volume and length in the gradual decrease by prolonged the storage period. The treatment of soy protein at 6% plus thyme oil as a carrier recorded the highest fruit diameter (2.15 cm) in first season and treatment of gelatin at 12% plus thyme oil (1.87 cm) in the second season, while the control fruit gave the lowest fruit diameter (1.48 and 1.72 cm) during the both seasons, respectively.

Fruit Rutab Percentage: Data in table 7 presented that, rutab percentage of "Barhi" date palmfruits during 28 days of cold storage at 5^{0}C was significantly reduced by all coatings treatments compared with control fruits (untreated). The lowest fruit rutab percentages were

Table 2: Effect of soy proteinorgelatin with thyme oil as a carrier onfruit weight (g)of "Barhi"date palm fruits stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	13.5 a	12.8 abc	12.5 a-d	12 b-f	11.65 b-g	12.45a	11.33c	11.21c	10.90 de	10.45 fg
Soy protein 9% +Thyme oil	13.5 a	12.6 a-d	11.85 b-f	11.4 c-g	10.75 fgh	12.45a	11.75 b	10.90 de	10.35gh	9.83 j
Soy protein 12%+Thyme oil	13.5 a	12.2 a-e	11.87 b-f	11.4 c-g	10.75 fgh	12.45a	11.73 b	11.25 c	10.84de	10.15 h
gelatin 6% +Thyme oil	13.5 a	13 ab	12.25 a-e	10.9 b-f	9.83 h	12.45a	12.00 b	11.77 b	10.22 gh	9.85 ij
gelatin 9%+Thyme oil	13.5 a	12.8 abc	12.2 a-f	11.19 d-h	9.43 hi	12.45a	11.93b	11.35c	10.73ef	10.15h
gelatin 12% +Thyme oil	13.5 a	12.75 abc	12.1 a-f	11 d-g	10.15 gh	12.45a	11.75b	11.10cd	10.65ef	10.13hi
Control	13.5 a	12.94 ab	11.2 d-h	10.2 gh	9.28 i	12.45a	11.87b	10.75e	9.62j	8.66k

Table 3: Effect of soy protein orgelatin with thyme oil as a carrier onfruit volume (cm^3)of "Barhi" date palm fruits stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	14.75 a	14 ab	13.35 a-d	13 b-e	12.22 c-h	13.50 a	13.00 ab	12.15def	11.75 f-i	11.22 i-l
Soy protein 9% +Thyme oil	14.75 a	13 b-e	12.25 c-h	11.7 e-i	11.21f-i	13.50 a	12.35 cde	11.10 jkl	10.85 klm	10.25 no
Soy protein 12%+Thyme oil	14.75 a	14 ab	12 d-h	11.67 e-i	11 hi	13.50 a	13.00 ab	11.93 d-g	11.33 h-k	10.68 lmn
gelatin 6% +Thyme oil	14.75 a	13.5 abc	12.93 b-e	11,17 ghi	10.25 i	13.50 a	13.00 ab	12.36 cde	11.55 g-j	10.54 mno
gelatin 9%+Thyme oil	14.75 a	13 b-e	12.77 b-e	11.95 d-h	10.65 hi	13.50 a	12.43 cd	12.21def	11.85 e-h	10.92 klm
gelatin 12% +Thyme oil	14.75 a	14 ab	12,5 c-g	11.8 efgh	10.84 hi	13.50 a	12.80 bc	12.30 c-f	11.00 jklm	10.75 lmn
Control	14.75 a	13.33 abcd	12 d-h	11.3 fghi	10 i	13.50 a	12.45 cd	11.32 h-k	10.88 klm	10.12 o

obtained by gelatin at 9% plus thyme oil as a carrier (1.16 and 3.63%) respectively, during the two seasons under study. On the other side, untreated fruits were revealed the highest fruit rutab percentages (12.96 and 13.50%) in both seasons.

Total soluble solids percentage (TSS %): It is clear from the results in table 8 that, TSS% of Barhi fruits was gradually increased with prolonged the storage period at 5^{0}C. The statistical analysis indicated that there was a significant difference between the coating treatments during the storage periods in the two seasons of the study. In the first season, after 28 days of storage,

Table 4: Effect of soy proteinorgelatin with thyme oil as a carrier onfruit length (cm)of "Barhi" date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	3.5 a	3.3 abc	3.27 abc	2.95 a-f	2.76 a-f	3.11a	2.85 ab	2.45 bcd	2.11 def	1.87 efg
Soy protein 9% +Thyme oil	3.5 a	3.2 a-d	3 abc	2.34 b-f	1.88 f	3.11a	3.00 ab	3.00 ab	2.26 cde	1.75 e-h
Soy protein 12%+Thyme oil	3.5 a	3.34 abc	3.2 a-d	2.8 a-f	2.25 c-f	3.11a	3.00 abc	2.8 abc	2.56 a-d	2.11def
gelatin 6% +Thyme oil	3.5 a	3.39 ab	3.1 a-e	2.75 a-f	2.1 def	3.11a	2.60 a-d	2.82 abc	2.63 a-d	1.87efg
gelatin 9%+Thyme oil	3.5 a	3.3 abc	2.9 a-f	2.35 b-f	1.95 ef	3.11a	3.00 ab	2.66 a-d	2.15 de	1.57 fgh
gelatin 12% +Thyme oil	3.5 a	3.3 abc	2.9 a-f	2.2 cdef	1.75 g	3.11a	3.05 a	2.74 abc	2.15 de	1.47 gh
Control	3.5 a	3.1 a-e	2.5 cdef	2,10 def	1.7 g	3.11a	2.83 ab	2.26 cde	1.31 h	1.23 h

