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ANTI-TRANSPIRATION EFFECT OF DISPER CU ^{MAX}, PACKAGING METHOD, AND ENCAPSULATION ON SOME STORAGE CHARACTERISTICS OF POMEGRANATE, *PUNICA GRANATUM*

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ABSTRACT

The experiment was conducted on the pomegranate fruits, salimi cultivar in a cold store belonging to the College of Agriculture, University of Diyala, and the chemical properties were measured in the laboratory of the College of Agriculture, Department of Horticulture and Landscaping, University of Diyala, where pomegranate fruits of almost identical size and weight were selected from an orchard in Al-Wajihiya district during the agricultural season (2021), where the pomegranate fruits were taken on 11/20/2121. A factorial experiment was conducted with two factors, the first factor included the anti-transpiration of Disper Cu ^{Max} with three concentrations: 0, 400, and 600 mg. L^{-1}, the second factor included three packing methods for pomegranate fruits: without packing (the control treatment), polyethylene bags, and paper bags.The results were analyzed according to Duncan's polynomial test at a probability level of 0.05, and the results showed that the treatment of fruits with the anti-transpiration Disper Cu ^{Max} had a significant effect, as the concentration of 600 mg. L^{-1} led to a decrease in the change of the weight percentage, the percentage of fruits damage, the change of the respiratory percentage, and it was superior in the change of the total acidity percentage, as well as giving the least amount of change in the percentage of fruit firmness and the highest percentage of change in the anthocyanin pigment compared to the control. The percentage of change in total soluble solids (TSS) was not significantly affected by the anti-transpiration of Disper Cu ^{Max} and packaging methods compared to the control treatment. The packaging methods had a significant effect on the results of the study, where the polyethylene bags led to a reduction in the percentage of fruits weight loss and the paper bags reduced the change in the percentage of fruit damage and reduced change in the respiratory percentage, and also gave the highest percentage of fruit firmness and the highest percentage of anthocyanin pigment. The two methods of packing did not differ in the amount of change in the percentage of total acidity compared with the control treatment.

Key words: Pomegranate, Disper Cu ^{Max} and packing methods

INTRODUCTION

Pomegranate (*Punica granatum* L.) belongs to punicaceae family. It is one of the important fruit crops for food and health. Its fruits are used for fresh consumption and processing. Interest in pomegranate fruits has increased recently due to their high content of nutrients and antioxidants such as sugars, vitamins, minerals, anthocyanins, flavonoids, phenols, and tannins in the juice of the grains and the peel and pulp of the fruit **(Mirdehghan and Rahemi, 2007; Ismail et al., 2012; Abid et al., 2017).** Local pomegranate fruits are available in local markets from late summer until the beginning or middle of winter **(Al-Jumaili and Al-Dujaili, 1989)**, they are non-climacteric fruits, so they must be harvested at the final maturity stage in order to have the best qualities in terms of taste, flavor, and color **(Melgarejo, 1993; Al-Shamri 2014)**, which delays the date of their appearance in the market, as is the case in the Salimi cultivar under study. In order to meet the increasing demand for pomegranate fruits and provide them in the local market for the longest possible period, it was necessary to take care of the storage process. It was noted through experiments that the pomegranate fruits are sensitive to cold storage conditions, as they face weight loss problems and cold damage, and that the appropriate storage conditions for pomegranate fruits are at a temperature of 5-7 ° C with a relative humidity of 95–95%, as the temperature and relative humidity are important in preventing the drying of the fruit peel and weight loss **(Ardense et al. 2014; Kahramanoglo, Usanma 2016)**. The use of anti-transpiration leads to prolonging the storage life of the fruits and maintaining them in the best possible condition, as these substances reduce the speed of evaporation and transpiration as they act as a barrier that leads to restricting the transfer of water to the outside of the fruit and protecting its peel through partial closure of the stomata on the peel, then delaying its dehydration and reducing weight loss **(Bisen et al., 2012)**. Packaging is an ideal way to preserve stored fruit as it is inexpensive and easy to use. The choice of packaging materials is very important because the permeability of the used packaging leads to the formation of an appropriate environment inside the closed package, and this environment surrounds the packed fruit **(Jacobsson et al., 2004)**. Adjusting the concentration of oxygen and carbon dioxide inside the packages helps maintain fruit quality by reducing the respiration rate, reducing ethylene production, and reducing the physiological deterioration of fruits during storage **(Rocha et al., 2003).** This experiment was conducted with the aim of maintaining the qualitative and marketing characteristics and reducing the damage caused to the fruits after harvesting, as well as prolonging their storage life by determining the best level of anti-transpiration and the best packaging method, thus prolonging the period of its presentation in the market and delivering it to the consumer with the best quality.

