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Study the Effect of Moringa Leaf, Seed Extract and Carboxymethyl Cellulose on Storability of Persimmon Fruit Cv. Rojo Brillante

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ABSTRACT

This study was carried out on persimmon fruit cv. "Rojo Brillante" were obtained from a commercial orchard located in Chrane, Duhok governorate, Kurdistan region, Iraq, in order to investigate the effect of immersed fruits in)Distilled water, 5, 10 %(moringa leaf extract and)Distilled water, 5, 10%(moringa seed extract solution for five min and carboxymethyl cellulose)Distilled water, 1, 2 %(for three min on the fruit quality of persimmon after two months of cold storage at 1+1℃ and 85-90% relative humidity. Fruit firmness, fruit weight loss%, ascorbic acid contents, total soluble solids%, titratable acidity%, Pectin and tannin contents% were recorded for this experiment. Results explained that all treatment (moringa leaf, moringa seed extracts and carboxymethylcellulose) significantly reduce the fruit weight loss%. Additionally, fruit treated with 5% moringa leaf extract and 2% carboxymethylcellulose caused increase in total soluble solids%, ascorbic acid and maintained fruit firmness compared with untreated. Fruit dipped with 5% moringa seed extract were superior in maintained fruit firmness, while 10% moringa seed extract gave the highest ascorbic acid and tannin content%. There was a significant increase in fruits titratable acidity % and tannin content were fruits treated with 10% moringa leaf extract and 1% carboxymethyl cellulose. pectin content was better preserved in coated fruits (moringa leaf extract, moringa seed extract and carboxymethyl cellulose). The triple interaction treatments obtained positive effect on the quality parameters of persimmon fruits.

***Keywords*:** Moringa, carboxymethyl cellulose, post-harvest, persimmon, storage.

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INTRODUCTION

Persimmon (*Diospyros kaki* Thumb.) belongs to the Ebenaceae family. It originated around 3,000 years ago in China and spread throughout Korea in the ninth century and Japan in the seventh [1] and [2]. The cultivation of it in Europe was first recorded in the seventeenth century, when it spread across the Mediterranean region. The cultivation of persimmon was also brought to North America by migrations that travelled from Asian nations to California (USA) and Brazil [3]. According to the [4], the worldwide persimmon production in 2023 was (5.07million metric tons). The production of persimmons, a relatively new fruit to the Kurdistan Region, has experienced significant growth, particularly in the governorates of Duhok, Erbil, and Sulaymaniyah. In Duhok, annual production surpasses 44 tons, indicating a rise in consumer interest and contributing to the fulfillment of the region growing demand according to [5]. Persimmons are temperate, climacteric fruit, externally attractive with very little acidity and primarily sweet flavor. Maturation involves color changes from green to yellow-orange or red [1].

Persimmon contains a variety of nutrients, including carbohydrates, fiber, minerals, vitamins, carotenoids, as well as and phenolic compounds, bioactive phenolic components are essential for the medicinal qualities of persimmon, which lowers the risk of disease. In addition to protecting pancreatic beta cells and preventing lipoprotein oxidation, the phenolic chemicals also lower the risk of diabetes, cancer, cardiovascular disease, and harm from long-term alcohol use [6] and [7]. High perishability, that is typically associated with ripening, production of ethylene, accelerated respiration, and softening of the fruits [8], as well as improper handling techniques and overproduction at harvest [9] and [10], are some of the major causes of post-harvest fruit losses. Numerous postharvest techniques are employed for improve the quality and storage of fruits, including chemicals treatment, oil coating, wax emulsion, edible coatings, low temperature techniques, calcium treatment, use of various fungicides, a wide range of packaging materials, controlled atmosphere storage, and heat treatment. Edible coatings have a significant impact on fruit losses and post-harvest fruit storage [11] and [12]. A lot of research has concentrated on using natural substances and biocontrol agents in place of synthetic fungicides [13].