Table 5: Effect of soy protein orgelatin with thyme oil as a carrier onfruit diameter(cm)of "Barhi" date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	3. 0 a	2.6 ab	2.5 ab	2.3 ab	2.15 ab	2.75a	2.34c	2.11g	1.90ij	1.83kl
Soy protein 9% +Thyme oil	3. 0 a	2.5 ab	2.25 ab	2.17 ab	1.85 b	2.75a	2.31cd	2.19f	2.10g	1.78lm
Soy protein 12%+Thyme oil	3.0 a	2.5 ab	2,35 ab	2.17 ab	1.9 b	2.75a	2.32c	2.11g	1.94hi	1.76mn
gelatin 6% +Thyme oil	3. 0 a	2.6 ab	2.5 ab	2.3 ab	1.95 b	2.75a	2.34c	2.10g	1.96h	1.84k
gelatin 9%+Thyme oil	3.0 a	2.54 ab	2.44 ab	2.15 ab	1.9 b	2.75a	2.43b	2.25e	1.97h	1.86jk
gelatin 12% +Thyme oil	3. 0a	2.66 ab	2.62 ab	2.15 ab	1.95 b	2.75a	2.44b	2.26de	1.95hi	1.87jk
Control	3.0 a	2.56 ab	2.5 ab	1.85 b	1.48 bc	2.75a	2.30cde	2.11g	1.84k	1.72n

Table 6: Effect ofsoy protein or gelatin with thyme oil as a carrier onfruit firmnessof(Ib/inch^2)"Barhee" date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	5.00 a	3.53 b-f	3.11 d-j	2.47 f-j	2.15 g-j	4.43a	3.02 l	2.94 m	2.32 r	2.04 v
Soy protein 9% +Thyme oil	5.00 a	4.83 ab	3.47 d-h	2.86 e-j	2.16 g-j	4.43a	4.26 c	4.26 c	3.26 i	2.77 n
Soy protein 12%+Thyme oil	5.00 a	4.03 a-e	3.5 b-g	2.64 f-j	2.1 hij	4.43a	3.94 e	3.22 j	2.55 p	1.97 x
gelatin 6% +Thyme oil	5.00 a	3.27 c-i	2.85 e-j	2.3 f-j	1.94 ij	4.43a	3.15 kl	2.67 o	2.140 t	1.83 y
gelatin 9%+Thyme oil	5.00 a	4.5 abc	3.25 c-i	2.17 ghij	1.92 ij	4.43a	3.95 e	3.17 k	2.11 u	1.84 y
gelatin 12% +Thyme oil	5.00 a	4.8 ab	3.75 a-f	2.5 f-j	1.63 j	4.43a	4.23 d	3.35 gh	3.36 g	1.54 ij
Control	5.00a	2.83 e-j	2.45 f-j	1.93 ij	1.22 j	4.40 b	2.54 q	2.15 s	1.84 y	1.14 z

the highest values of TSS% were noticed by fruits coated by soy protein at 9% or gelatin at 12% plus thyme oil as a carrier and soy protein 9% in the second one. On the contrary, control fruits exhibited the lowest percentage of TSS in both seasons.

Fruit chemical properties

Titratable Acidity (%): Fruit acidity is important consumer variable as the balance of SSC and TA relates to overall taste and consumer acceptability. The changes in titratable acidity of Barhi dates palm fruits during cold storage at 5°C subjected to some edible coating treatments are presented in table 9. The results revealed that date palm fruits cv. Barhi had gradual and significant decrease in titratable acidity recorded the least values at the end of cold storage period at 5°C during the two studies

Table 7: Effect of soy protein or gelatin with thyme oil as a carrier onfruit rutab percentageof "Barhi" date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	first season					second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6% +Thyme oil	0 1	0 1	0 1	8.41 b	12.96 a	0 p	0 p	0 p	7.33 g	12.45 b
Soy protein 9% +Thyme oil	0 1	0 1	0 1	1.16 ij	2 hi	0 p	0 p	0 p	2.64 n	4.12 i
Soy protein 12%+Thyme oil	0 1	0 1	0 1	1.04 jk	2.89 efg	0 p	0 p	0 p	2.47 o	3.68 j
gelatin 6% +Thyme oil	0 1	0 1	0 1	8.41 b	12.25 ab	0 p	0 p	0 p	7.53 f	11.50 d
gelatin 9%+Thyme oil	0 1	0 1	0 1	1.04 jk	1.16 ij	0 p	0 p	0 p	2.87 m	3.63j
gelatin 12% +Thyme oil	0 1	0 1	0 1	4.84 cd	9.64 b	0 p	0 p	0 p	3.45 k	11.70 c
Control	0 1	0 1	0 1	1.09 j	12.96 a	0 p	2.971	5.47 h	9.60 e	13.50 a

Table 8: Effect of soy protein or gelatin with thyme oil as a carrier onsoluble solids content (%) of"Barhi"date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	First season					Second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6%+Thyme oil	12 u	15 q	17 k	21 e	23 b	13.00 j	16.00 hi	18.00 gh	22.00 cde	25.00 ab
Soy protein 9% +Thyme oil	12 u	15 q	19 g	22.5 c	25 a	13.00 j	17.00 gh	21.00 ef	24.00 abc	26.37 a
Soy protein 12%+Thyme oil	12 u	13.33 t	15 q	17.5 j	21 e	13.00 j	10.17 k	17.00 gh	19.00 fg	23.00 b-e
Gelatin 6%+Thyme oil	12 u	15.3 p	17.47 j	20.85 e	22 d	13.00 j	17.00 gh	19.30 fg	22.00 cde	23.43 b-e
Gelatin 9%+Thyme oil	12 u	14.65 r	16 n	19 g	21 e	13.00 j	16.30 hi	18.00 gh	21.00 ef	23.00 b-f
Gelatin 12%+Thyme oil	12 u	14.45 s	18 i	22 d	25 a	13.00 j	16.00 hi	19.30 fg	23.45 bcd	26.20 a
Control	12 u	13.33 t	15 q	18.15 i	20 f	13.00 j	14.50 ij	16.40 hi	19.00 fg	21.20 def