Materials and Methods

An experiment was conducted on the pomegranate fruits of the Salimi cultivar in one of the special cold stores in Diyala Governorate, Baqubah, for the period from 20 November 2021 to 4 April 2022. The fruits were brought from trees planted in a private orchard in Al-Wajihiya district, Diyala governorate. The homogeneous fruits were selected, and the infected and injured fruits were excluded. They were then cleaned with water, and the fruits were left to dry before being treated and stored. Initial measurements of the studied traits and the necessary chemical analyses were carried out in the central laboratory of Diyala University, College of Agriculture, Department of Horticulture and Landscaping before the fruits were treated and stored. The fruits were treated with anti-transpiration materials, filled with different methods of packing materials, and stored in the refrigerated store at a temperature of (6 ± 1) Celsius for 5 months **(Al Shammari, 2017).**

Experimental treatments

The research included the study of two factors, the first factor is the effect of immersion with anti-transpiration (DISPER Cu ^{MAX}), and with three concentrations, the first concentration included immersion of fruits in distilled water only (comparison), the second concentration included immersion of fruits with anti-transpiration (400 mg L^{-1}), and the third concentration included immersion of fruits with anti-transpiration (600 mg L^{-1}). The fruits were dipped in anti-transpiration material for only two minutes and left to air dry. The second factor is the method of packaging, where three methods were used: without packing (comparison), packing with polyethylene bags, and packing with paper bags.

The factorial experiment was carried out with a weight of 2 kg of fruits for each experimental unit, and with three replications, all experimental units were 27. The results were analyzed using the SAS program, and the averages were compared using Duncan's polynomial test at a probability level of 0.05 **(Al-Rawi and Khalaf Allah, 2000).**

Studied traits

1-Percentage of weight loss after storage (%)

It was calculated according to the following equation:

Weight loss % = (fruit weight before storage) - (fruit weight after storage) / (fruit weight before storage) X100

2-Percentage of physiological damage (%)

It was calculated on the basis of the number of damaged fruits after the end of the storage period divided by the total number of fruits as mentioned **in Al-Ani et al. (1989)** and **Mitra (1997)**, and according to the following equation:

Physiological damage % = (number of damaged fruits) / (total number of fruits)X 100

3-Percentage of change in total soluble solids%

Measurements were taken using a digital refractometer by placing 1-3 drops of clear juice on the measuring glass of the device and recording the reading directly, cleaning the place of the drops with distilled water, and adjusting the device before taking each reading of the fruits before and after storage.

% change in total dissolved solids = device reading before storage - device reading after storage / device reading after storage * 100 **(Khaled et al. 2014).**

4-Percentage change in fruit respiration rate (CO_2mg) / (kg.hour)

The speed of respiration was measured by taking a specific weight of pomegranate fruits and placing them in a disketter after placing an amount of 20 ml of sodium hydroxide (0.1 caliber), then closing the device tightly and placing it at room temperature for 24 hours, then the base NaOH (0.1 caliber) with HCl was placed in a burette using phenolphthalein dye (a reagent) for fruits before and after storage, the following equation was applied:

(CO_2 mg /kg. hour) = (Amount of base x standard - acid amount x standard x 22)/(weight of fruits x time)

Percentage change in respiratory rate % = respiratory rate before storage - respiratory rate after storage / respiratory rate after storage * 100 **(Khaled et al. 2014)** .