Application of edible coatings and dipping fruits in an edible material that can be eaten with fruit, non-toxic and eco-friendly is comparatively a new technique that can be used for prolonging post-harvest life and maintains the quality of fruit. Also,

has the ability to form a semi permeable covering on outer surface of the fruit that minimizes loss of water, reduces the rate of respiration, control metabolic and oxidative reactions inside the fruits as well as lower the chances of microbial attack [14]. Among these natural edible coating materials, Moringa is a small size tree. Every part of Moringa is used for certain nutritional and medicinal propose. Besides being a good source of protein, vitamins, oils, fatty acids, micro-macro minerals elements and various phenolics, it is also reported as anti-inflammatory, antimicrobial, antioxidant, anticancer, cardiovascular, hepatoprotective, anti-ulcer, diuretic, ant-urolithiasis, and anthelmintic. Its multiple pharmaceutical effects are capitalized as therapeutic remedy for various diseases in traditional medicinal system [15].

Moringa extracts applied to fruits and vegetables enhance texture quality, retain volatile components, inhibit respiration, and lower microbiological growth [16]. Moringa is well known for its capacity to prevent degradation of perishable fruit goods when used as a coating agent. Moringa seed extract presents a promising strategy for maintaining fruit quality, increasing shelf life, and improving the sustainability of fresh food, especially when added to edible coatings [17]. Plant disease-causing bacteria and fungus may be controlled by these extracts, which show promise as natural antibacterial agents [18]. As described by [17] that a postharvest treatment (2%) of moringa leaf, and seed extracts stored at 5.5 °C for 21day, improved avocado fruit quality and disease control. The treatment resulted in higher fruit firmness, lower mass loss, ethylene, and respiration rates, and improved storage life of fruit. [19] studied treatment mango fruit with moringa leaf extract (2.5%, 5%, and 10%) at 10°C with 90-95% relative humidity stored up to 6 weeks result proved that all treatments have a positively reduced weight loss, decay, acidity, while enhancing TSS, TSS/acid ratio, vitamin C, antioxidant activity and total phenols but 10% were obtained more effectives for preserve quality of mango fruit. [20] examined that moringa leaf extract at 10% was found to be more successful than other treatments in terms of reducing weight loss, softening and preserving titratable acidity, total carotene, total phenolics, total flavonoids, and antioxidants activity in plum fruits.

[21] evaluated that Moringa leaves extracts (200 g/100 ml) significantly improved fruit quality parameters of persimmon fruit, preserve fruit weight, pH, titratable acidity, fruit firmness, vitamin C, Total soluble solid, TSS/acid ratio, even up to 28 days of storage. [22] cleared that 5% MLE slowing down the ripening process and preserving peach fruit quality throughout storage. Carboxyl methylcellulose (CMC) is a long-chain, anionic linear molecule with a high molecular weight that is derived from cellulose [23]and [24]. CMC-based natural coatings are typically odorless, tasteless, biodegradable, nontoxic, and nonallergenic. CMC coatings postpone fruit ripening and have antifungal and antisenescence properties. Due to its commercial availability and low cost, CMC is a well option for preserving fruit quality and increasing fruit shelf life [25] and [26]. As reported by [27] the application of CMC (2% w/v) with or without ZNONPs (20%, w/v) in persimmon fruit, cause decreased fruit weight loss and respiration rate, increased antioxidant compounds and firmness of fruit at 25□ and 65-70% (RH) for 15 days.[28] showed that postharvest application of the 1.5% CMC in bananas fruits stored at 20 ± 1 ºC about 15 day were caused increase in total soluble solids and higher titratable acidity, slow down ripening significantly delay decay incidence and physiological fruit weight loss and maintain higher firmness fruit. [29] examined the impact of (0, 0.5 ,1%) carboxymethyl on "Niuxin" persimmon fruit, The findings of this study are significant in terms of increasing storage time and maintaining higher SSC content values, as well as inhibiting the loss of TTA content and fruit firmness. [30] clarified that application of CMC resulted extending and improving postharvest qualitative characteristics of plum fruit.

Because there is a little information available about the treatment of persimmon fruit with plant extracts and natural edible coating, the aims of this study were to evaluate the effect of moringa leaf and seed extract, Carboxymethylcellulose on the storability of persimmon fruits and to improve fruits quality, also to delay ripening, reduce physiological disorders, and maintain desirable texture and flavor of fruit.