Table 9: Effect ofsoy protein or gelatin with thyme oil as a carrier ontitratable acidity (%)of"Barhi"date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	First season					Second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6%+Thyme oil	0.85 a	0.79 abc	0.65 bcd	0.44 ghij	0.28 lm	0.90 a	0.84 ab	0.79 bcd	0.56 kl	0.35 p
Soy protein 9% +Thyme oil	0.85 a	0.66 bcd	0.62 cde	0.59 cdef	0.52 fgh	0.90 a	0.74 cdef	0.69 efgh	0.61 ijk	0.56 kl
Soy protein 12%+Thyme oil	0.85 a	0.69 bc	0.53 efg	0.48 fghi	0.43 ghij	0.90 a	0.72 defg	0.61 ijk	0.56 kl	0.47 mn
Gelatin 6%+Thyme oil	0.85 a	0.55 defg	0.43 ghij	0.26 lmn	0.19 no	0.90 a	0.64 hij	0.54 klm	0.38 op	0.27 q
Gelatin 9%+Thyme oil	0.85 a	0.53 efg	0.48 fghi	0.41ghijk	0.35 ijkl	0.90 a	0.66 ghi	0.57 jk	0.49 lmn	0.44 no
Gelatin 12%+Thyme oil	0.85 a	0.51fgh	0.42 ghijk	0.37hijkl	0.28 lm	0.90 a	0.64 hij	0.54 klm	0.46 n	0.35 p
Control	0.85 a	0.81 ab	0.79 abc	0.7 bc	0.62 cde	0.90 a	0.85 ab	0.81 bc	0.76cde	0.68 fghi

seasons after some edible coating treatments. Coated fruits by gelatin at 6% as a carrier of thyme oil showed the minimum titratable acidity after 28 days of cold storage (0.19 and 0.27%) followed by gelatin at 12% (0.28 and 0.35%), soy protein at 6% (0.28 and 0.35%), gelatin at 9% (0.35 and 0.44%) and soy protein at 9% (0.52 and 0.56%) during the two successive seasons respectively. Meanwhile, control fruits (untreated) recorded the highest titratable acidity (0.62 and 0.68%) when compared with treated fruits.

Ascorbic acid content (mg·100 g^{-1} F.W.): Ascorbic acid content (vitamin C) of date palm fruits cv. Barhi had a gradual and significant decrease with increasing cold storage period at 5^0C in all coated treatments including untreated fruit (control) during the two successive seasons table 10. Soy protein at 6% plus thyme oil as a carrier treatment recorded the highest content of ascorbic acid (25.83 and 24.13 mg·100 g^{-1} F.W.). Meanwhile, gelatinat 12% treatment showed less ascorbic acid content with expanding storage period (15 and 13.43mg. 100 g^{-1} F.W.) compared with control fruits which recorded the least values (11.43 and 10.05mg. 100 g^{-1} F.W.).

Total carotenoids content(mg\g F.W.): There was gradual and significant decrease in total carotenoids concentration of date palm fruits *cv.* Barhi with the advance of cold storage period at 5ºC under all coated treatments during the two successive seasons Figs. 1 and 2. Treating fruits by gelatin at 12% as a carrier of thyme oil resulted in significantly the highest concentration of carotenoids (0.194 and 0.142) while the minimum concentration of carotenoids (0.170 and 0.05) was noted in the fruit treated with soy protein at 12% compared with untreated fruits which recorded the highest reduction of carotenoids concentration (0.107 and 0.013).

Total flavonoids content(mg\g F.W.): The statistical analyses showed a slight significant increase of total flavonoids content (TFC) for Barhi date palm fruits during cold storage at 5^oC due to different edible coating treatments reached the highest values at the end of storage period (28day) during the both studies seasons Figs. 3 and 4. Gelatinat 12% as a carrier of thyme oil treatment gave the highest flavonoids content (7.703 and 9.1660 (mg\g F.W.)), followed by soy protein at 12% (7.034 and 8.835 (mg\g F.W.)), gelatin at 12% (5.801 and 6.933 (mg\g F.W.)), gelatin 6% (5.363 and 6.495 (mg\g F.W.)) and soy protein at 6% (3.803 and 5.861(mg\g F.W.)). On contrast, the lowest flavonoid content was obtained with the control fruits which recorded (4.927 and 4.935 (mg\g F.W.)) at the end of storage periods of both studied seasons.

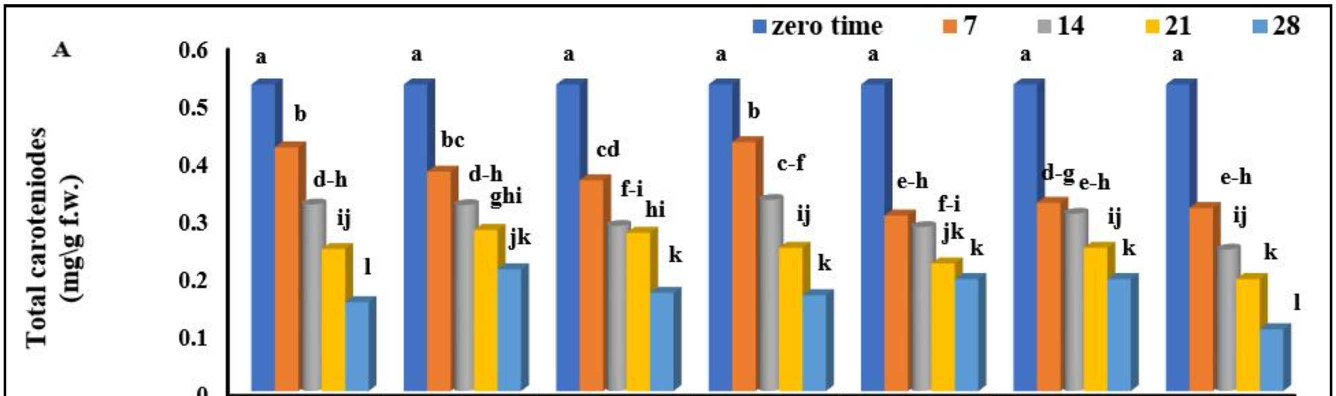
7Pectinase enzyme activity(u/g F.W.): There were a gradual and significant increases in pectinase enzyme activity of Barhi date palm fruits during cold storage at 5^oC due to different edible coating treatments were showed in Figs. 5 and 6. All treatments increased pectinase activity through all the storage period including the untreated fruit (control) which showed the greatest values in pectinase activity at last week of the storage period (62.77 and 65.09u/g F.W.). Soy protein at 9% plus as a carrier of thyme oil treatment gave the lowest level of pectinase activity after 28 days of cold storage at 5^0C (26.74 and 28.06 u/g F.W.) compared with at harvest (10.33 and 11.65 u/g F.W.) during the two studied seasons respectively. Meanwhile, gelatin at 6% or at 9% gave the highest pectinase activity (62.198, 63.52 u/g F.W.) and (61.295, 64.32 u/g F.W.), during two seasons under study.