5-Percentage change in total acidity (%)

Five ml of juice was taken and diluted by adding 5 ml of distilled water with the addition of three drops of phenolphthalein dye (a reagent), then it was placed in a burette with sodium hydroxide

(NaOH) solution (0.1 caliber), and the total acidity was calculated on the basis of the citric acid prevailing in the pomegranate fruits before and after storage according to the following equation:-
Total acidity percentage = (base volume x standard x equivalent weight to citric acid) / (juice volume) x 100
Percentage change in total acidity % = acidity before storage - acidity after storage / acidity after storage * 100 **(Khaled et al. 2014).**

6-Percentage change in fruit firmness %

The firmness of the fruits was measured before and after storage to determine the change in the firmness of the fruits after the end of storage by using a fruit firmness tester. Percentage change in fruit firmness % = device reading before storage - device reading after storage / device reading after storage* 100 **(Khaled et al. 2014).**

7-Percentage change of anthocyanin dye mg 100 ml $^{-1}$

Anthocyanins were estimated in fruit juice according to **Ranganna (1986).** Five ml of clear juice (the compound sample) was taken and placed in a test tube of 10 ml capacity, 5 ml of extraction solution was added (ethanol 95% and hydrochloric acid 5.1 N at a ratio of 85:15 for each, respectively), and then a centrifugation process was carried out for 3 minutes at 3000 rpm. The sediment was excluded, and the filtrate was taken and completed to 10 ml with the extraction solution (acidified alcohol), and the light absorption was read by a spectrophotometer at the wavelength of 535 nm for the fruits before and after storage and the following equation was applied with a dilution of samples with high concentrations of dye:
Anthocyanin mg 100 ml $^{-1}$ = (dilution x 100 device reading x solution volume) / (sample volume * 98.2) * dilution * 100
Percentage change in anthocyanin dye mg 100 ml -1 = before storage - after storage / after storage * 100 **(Khaled et al. 2014).**

RESULTS

Data presented in Table (1) revealed that anti-transpiration 600 mg L^{-1} was significantly superior in decreasing the weight loss and physiological damage, reaching 8.7933 % and 2.2222 % respectively, followed by anti-transpiration 400 mg L^{-1} as compared with the control treatment, , and physiological damage in the fruits. While the interaction between the anti-transpiration and the packaging method was significant, where the anti-transpiration of 600 mg L^{-1} with the paper bags achieved the lowest rate in weight loss and physiological damage, reaching 8.7000% and 0.0000% respectively. There were no significant differences in total soluble solids between the anti-transpiration and the packaging methods. The anti-transpiration 600 mg L^{-1} and paper bags were separately superior in increasing the fruit respiration rate, reaching -8.3067% and -11.05 % respectively, as compared with the control treatment. As for the interaction between packaging methods and anti-transpiration, the polyethylene bags with the anti-transpiration 600 mg L^{-1} recorded the highest mean in the fruit respiration rate -6.2333%. The anti-transpiration 600 mg L^{-1} was superior in increasing the total acidity and anthocyanin dye, reaching 25.603 % and 3.07556 % respectively, as compared with the control treatment, whereas paper bags recorded the highest mean in the total acidity and anthocyanin dye, reaching 24.736 % and 2.81667 % respectively as compared with the control treatment that recorded the lowest mean. As for the interaction between packaging methods and anti-transpiration, the paper bags and the anti-transpiration 600 mg L^{-1} recorded the highest mean in the total acidity 37.863 %, whereas the treatment (without packing) and the anti-transpiration 600 mg L^{-1} recorded the highest mean in the anthocyanin dye 3.4333 %.The highest fruit firmness was recorded in the control treatment, which amounted to 20.9278%, compared with the anti-transpiration treatment at a concentration of 600 mg L^{-1} also packing with paper bags significantly outperformed the rest of the packing methods in fruit firmness, which amounted to 13.0433%. The interaction also had a significant effect on the percentage change in fruit firmness, as it was the highest value when the interaction between anti-transpiration treatment at a concentration of 400 mg L^{-1} and packing with paper bags, which amounted to 19.183% compared with the other of the treatments.