Materials and methods

Persimmon fruits at mature stage and medium sized of the cv. "Rojo Brillante" were manually harvested from trees of 9 years old at a commercial orchard located in Chrane, Duhok Governorate, Kurdistan region, Iraq, during early morning in 13 November 2024. Harvested fruits were transferred directly to the College of Agricultural Engineering Sciences, Central Laboratory. Sound, uniform-size fruit were maintained in a cold room for precooling to study the effect of three factor that be used in this experiment include (moringa leaf, moringa seed extract and Carboxymethyl cellulose) on the quality of persimmon fruits during storage, after that fruits were divided in to three groups, fruits of the first and second groups were dipped for 5 minutes in{Distilled water(control), 5 % and 10 %} moringa leaf and seed extract solution respectively. The third group of fruit were dipped in {Distilled water(control), 1%, 2%} Carboxymethyl cellulose solution for 3 minutes. After dipping, fruits were furnished on the cloth and air-dried, after that fruits were placed in punched white polyethylene bags. the bags were tied well then stored in cold storage at 1+1 °C with 85- 90% RH. The bags were opened for analysis after two months of storage period. experiment was laid out in factorial experiment with Complete Randomized Design (CRD), including three factors moringa leaf extract, moringa seed extract, carboxymethyl cellulose (3×3×3) with three replicates and 9 fruits for each replicate. Data were tabulated and statistically analyzed with the computer using SAS program [31]. The differences between various treatment means were tested with Duncan Multiple Range test at 0.05 level [32]. The following are the experiment's parameters.

Fruit firmness (lb.): The firmness of the fruit flesh was measured using a penetrometer 3/16 lb/cm^2[33].

Fruit Weight Loss%: fruit weights were recorded before storage and at the end of storage of the same fruits [34].

Ascorbic Acid (mg. 100 ml^{-1} juice), Total soluble solid%, Titratable acidity%, were determined as recommended in [35]. The ascorbic acid was measured with the titration method by using 2,6- Dichlorophenol indophenols. **(TSS%)** was determined by Hand Refractometer. While (**TA%)** was determined by juice titrated with (0.1N NaOH) phenolphthalein used as indicator respectively.

Pectin content (%): Depending on procedure mentioned by [36].

Tannin content (%): based on the method [37].

Results and Discussion

1-Fruit firmness (lb.): As indicated in Table (1) that both concentration of MLE, MSE at 5% and CMC at 2%, each alone significantly increased firmness of persimmon fruits compared to the control ,the finding results agree with those by [21].The increase might be due to MLE and MSE contains a high amount of calcium, and this mineral is very important for maintaining the structure of fruit tissues, which helps to strengthen the pectin network in the cell wall, which makes the fruit flesh firmer and slows down the softening process during ripening [38].The positive effect of CMC on fruit firmness attributable to the semi-permeable CMC film together with the bioactive phytochemicals from moringa that retard respiration and water loss as well as cell wall–degrading enzyme activity, thereby slowing softening during storage [28]. The combination of 5% MLE + 5% MSE + 2% CMC produced the highest firmness, suggesting a significant synergistic effect. Similar study [17] showed that combination CMC+ MSE+ MSE on avocado fruit observed that significantly reduced firmness loss.

2-Fruit Weight Loss (%): According to the Table (2), all concentrations (5, 10 % of both MLE, MSE and 1, 2% CMC) lowered the fruit weight loss (%) significantly in comparation with untreated fruits of the MLE, MSE and CMC, which recorded the maximum fruit weight loss. This results due to increased transpiration, the natural process of water loss from the fruits surface through evaporation in untreated fruit, while in MLE and MSE might be due to the high content of antioxidants and phenolic compounds in leaves and seeds which help maintain cell membrane integrity and reduce metabolic activity [39]and [40]. The decreased weight loss in fruits treated with CMC might be due to CMC-based coatings they offer barriers to oil and moisture transfer and help to maintain the firmness [41]. Also, [17] demonstrated that polysaccharide coatings carboxymethyl cellulose were able to retard weight loss in avocados. The triple interaction treatments cleared that the lowest fruit weight loss was recorded in interaction between 5% MLE + 5% MSE + 2% CMC compared with, the highest fruit weight loss from control.