Discussion

These results are in agreement with those found by

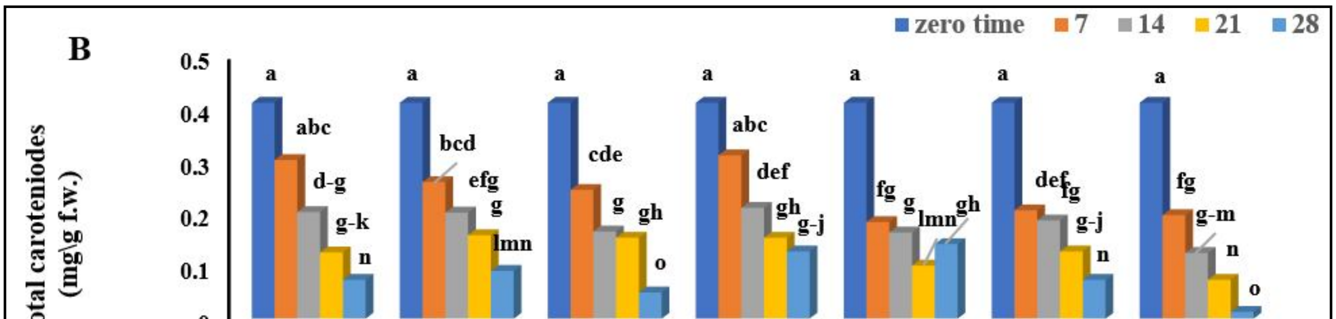
Table 10: Effect ofsoy protein or gelatin with thyme oil as a carrier onascorbic acid content(mg100 g^{-1} F.W)of "Barhi"date palm stored at 5°C ± 1 during two seasons (2018 and 2019).

Treatments	First season					Second season				
	0	7	14	21	28	0	7	14	21	28
Soy protein 6%+Thyme oil	35 a	32.65 ab	30.11 bcd	29.37 b-e	25.83 e-i	33.70 a	31.35 b	28.81c	28.07d	24.13 h
Soy protein 9% +Thyme oil	35 a	28.22 c-f	26.01 e-h	22 i-n	19.5 mn	33.70 a	26.91 e	24.71g	20.20 m	18.20 g
Soy protein 12%+Thyme oil	35 a	28.22 c-f	26 e-h	23.24 g-m	20.11 lmn	33.70 a	26.92 e	24.70 g	21.94 k	18.81p
Gelatin 6%+Thyme oil	35 a	26.56 d-g	24.9 f-k	21 k-n	18.5 n	33.70 a	25.26 f	23.60 i	19.70 o	16.70 s
Gelatin 9%+Thyme oil	35 a	24.9 f-k	23 g-h	21.58 j-n	19 mn	33.70 a	23.60 i	21.70 l	19.88 n	17.70 r
Gelatin 12%+Thyme oil	35 a	24.35 f-l	20.22 lmn	17.71 mn	15 n	33.70 a	22.55 j	18.92 p	16.41 t	13.40 v
Control	35 a	17.71 mn	16.6 no	14 o	11.43 p	33.70 a	16.41 t	15.30 u	12.70 w	10.05 x



	T1	T2	T3	T4	T6	T7	Control
zero time	0.531	0.531	0.531	0.531	0.531	0.531	0.531
7	0.422	0.38	0.365	0.431	0.304	0.326	0.317
14	0.323	0.322	0.286	0.331	0.284	0.307	0.245
21	0.246	0.279	0.274	0.248	0.221	0.248	0.194
28	0.154	0.211	0.17	0.166	0.194	0.194	0.107