Table 1. Effect of the anti-transpiration of Disper Cu ^{Max} and packaging method on pomegranate fruit characteristics in cold storage

Weight loss %				
anti-transpiration of DISPER Cu ^{MAX} mg L^{-1}	Packaging method			Mean
	without packing	Polyethylene bags	Paper bags	
0	14.2967 a	11.1933 b	12.1300 b	12.5400 A
400	12.0433 b	8.7700 c	10.5033 b	10.4389 B
600	10.4700 b	7.2100 c	8.7000 c	8.7933 C
Mean	12.2700 A	9.0578 C	10.4444 B	
Physiological damage %				
0	20.4367 a	15.1200 b	10.5500 d	15.3689 A
400	12.7300 c	11.0367 dc	6.8067 e	10.1911 B
600	6.1200 e	0.5467 f	0.0000 f	2.2222 C
Mean	13.0956 A	8.9011 B	5.7856 C	
Total soluble solids %				
0	19.490 c	8.033 ab	5.610 ab	11.044 A
400	10.047 abc	6.260 ab	14.020 cb	10.109 A
600	6.343 ab	12.743 cb	2.850 a	7.312 A
Mean	11.960 A	9.012 A	7.493 A	
Fruit respiration rate %				
0	-17.7467 a	-15.3033 b	-15.5533 b	-16.20 A
400	-14.2267 c	-11.6367 d	-13.7633 c	-13.20 B
600	-11.1300 d	-6.2333 f	-7.5567 f	-8.3067 C
Mean	-14.36 A	-12.29 B	-11.05 C	
Total acidity %				

0	11.890 c	19.260 bc	17.880 bc	16.343 B
400	11.030 c	19.847 bc	18.463 bc	16.447 B
600	10.507 c	28.440 ab	37.863 a	25.603 A
Mean	11.142 B	22.516 A	24.736 A	
Fruit firmness %				
0	23.477 a	21.137 ab	18.170 b	20.9278 A
400	4.437 c	3.083 c	19.183 b	8.9011 B
600	2.877 c	3.667 c	1.777 c	2.7733 C
Mean	10.2633 B	9.2956 B	13.0433 A	
Anthocyanin dye %				
0	2.0200 dc	2.3033 bc	1.8200 de	2.04778 C
400	1.5400 e	2.1533 c	3.3467 a	2.34667 B
600	3.4333 a	2.5100 b	3.2833 a	3.07556 A
Mean	2.33111 B	2.32222 B	2.81667 A	

DISCUSSION

The results of Table (1) showed that there was a significant effect of treatment with physiological damage, reducing the percentage of change in the fruit respiration rate, as well as giving the highest value of acidity and reducing the percentage of change in the fruit firmness, it also gave the highest value in the percentage of anthocyanin dye.

The use of anti-transpiration materials was superior in giving the highest percentage of the above-mentioned traits compared to the comparison treatment. The reason is attributed to the fact that the anti-transpiration materials have an effect similar to that of wax, which may work to form an insulating waxy layer surrounding the fruits treated with these materials, covering the stomata on the surface of the outer layer of the fruit, and then working to reduce water evaporation and moisture loss of the fruits, then keep a moisture level for the longest period **(AL -Rawi and Chacravarty, 1988; Al-Amiri, 2001; Al-Bayati, 2020).** It was found that packing with perforated polyethylene bags improved the previous traits as compared with the control treatment. The reason is attributed to the fact that polyethylene bags play an important role in preserving the fruits by preventing them from losing moisture and maintaining their quality for as long as possible. This is also due to the physical structure of the bags, which are impermeable to water and air. Hence, the relative humidity increases to reach a level equivalent to the relative humidity level in the plant tissues, and then the transpiration process almost stops and a higher humidity is maintained inside the covers **(Ben, 1985)**, and this agrees with **(Al-Bayati 2020).** In addition, when compared to the other treatments, packing with paper bags resulted in a lower percentage of fruit damage, a lower percentage of acidity change, and the highest percentage of anthocyanin dye change. This is due to the fact that paper bags keep the lowest level of carbon dioxide inside the packages, which shows an inhibitory effect on the growth of fungi **(Li and Kader, 1989).** These results are consistent with those of **(Selcuk and Erkan, 2016).**

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