Table (1): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on fruit firmness (lb.) of Rojo Brillante persimmon after 2 months of storage at 1+1°C.

MLE (%)	MSE (%)	CMC (%) 0	1%	2%	MLE X MSE	MLE Mean
0	0	5.33 h	5.67 hg	6.00 d-h	5.67 d	6.18 b
	5%	5.90 f-h	6.83 a-g	6.80 a-g	6.51 bc	
	10%	5.90 f-h	6.43 b-h	6.73 a-g	6.36 bc	
5 %	0	6.17 d-h	7.70 ab	7.37 a-d	7.08 a-c	7.25 a
	5%	7.50 a-c	7.33 a-e	8.00 a	7.61 a	
	10%	6.87 a-g	7.00 a-g	7.33 a-e	7.07 a-c	
10%	0	5.93 f-h	6.87 a-g	6.83 a-g	6.54 bc	6.90 a
	5%	6.40 b-h	7.20 a-f	7.80 ab	7.13 ab	
	10%	7.37 a-d	6.47 b-h	7.20 a-f	7.01 a-c	
MLE X CMC	0 MLE	5.82 d	6.20 cd	6.51 cd	MSE MEAN	
	5%MLE	6.84 a-c	7.34 a	7.57 a		
	10%MLE	6.57 bc	6.84 a-c	7.28 ab		
MSE X CMC	0 MSE	5.92 c	6.63 bc	6.73 b	6.43 b	
	5% MSE	6.60 bc	7.12 ab	7.53 a	7.09 a	
	10%MSE	6.71 b	6.63 bc	7.09 ab	6.81 ab	
CMC Mean		6.41 b	6.80 ab	7.12 a		

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

Table (2): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on the fruit weight loss (%) of Rojo Brillante persimmon after 2 months of storage at 1+1°C.

MLE (%)	MSE (%)	CMC (%) 0	1%	2%	MLE X MSE	MLE Mean
0	0	4.26 a	0.77 e	0.88 e	1.97 a	2.00 a
	5%	2.01 b-d	2.11 bc	2.16 bc	2.10 a	
	10%	1.74 d	2.11 bc	1.97 b-d	1.94 a	
5 %	0	2.02 b-d	2.11 bc	2.13 bc	2.09 a	1.42 b
	5%	2.20 bc	0.71 e	0.55 e	1.15 b	
	10%	1.88 cd	0.56 e	0.64 e	1.03 b	
10%	0	1.96 b-d	2.08 b-d	2.25 b	2.10 a	1.47 b
	5%	2.13 bc	0.64 e	0.65 e	1.14 b	
	10%	2.05 b-d	0.75 e	0.72 e	1.17 b	
MLE X CMC	0 MLE	2.67 a	1.67 c	1.67 c	MSE Mean	
	5%MLE	2.03 b	1.13 d	1.11 d		
	10%MLE	2.04 b	1.16 d	1.21 d		
MSE X CMC	0 MSE	2.74 a	1.65 d	1.76 cd	2.05 a	
	5% MSE	2.11 b	1.15 e	1.12 e	1.46 b	
	10%MSE	1.89 c	1.14 e	1.11 e	1.38 b	
CMC Mean		2.25 a	1.32 b	1.33 b		

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

3-Ascorbic Acid (mg. 100 ml^{-1} juice): Result in (Table 3) showed that the Fruit juice vitamin C was positively impacted by MLE. Fruit immersed in 5% MLE had a maximum vitamin C content that was noticeably higher than that of untreated fruit. MSE at 10%, CMC at 2% produced significantly highest vitamin C in persimmon fruits compared with Control fruit. Loss of vitamin C in untreated fruits may occur due to oxidation of L-ascorbic acid into dehydroascorbic acid by enzymatic action (such as
ascorbic acid oxidase), which is accelerated during storage [42]. The protective effect of moringa leaf extract can be attributed to their antioxidant phytochemicals, which inhibit enzymatic degradation. [43] reported that decreased of ascorbic acid degradation in fruit coated CMC could be due to oxygen diffusion is slowed down, which cause to prevents the oxidation of ascorbic acid in fruits due to enzymatic reactions. [19] found that MLE 5% Significantly increased compared with control in mango fruit. A combination of 5% MLE + 10% MSE + 1% CMC seems to be significant and the most effective combination for maintaining ascorbic acid