Treatments



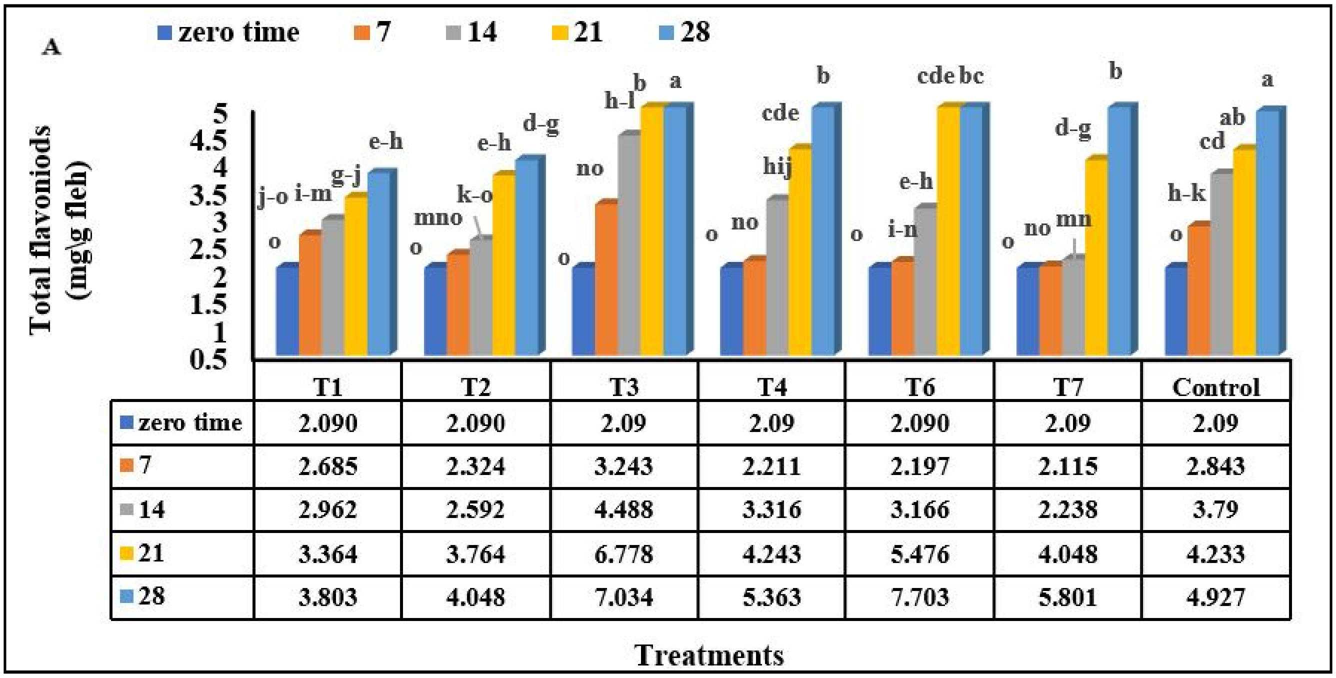
	T1	T2	T3	T4	T6	T7	Control
zero time	0.411	0.411	0.411	0.411	0.411	0.411	0.411
7	0.302	0.26	0.245	0.311	0.184	0.206	0.197
14	0.203	0.202	0.166	0.211	0.164	0.187	0.125
21	0.126	0.159	0.154	0.154	0.101	0.128	0.074
28	0.074	0.091	0.05	0.128	0.142	0.074	0.013

Treatmrnts

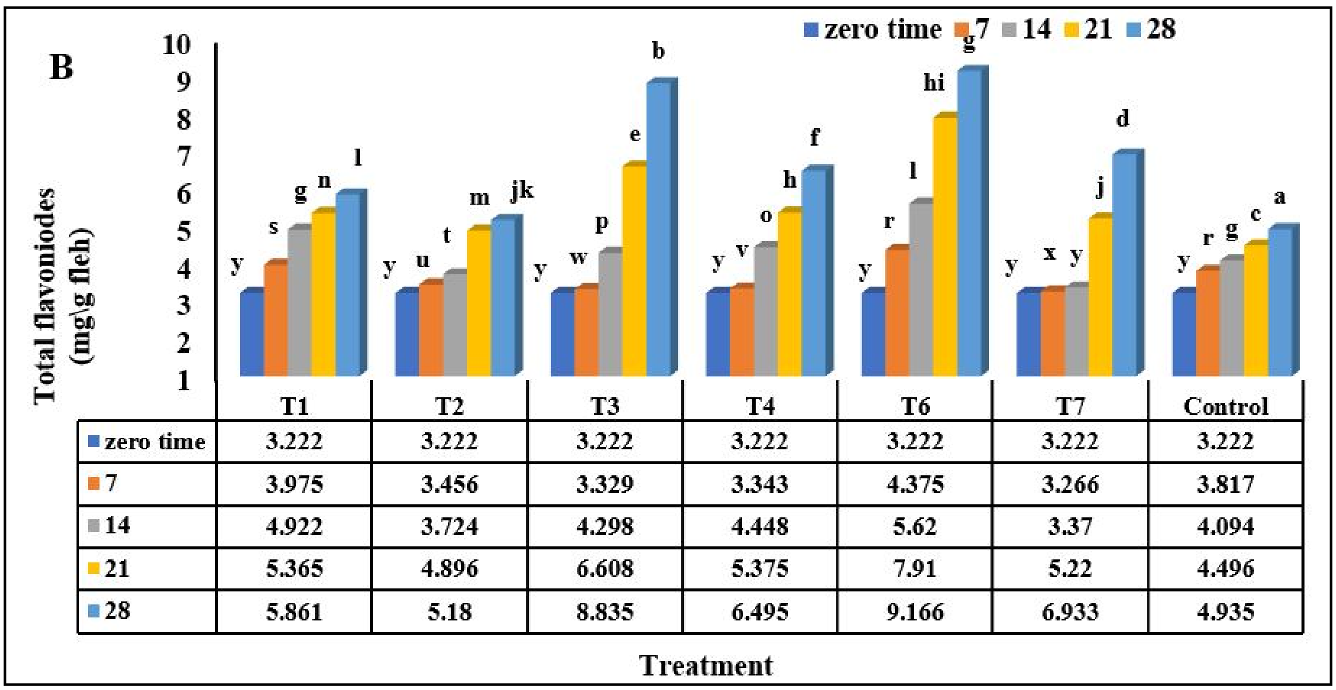
Figs. 1 and 2: Carotenoids content of "Barhi" date palm fruits as affected by edible coating ofsoy protein or gelatinwith thyme oil as a carrier during the two seasons (2018 and 2019).

Nandane and Jain (2014) demonstrated that addition of soy protein (SP) increases tensile strength and thickness of edible films. Thus, SP forms a stable film on the fruit surface and hence may help reduce the moisture loss. Lim *et al*., (2011) and Nandane *et al*., (2017) obtained similar results for sweet cherries and pear fruit coated with edible films containing SP. Furthermore, Debeaufort *et al*., (1998) reported that the effect ofedible coating are selective barriers to O_2 and CO_2, modifying internal atmospheres and slowing down the respiration rate of fruit, which in turn reduced weight loss. Normally, the weight loss occurs during the fruit storage due to its respiratory process, the transference of humidity and some processes of oxidation (Ayranci and Tunc, 2003).

Also, all coating treatments decreased the fruit firmness with extending the storage period due to ripening which mainly occurs because of degradation of the middle lamella of the cell wall of cortical parenchyma cells. The highest values of firmness were achieved in Barhi fruits coated with soy or gluten plus thyme oil at the end of the storage period. Edible coating showed a good result with respect to the retention of fruit firmness probably because this coating slowed down metabolism and prolonged the storage life Amal *et al*., (2010).



	T1	T2	T3	T4	T6	T7	Control
zero time	2.090	2.090	2.09	2.09	2.090	2.09	2.09
7	2.685	2.324	3.243	2.211	2.197	2.115	2.843
14	2.962	2.592	4.488	3.316	3.166	2.238	3.79
21	3.364	3.764	6.778	4.243	5.476	4.048	4.233
28	3.803	4.048	7.034	5.363	7.703	5.801	4.927

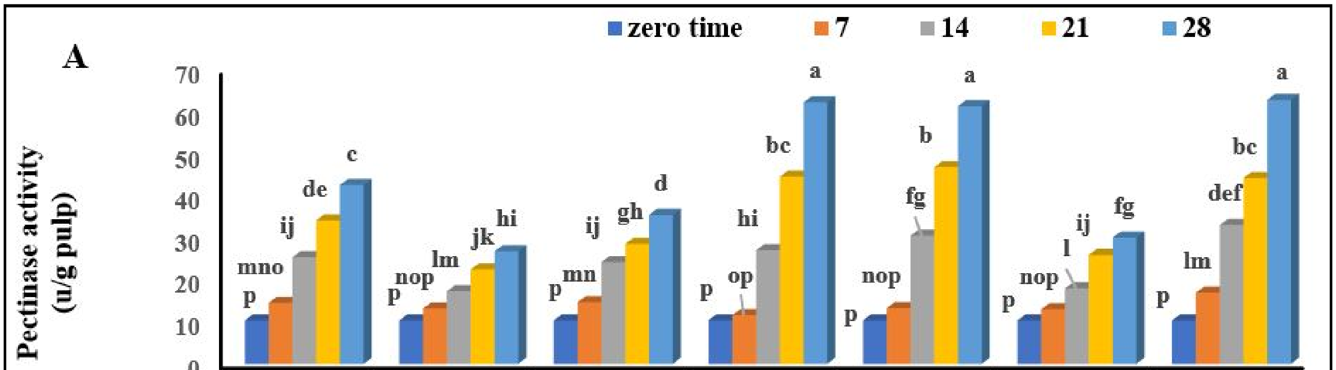


	T1	T2	T3	T4	T6	T7	Control
zero time	3.222	3.222	3.222	3.222	3.222	3.222	3.222
7	3.975	3.456	3.329	3.343	4.375	3.266	3.817
14	4.922	3.724	4.298	4.448	5.62	3.37	4.094
21	5.365	4.896	6.608	5.375	7.91	5.22	4.496
28	5.861	5.18	8.835	6.495	9.166	6.933	4.935

Figs. 3 and 4: Flavonoids content of "Barhi" date palmfruitas affected by edible coating ofsoy protein or gelatin with thyme oilas a carrierduring the two seasons (2018 and 2019).

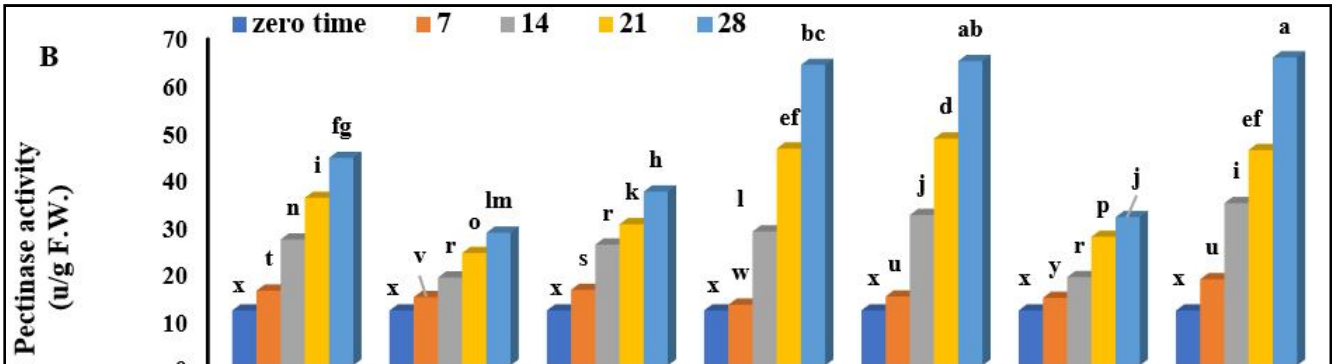
Result is in conformity with similar results were reported by numerous investigators (Amal *et al*., 2010; Mahajan *et al*., 2014; Nandane and Jain, 2017; Alparslan *et al*., 2019) who are concluded that the coating film on the surface of fruits reduced respiration rate and vital process, thus reducing the loss of TSS during storage. Moreover, thyme oil carried by soy protein or gelatin provides a partial barrier to the movement of moisture on the surface of fruits thereby minimizing moisture loss during storage; also, a gas barrier thereby establishing a modified atmosphere around the fruits, which slows down respiration, senescence and enzymatic oxidation and increase the effective of film in maintaining TSS during storage.

On the other hand, Pila *et al*., (2010) obtained that the reduction in juice acidity by antioxidants treatments could be attributed to its influence on increasing the tissue respiration and increasing ripening-associated activities. Also, carotenoids considered as a major class of phytochemicals occur in the lipid fractions of date fruit.