Table (3): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on ascorbic acid (mg.100ml^{-1}juice) of Rojo Brillante persimmon after 2 months of storage at 1+1°C.

MLE (%)	MSE (%)	CMC (%) 0	1%	2%	MLE X MSE	MLE Mean
0	0	7.20 f	9.39 c-e	8.44 d-f	8.34 d	8.89 b
	5%	8.64 d-f	10.14 b-e	8.91 c-f	9.23 cd	
	10%	9.27 c-e	8.21 ef	9.81 b-e	9.10 cd	
5 %	0	10.08 b-e	10.08 b-e	10.38 a-d	10.18 a-c	10.11 a
	5%	9.36 c-e	9.36 c-e	9.28 c-e	9.33 b-d	

	10%	8.65 d-f	12.24 a	11.52 ab	10.80 a	
	0	8.64 d-f	8.88 c-f	10.08 b-e	9.20 cd	
10%	5%	10.08 b-e	9.36 c-e	11.58 ab	10.34 ab	9.71 a
	10%	8.88 c-f	9.07 c-f	10.82 a-c	9.59 bc	
MLE X CMC	0 MLE	8.37 b	9.25 b	9.06 b	MSE Mean	
	5%MLE	9.36 b	10.56 a	10.39 a		
	10%MLE	9.20 b	9.11 b	10.83 a		
MSE X CMC	0 MSE	8.64 c	9.45 bc	9.63 bc	9.24 b	
	5% MSE	9.36 bc	9.62 bc	9.92 ab	9.64 ab	
	10%MSE	8.93 bc	9.84 ab	10.72 a	9.83 a	
CMC Mean		8.98 b	9.64 a	10.09 a		

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

during cold storage compared with control and most other interaction which recorded the lowest vitamin C.

4-Total soluble solid (TSS %): The results revealed that both of the treatments (5, 10% MLE and 1, 2% CMC) had a significant effect on the Total soluble solid compared with untreated fruits. MSE in both treatments showed no significant differences in Total Soluble Solid compared with control fruits as clarified in (Table 4). The increase in Total Soluble Solid content in treatment fruits is caused by a decrease in fruit water content and the transformation of cell wall components such starch, protein, pectin, and hemicelluloses into simple soluble sugars during storage [44]. The increased of Total Soluble Solids in the fruit treated with moringa leaves extract might be due to protective O2 barrier reduction of oxygen supply on the fruit surface, which inhibited respiration [45]. The results of the present investigated are in agreement with those found by [46], who noticed that MLE treatment significantly increased total soluble solid in plum fruit after cold storage.

Best interaction was observed in treatments combining 10% MLE + 0% MSE + 2% CMC which were significantly higher than some interaction treatments.

Table (4): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on TSS (%) of Rojo Brillante persimmon after 2 months of storage at 1+1°C.

MLE (%)	MSE (%)	CMC (%) 0	1%	2%	MLE X MSE	MLE Mean
	0	19.67 d	20.67 bc	19.33 d	19.89 c	
0	5%	19.67 d	20.67 bc	21.00 ab	20.44 b	20.26 c
	10%	19.33 d	21.00 ab	21.00 ab	20.44 b	
	0	21.00 ab	21.00 ab	21.33 ab	21.11 a	
5 %	5%	21.33 ab	21.00 ab	21.00 ab	21.11 a	21.11 a
	10%	21.00 ab	21.00 ab	21.33 ab	21.11 a	
	0	19.67 d	21.00 ab	21.67 a	20.78 ab	
10%	5%	21.00 ab	20.00 cd	21.33 ab	20.78 ab	20.81 b
	10%	21.00 ab	20.67 bc	21.00 ab	20.89 ab	
MLE X CMC	0 MLE	19.56 e	20.78 cd	20.44 d	MSE Mean	
	5%MLE	21.11 ab	21.00 a-c	21.22 ab		
	10%MLE	20.56 cd	20.56 cd	21.33 a		
MSE X CMC	0 MSE	20.11 c	20.89 ab	20.78 ab	20.59 a	
	5% MSE	20.67 ab	20.56 bc	21.11 a	20.78 a	
	10%MSE	20.44 bc	20.89 ab	21.11 a	20.81 a	
CMC Mean		20.41 b	20.78 a	21.00 a		

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

5-Titratable acidity (TA %): Treated fruit with 10 % MLE and 1% CMC recorded highest significantly differences in titratable acidity as compared with control. Fruit dipped in 10%MLE was significantly increased compared with 5% MLE. while 5% and 10% MSE showed no significant differences in titratable acidity compared with untreated as clarified in (Table 5). Our results were similar to those reached by [28]. According to the current study, the breakdown of organic acids into sugars during respiration may be the cause of the reduced acidity in uncoated fruits during storage.[47]. Fruits' acidity is caused by organic acids, which release hydrogen ions and cause the fruit's acidity to rise, which indicates the ripening and senescence stages of the fruit.[48].

Among all of combination treatments, the highest titratable acidity was present in fruits treated with (10% MLE + 0% MSE + 1% or 2% CMC) and (10% MLE + 5% MSE + 1% or 2% CMC) which was higher than the other interaction, indicating that this triple combination was most effective in retaining acidity.

6-Pectin content (%): The data cleared in (Table 6) that fruits treated with 5% , 10% MLE or MSE, and 1%, 2% CMC recorded significantly higher pectin values compared to untreated fruits, the increase in pectin was consistent with increased concentration, this might be attributed to the formation of a semi-permeable film that reduces oxygen uptake and respiration, slows the ethylene production, suppresses of pectin-degrading acidity enzymes such as polygalacturonase and pectin methyl esterase [49] and [50]. Moreover, MLE and MSE, which are rich in antioxidants and phenolic compounds, may have provided additional protection against enzymatic degradation by enhancing cell wall integrity and reducing oxidative stress [51] and [52].

The triple interaction demonstrated that the highest pectin content was observed in fruits treated with 5% MLE + 5% MSE + 2% CMC or 5% MLE + 0% MSE + 1% CMC which gave the highest value and was significantly differ than other interaction treatments except the interaction of 5% MLE + 0% MSE + 1% CMC. On the other hand, the lowest pectin content recorded from the interaction among 5% MLE + 0% MSE + 0% CMC.

Table (5): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on TA (%) of Rojo Brillante persimmon after 2 months of storage at 1+1°C

MLE (%)	MSE (%)	CMC (%) 0	CMC (%) 1%	CMC (%) 2%	MLE X MSE	MLE Mean
0	0	0.13 b	0.22 ab	0.13 b	0.16 b	0.18 b
	5%	0.18 ab	0.22 ab	0.22 ab	0.21 ab	
	10%	0.18 ab	0.22 ab	0.13 b	0.18 b	
5 %	0	0.22 ab	0.18 ab	0.18 ab	0.19 ab	0.20 b
	5%	0.22 ab	0.22 ab	0.13 b	0.19 ab	
	10%	0.18 ab	0.22 ab	0.22 ab	0.21 ab	
10%	0	0.13 b	0.27 a	0.27 a	0.22 ab	0.23 a
	5%	0.22 ab	0.27 a	0.27 a	0.25 a	
	10%	0.22 ab	0.22 ab	0.22 ab	0.22 ab	
MLE X CMC	0 MLE	0.16 b	0.22 ab	0.16 b	MSE Mean	
	5%MLE	0.21 ab	0.21 ab	0.18 b		
	10%MLE	0.19 ab	0.25 a	0.25 a		
MSE X CMC	0 MSE	0.16 b	0.22 ab	0.19 ab	0.19 a	
	5% MSE	0.21 ab	0.24 a	0.21 ab	0.22 a	
	10%MSE	0.19 ab	0.22 ab	0.19 ab	0.20 a	
CMC Mean		0.19 b	0.23 a	0.20 ab		