	T1	T2	T3	T4	T6	T7	Control
zero time	10.33	10.33	10.33	10.33	10.33	10.33	10.33
7	14.495	13.15	14.66	11.537	13.24	12.971	16.915
14	25.32	17.274	24.176	27	30.5	17.97	33
21	34.12	22.45	28.533	44.52	46.77	25.88	44.2
28	42.543	26.74	35.42	62.198	61.295	30.036	62.77

Treatments



	T1	T2	T3	T4	T6	T7	Control
zero time	11.650	11.650	11.650	11.650	11.650	11.650	11.650
7	15.83	14.46	15.98	12.86	14.59	14.3	18.24
14	26.64	18.6	25.55	28.32	31.82	18.69	34.32
21	35.44	23.77	29.85	45.84	47.95	27.2	45.52
28	43.86	28.06	36.74	63.52	64.32	31.36	65.09

Treatments

Figs. 5 and 6: Pectinase activity (u/g F.W.) of "Barhee" date palm fruit as affected by edible coating ofsoy proteinor gelatin with thyme oilas a carrier during the two seasons (2018 and 2019).

They are precursors of vitamin A, which plays a central role in vision and protects the cell from deleterious effects of free radicals by acting as antioxidants (Julia *et al*., 2015). The carotenoid degradation may be due primarily to the loss of moisture during maturation and is probably unrelated to the gradual darkening of the ripening fruit. The pattern of the retained carotenoids remained essentially similar (Gross *et al.,* 1983).

Conclusions

All edible coatings under investigation helped to preserve the quality of Barhi fruits during cold storage at 5°C and 85-90% relative humidity for 28 days compared with the control fruits. Fruits coated with soy protein at 6% plus thyme oil as a carrier showed a least fruit weight loss and highest fruit volume, length, diameter and ascorbic acid content. Soy protein at 9% plus thyme oil gave the lowest level of pectinase enzyme activity and the highest fruit firmness after 28 days of cold storage at 5°C. The highest TSS% values were noticed by soy protein at 9% or gelatin at 12% plus thyme oil. Coated fruits by gelatin at 6% plus thyme oil showed the minimum acidity. Gelatin at 9% plus thyme oil obtained the lowest fruit rutab percentages. Therefore, it can be recommended to use soy protein as a carrier for thyme oil in the coating of date fruits, especially Barhi, to maintain acceptable quality characteristics during cold storage.

References

A.O.A.C. (1990). Official methods of analysis of AOAC International. 13th ed. AOAC International. Gaithersburg, MD, USA, Method No. 950.46.

A.O.A.C. (2000). Association of Official Analytical Chemists. Washington DC. International 17th Edition, Revision I.

Abd El-Moneim, E. A. A., S.F. EL-Gioushy and M.H.M. Baiea (2015).

Effect of some natural coating materials on storability and fruit quality of Zaghloul date palm *cv.* under cold storage. *Middle East Journal of Agriculture Research,* **4(3):** 602-612.

Aitboulahsen, M., S. Zantar, A. Laglaoui, H. Chairi, A. Arakrak, M. Bakkali and M.H. Zerrouk (2018). Gelatin- based edible coating combined with menthe pulegium essential oil as bioactive packaging for strawberries. *Journal of Food Quality,* **15:** 1-7.

Al-Farsi, M., C. Alasalvar, A. Morris, M. Baron and F. Shahidi (2005). Comparison of antioxidant activity, anthocyanins, carotenoids and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. *J. Agric. Food Chem.,* **53(19):** 7592–7599.

Al-Obeed, R.S. (2010). Improving fruit quality, marketability and storability of Barhee date palm. *World Applied Sci. J.,* **9(6):** 630-637.

Alparslan, Y., T. Baygar, C. Metin, H.H. Yapici and T. Baygar (2019). The role of gelatin-based film coating combined with orange peel essential oil on the quality of refrigerated shrimp. *Acta Aquatica Turcica,* **15(2):** 197-212.

Al-Qurashi, A.D. and M.A. Awad (2011). Quality characteristics of bisir Barhee dates during cold storage as affected by postharvest dipping in gibberellic acid, naphthalene acetic acid and benzyladenine. *Fruits,* **66:** 343-352.

Al-Redhaiman, K.N. (2005). Chemical changes during storage of 'Barhi' dates under controlled atmosphere conditions, *Hort. Science,* **40(5):** 1413–1415.

Amal, S.H., M.M. Atress, H.E. El-Mogy and B.W. Aboul-Anean (2010). Improving strawberry fruit storability by edible coating as a carrier of thymol or calcium chloride. *J. Food Sci. Technol.,* **2(3):** 88–97.

Artharn, A., T. Prodpran and S. Benjakul (2009). Round scad protein-based film: Storage stability and its effectiveness for shelf-life extension of dried fish powder. *LWT-Food Science and Technology,* **42(7):** 1238-1244.

Atia, A., D. Abdelkarim, M. Younis and A. Alhamdan (2018). Effects of Gibberellic Acid (GA3) and Salicylic Acid (SA) postharvest treatments on the quality of fresh Barhi dates at different ripening levels in the Khalal maturity stage during controlled atmosphere storage extract of date fruit (*Phoenix dactylifera* L. Arecaceae). *Int. J. Agric & Biol. Eng.,* **11(3):** 211-219.

Attia, M.M., A.A. Etman, A.M. Hussein and N. El-Naggar (1997). Effect of wrapping with two polyethylene types on postharvest behavior and shelf life of three soft date *cvs. Zagazig J. Agric. Res.,* **24:** 124–134.

Awad, M.A. (2007). Increasing the rate of ripening of date palm fruit (*Phoenix dactylifera* L.) *cv.* 'Helali' by preharvest and postharvest treatments. *Postharvest Biol. Technol.,* **43:** 121–127.

Ayranci, E. and S. Tunc (2003). A method for the measurement of the oxygen permeability and the development of edible films to reduce the rate of oxidative reactions in fresh foods. *Food Chem.,* **80:** 423-431.