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

7-Tannin content (%): The result in (Table 7) clarified that all treatment means (MLE, MSE, CMC) produce higher tannin content, especially the application of 10% MLE, 10% MSE, and 1% CMC significantly increased the tannin content compared with control. The lowest tannin content found in untreated fruits of MLE, MSE and CMC. Tannins are phenolic compounds

that produce astringency and turbidity in fruit juices [53]. Tannin content is important in fruit ripening and senescence, and it typically decreases over time during storage [54].

The decreased of soluble tannins in control could be attributed to the formation of a complex between the tannin and pectin released in the cell wall during tissues softening. throughout postharvest, the soluble tannin disintegrates and becomes insoluble after combining with pectin [55]. However, the triple interaction of 10% MLE + 10% MSE + 0% CMC, resulted in a significantly higher tannin value compared all other interactions except the triple interaction among 10% MLE, 10%MSE and 2%CMC.

Table (6): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on pectin content (%) of Rojo Brillante persimmon after 2 months of storage at 1+1°C.

MLE (%)	MSE (%)	CMC (%) 0	1%	2%	MLE X MSE	MLE Mean
0	0	0.92 ij	0.99 g-j	0.92 ij	0.94 d	1.06 b
	5%	1.12 d-h	1.08 d-i	1.15 c-g	1.12 c	
	10%	1.05 f-j	1.15 c-g	1.15 c-g	1.12 c	
5 %	0	0.89 j	1.49 a	1.45 ab	1.27 a	1.18 a
	5%	1.02 f-j	0.95 g-j	1.49 a	1.15 bc	
	10%	1.02 f-j	1.13 c-g	1.17 c-f	1.11 c	
10%	0	1.07 d-i	1.08 d-i	1.09 d-i	1.08 c	1.19 a
	5%	1.25 cd	1.24 c-e	1.24 c-e	1.24 a	
	10%	1.30 bc	1.24 c-e	1.17 c-f	1.23 ab	
MLE X CMC	0 MLE	1.03 cd	1.07 c	1.07 c	MSE Mean	
	5%MLE	0.97 d	1.19 b	1.37 a		
	10%MLE	1.21 b	1.18 b	1.17 b		
MSE X CMC	0 MSE	0.96 c	1.18 b	1.15 b	1.10 b	
	5% MSE	1.13 b	1.09 b	1.29 a	1.17 a	
	10%MSE	1.12 b	1.17 b	1.16 b	1.15 a	
CMC Mean		1.07 c	1.15 b	1.20 a		

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

Table (7): Effect of Moringa leaves and seeds extract, carboxymethyl cellulose and their interactions on Tannin content (%) of Rojo Brillante persimmon after 2 months of storage at 1+1°C.

MLE (%)	MSE (%)	CMC (%) 0	1%	2%	MLE X MSE	MLE Mean
0	0	2.43 f	3.11 d-f	3.20 df	2.91 c	3.07 b
	5%	3.11 d-f	3.20 de	3.08 d-f	3.13 bc	
	10%	3.17 de	3.34 c-e	2.99 d-f	3.17 bc	
5 %	0	2.92 d-f	3.99 bc	3.52 cd	3.48 b	3.32 a
	5%	2.92 d-f	3.49 de	3.45 c-e	3.28 bc	
	10%	2.77 ef	3.64 cd	3.21 de	3.20 bc	
10%	0	3.24 de	3.19 de	2.98 d-f	3.14 bc	3.52 a
	5%	3.26 de	3.49 c-e	3.02 d-f	3.25 bc	
	10%	4.71 a	3.28 de	4.50 ab	4.17 a	
MLE X CMC	0 MLE	2.90 d	3.22 b-d	3.09 cd	MSE Mean	
	5%MLE	2.87 d	3.70 a	3.39 a-c		
	10%MLE	3.74 a	3.32 bc	3.50 ab		
MSE X	0 MSE	2.86 c	3.43 ab	3.24 a-c	3.18 b	
	5% MSE	3.10 bc	3.39 ab	3.18 a-c	3.22 b	

CMC	10%MSE	3.55 a	3.42 ab	3.57 a	3.51 a
	CMC Mean	3.17 b	3.41 a	3.33 ab	

Means followed by the same letters did not differ significantly according to Duncan's test at 0.05 level.

Conclusion

Depending on the results of this study, it can be concluded that persimmon fruits treated with edible coatings of moringa leaf extract, moringa seed extract and carboxymethyl cellulose, whether applied alone or in combination, were effective in reducing (fruit weight loss and maintaining firmness, as well as preserving total soluble solids, titratable acidity, vitamin C, pectin, and tannin content) compared to untreated fruits after two months of cold storage. The combination between (5% MLE + 5% MSE + 2% CMC) was the best interaction in reduce fruit weight loss, increase fruit firmness and pectin content. Overall, the application of moringa leaf extract, seed extract and carboxymethyl cellulose proved to be a promising approach for maintaining the postharvest quality and extending the storability of persimmon fruits.

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دراسة تأثير مستخلص أوراق المورينغا والبذور والكربوكسي ميثيل السليلوز على قابلية تخزين ثمار الكاكي من الصنف روجو بريلانتي

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الخلاصة

أُجريت هذه الدراسة على ثمار الكاكي من الصنف "***Rojo brillante***"، والتي تم الحصول عليها من بستان تجاري يقع في قرية جرانى، محافظة دهوك، إقليم كردستان، العراق، وذلك بهدف دراسة تأثير غمر الثمار في محاليل مستخلص أوراق المورينجا (ماء مقطر، 5%، 10%) ومستخلص بذور المورينجا (ماء مقطر، 5%، 10%) لمدة خمسة دقائق، وكذلك في محلول كاربوكسي ميثيل سيليلوز (ماء مقطر، 1%، 2%) لمدة ثلاث دقائق على جودة ثمار الكاكي بعد شهرين من التخزين البارد عند درجة حرارة (1±1 م°) ورطوبة نسبية 85-90 % تم تسجيل البيانات المتعلقة بصلابة الثمار، ونسبة الفقدان في الوزن، ومحتوى حمض الأسكوربيك، والمواد الصلبة الذائبة الكلية، والحموضة المعايرة، ومحتوى البكتين والتانين.%أوضحت النتائج أن جميع المعاملات (مستخلص أوراق المورينجا، مستخلص بذور المورينجا، وكاربوكسي ميثيل سيليلوز) أدت إلى انخفاض معنوي في نسبة فقدان وزن الثمار. كما أن معاملة الثمار بـ 5% من مستخلص أوراق المورينجا و2% من وكاربوكسي ميثيل سيليلوز أدت إلى زيادة في نسبة المواد الصلبة الذائبة الكلية وفي محتوى فيتامين ***C***، بالإضافة إلى الحفاظ على صلابة الثمار مقارنة بالثمار غير المعاملة. كانت الثمار المعاملة بـ 5% من مستخلص بذور المورينجا الأفضل في الحفاظ على صلابة الثمار، بينما أعطت معاملة 10% من مستخلص بذور المورينجا أعلى محتوى من فيتامين ***C*** و التانين%.كما لوحظت زيادة معنوية في الحموضة الكلية والتانين في الثمار المعاملة بـ 10% من مستخلص أوراق المورينجا و1% من كاربوكسي ميثيل سيليلوز. وقد تم الحفاظ على محتوى البكتين بشكل أفضل في الثمار المغطاة ب (مستخلص أوراق المورينجا، مستخلص بذور المورينجاو كاربوكسي ميثيل سيليلوز). أظهرت التفاعلات بين المعاملات تأثيراً إيجابياً ومعنوياً على الصفات النوعية لثمار الكاكي.

الكلمات المفتاحية: المورينجا، كاربوكسي ميثيل السليلوز، ما بعد الحصاد، الكاكي، التخزين.