Botes, A. and Zaid, A. (1999). The economic importance of date production and international Trade, p. 45-57. In: A. Zaid and E.J. Arias (eds.), Date palm cultivation, FAO plant production and protection paper, No. 156.

Debeaufort, F.J., A. Quezada-Gallo and A. Voilley (1998). Edible films and coatings: tomorrow's packaging's: Areview. *Crit. Rev. Food Sci.,* **38:** 299-313.

Gómez-Guillén, M.C., M. Ihl, V. Bifani, A. Silva and P. Montero (2007). Edible films made from tuna-fish gelatin with antioxidant extracts of two different murta ecotypes leaves (Ugni molinae Turcz). *Food Hydrocolloids,* **21(7):** 1133-1143.

Gross, J., O. Haber and R. Ikan (1983). The carotenoid pigments of the date. *Scientia Horticulturae,* **20(3):** 251-257.

Hegazy, M.K., M.A. Fahmy, M.A. Sobaih and M.A. Abdul-Samad (2003). Effect of some postharvest treatments on Zagloul date fruits during storage. Proceedings of the International Conference on Date Palm. King Saud Univ., Qassim, Kingdom of Saudi Arabia: 353–362.

Jongjareonrak, A., S. Benjakul, W. Visessanguan, T. Prodpran and M. Tanaka (2006). Characterization of edible films from skin gelatin of brownstripe red snapper and bigeye snapper. *Food Hydrocolloids,* **20(4):** 492-501.

Julia, V., L. Macia and D. Dombrowicz (2015). The impact of diet on asthma and allergic diseases. *Nat. Rev. Immunol.,* **15:** 308–322.

Kester, J.J. and O. Fennema (1986). Edible lms and coatings: A review. *Food Technol.,* **40:** 47-59.

Lichtenthaler, H.K. and A.R. Wellburn (1983). Determinations of total carotenoids and chlorophylls a and b of leaf extracts in different solvents. *Biochem. Soc. Trans.,* **11(5):** 591–592.

Lim, R., C.E. Stathopoulos and J.B. Goldingm (2011). Effect of edible coatings on some quality characteristics of sweet cherries. *Int. Food Res. J.,* **18(4):** 1237–1241.

Liu, G., Y.L. Xiong and D.A. Butterfield (2000). Chemical, physical and gel forming properties of oxidized myofibrils and whey- and soy protein isolate. *J. Food Sci.,* **65:** 811-818.

Mansouri, A., G. Embarek, E. Kokkalou and P. Kefalas (2005). Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit (Phoenix dactylifera). *Food Chemistry,* **89:** 411-420.

Mariod, A.A. and H.F. Adam (2013). Review: gelatin, source, extraction and industrial applications. *Acta Sci. Pol., Technol. Aliment.,* **12(2):** 135-147.

McHugh, T.H. and E. Senesi (2000). Apple wraps: A novel method to improve the quality and extend the shelf life of fresh-cut apples. *J. Food Sci.,* **65:** 480-485.

Miller, G.L. (1959). Use of dinitrosalicylic acid reagent for determination of reducing sugar. *Journal of Analytical Chemistry,* **31:** 426-428.

Nandane, A.S. and R. Jain (2014). Study of mechanical properties of soy protein based edible film as affected by its composition and process parameters by using RSM. *J. Food Sci. Technol.,* **52(6):** 3645-3650.

Nandane, A.S., K.D. Rudri and T.V. Ramana Rao (2017). Optimization of edible coating formulations for improving postharvest quality and shelf life of pear fruit using response surface methodology. *J. Food Sci. Technol.,* **54(1):** 1–8.

Nilsuwan, K., S. Benjakul and T. Prodpran (2016). Quality changes of shrimp cracker covered with fish gelatin film without and with palm oil incorporated during storage. *International Aquatic Research,* **8(3):** 227-238.

Pila, N., N.B. Gol and T.V. Ramana Rao (2010). Effect of post-harvest treatments on physicochemical characteristics and shelf life of tomato (*Lycopersicon esculentum* Mill.) fruits during storage. *American Eurasian J. Agric. Environ. Sci.,* **9(5):** 470-479.

Re, R., N. Pellegrini, A. Proteggente, A. Pannala, M. Yang and C. Rice-Evans (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay". *Free Radic. Biol. Med.,* **26:** 1231-1237.

Shon, J., J.H. Eo and J.B. Eun (2010). Effect of soy protein isolate coating on quality attributes of cut raw Han-Woo (Korean cow) beef, aerobically packaged and held refrigerated. *J. Food Quality,* **33:** 42-60.

Slinkard, K. and V.L. Singleton (1977). Total phenol analyses: automation and comparison with manual methods. *Amer. J. Enol. Vitic.,* **28:** 49–55.

Steel, R.R. and J.H. Torrie (1982). Principles and Procedures of Statistics. 3rd Ed. London: Mc Graw-Hill International Book Company.

Thompson, K.A. and A.H. Abboodi (2003). Modified atmosphere packaging, p. 363-394. Proc. Intl. Conf. Date Palm. King Saud Univ., Qassim, Kingdom of Saudi Arabia.

Vayalill, P.K. (2002). Antioxidant and antimutagenic properties of aqueous extract of date fruit (*Phoenix dactylifera* L. Arecaceae). *J. Agri. & Food Chem.,* **50:** 610–617.

Were, L., N.S. Hettiarachchy and M. Coleman (1999). Properties of cysteine-added soy protein-wheat gluten films. *J. Food Sci.,* **64:** 514-518.

Zhang, Q., S. Tan, A. McKay and G. Yan (2005). Carrot browning on simulated market shelf and during cold storage. *J. Sci. Food Agr.,* **85:** 16-20.

Zhishen, J., T. Mengcheng and W. Jianming (1999). The determination of flavonoid contents in mulberry and their scavenging effects on superoxide radicals. *Food Chem.,* **64:** 555-559.