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The Effect of Acetaldehyde Vapor and Hot Water Postharvest Treatments on Quality and Reducing Chilling Injury of Persimmon 'Costata' Fruits

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AN EXPERIMENT with different postharvest treatments consisting in dipping in hot water at (45, 55, 60°C) for 15min. and fruits exposed to acetaldehyde vapor (10ml/kg fruits) carried out during 2013 and 2014 seasons on' Costatat' persimmon fruits are given in this paper. In all treatments the fruits were stored at 0°C and 90% relative humidity (RH)to reduce chilling injury and improving eating quality of the fruits under test were determined for chilling injury percentage, weight loss, peel color, firmness, soluble solids content (SSC) , titratable acidity percentage and tannins content. Results indicate that during the cold storage periods weight loss, chilling injury and SSC percentage increase while firmness, acidity, color and tannins content decreasing.

They also showed that fruits treated with acetaldehyde vapor(10ml/kg fruits) and hot water at 55°Cgave the highest values of lightness, fruit firmness, soluble solid content and lowest value of hue angle (high density of orange color), weight loss percentage, chilling injury% and titratable acidity % without significant differences between the two treatments.

Keywords: Persimmon, Hot water, Acetaldehyde vapor, Cold storage, Chilling injury and Fruit quality.

Persimmon (*Diospyros kaki L*.), was originally cultivated in China and Japan. Persimmon fruits are good source of carbohydrates organic acids, vitamins (mainly A and C), minerals, phenolic compounds, dietary fiber and carotenoids. (Homnava *et al*. 1991, Senter *et al*.1991).The beneficial effect of postharvest heat treatments to reduce chilling injury (CI) during cold storage has been shown in different horticultural crops (Fallik, 2004).Heat treatment has been shown to reduce susceptibility of some persimmons cultivars to CI. This phenomenon has observed both in hot air treated" Fuyu" (Woolf *et al*., 1997), hot water treated"Fuyu" (Burmeister *et al*., 1997 and Lay-yee *et al*., 1997). Also, preliminary results for the cultivar Karaj under hot water treatments, applied at 45°Cfor 30 min or 50°Cfor 20min, indicated that its postharvest quality was maintainedduring storage for up to 2 months (Khademi *et al*., 2012). It has been also observed that postharvest treatments of fruits with acetaldehyde vapor reduce the solubility of tannins with time after removal astringency, high concentrations of acetaldehyde vapor increase the residual tannins (Taira *et al*.,

1999). In order to study the effect of acetaldehyde vapor and hot water postharvest treatments on fruit quality and reducing chilling injury of persimmons the following experiment was carried out

Materials and Methods

Mature orange-color of persimmon fruits cv. "Costata" during two successive seasons (2013 and 2014) used in this experiment were harvested from a private orchard in El-Monofiya governorate. Fruits were sorted for size uniformity and absence of defects. Sound fruits were divided into five groups (each treatment containing 90 fruits).

The first group was dipped in hot water (HW) at 45°Cfor 15 min. The second group was dipped in hot water (HW) at 55°C for 15min. The third group of fruits was dipped in hot water (HW) at 60°C for 15min. The fourth group of fruits was exposed to acetaldehyde vapor 10 ml each one kilo gram. The fifth group of fruits was none treated and serves as control. For each treatment represented 3 replicates. All treatments were stored at 0°Cand 90% relative humidity (RH). The changes in physical and chemical properties of fruits were evaluated every two weeks from the beginning to the end of storage period.

Physical characteristics

Weight loss percentage: It was calculated according to the following equation:

$$\text{Weight loss (\%)} = \frac{\text{Initial weight} - \text{weight at sampling date}}{\text{Initial weight}} \times 100$$

Ten fruits were labeled in every replicate and initially weighed to calculate the fruits weight loss percent during the cold storage in relation to its original weight.

Firmness (Lb/inch^2)

Pulp texture: was determined as Lb/inch^2 by using fruit pressure tester.

Peel Color

Lightness and hue angle were estimated using Minolta calorimeter (Minolta co. Ltd., Osaka, Japan) as described by described by Mc Gire, (1992).

Chilling injury percentage

It was calculated according to the following equation:

$$\text{Chilling injury \%} = \frac{\text{Number of fruit with chilling}}{\text{Total number of fruit}} \times 100$$

Chemical properties
Total Soluble solids (TSS)

Abbe refractometer was used to determine the percentage of total soluble solids in fruit juice.

Titratable acidity (%)

Total acidity was determined by titrating 5 ml of the extracted juice against 0.1 N of NaOH using phenolphthalein indicator, titratable acidity was expressed as percentage of malic acid (g malic acid/100ml juice) according to A.O.A.C., (2005).

Total tannins content (%)

Total tannins content was evaluated according to the method of Yeshajahu and Clifton, (1977)

It was calculated as g/100gfresh weight.

Statistical Analysis

The experimental design was Factorial Complete Randomized with three replicates, and all the obtained data were statistically analyzed according to Snedecor and Cochran (1980). The individual comparisons were carried out by using the least significant difference (LSD) according to Duncan's multiple range tests at the 5% level of probability.

Results and Discussion

Physical properties
Weight loss percentage

Data in Table 1 showed that ,the effect of heat treatments and acetaldehyde vapor on weight loss percentage of persimmon' Costata' cv. fruits during 2014 and 2015 seasons. Weight loss percentage was gradually increased toward the storage periods with significant differences among all storage period in both seasons of study. The weight loss attributed mainly to water loss from the fruit tissues and partially for the respiration. The later results agree with those reported by Wahba (2007).

All treatments reduced weight loss% than the control fruits, with significant difference between them in the two seasons. Hot water at 45and 55°C treatments recorded the lowest values of weight loss in the two seasons, respectively. These results agree with Tiwari *et al*. (2008) and Naweton *et al*. (2013) on persimmon fruits.

As for interaction, after 6weeks of storage control fruits treatments recorded the highest percentage of weight loss, while Hot water at 45^0C treatments recorded the lowest values of weight loss in the two seasons.

TABLE 1. The effect of acetaldehyde vapor and hot water postharvest treatments on weight loss percentage of persimmon 'Costata' fruitsstored at 0° C and 90%RH during 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	0	0.47	0.99	1.42	0.72
H.w at 55° C	0	0.79	1.13	1.89	0.95
H.w at 60° C	0	1.11	1.22	2.09	1.11
Acetaldehyde vapor	0	0.48	0.86	2.10	0.86
Control	0	1.32	1.67	2.73	1.43
Means B	0	0.83	1.22	2.09	
L.S.D. Value at 5%	A	B	A×B		
	0.3905	0.3493	0.7810		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	0	0.89	1.14	1.75	0.95
H.w at 55° C	0	0.52	1.03	1.86	0.85
H.w at 60° C	0	0.85	1.22	1.94	1.00
Acetaldehyde vapor	0	0.68	1.18	1.76	0.91
Control	0	1.06	1.43	2.06	1.14
Means B	0	0.80	1.20	1.87	
L.S.D. Value at 5%	A	B	A×B		
	0.1953	0.1746	0.3905		

Fruit firmness

As shown in Table 2, it is clear that firmness decreased with progress of storage periods. The hot water at 60° C treatments had the highest fruit firmness (17.60and17.86Lb/inch^2) during the 1st and 2nd seasons, respectively. On the contrary, fruit treated by hot water at 55° C treatment recorded lowest values of fruit firmness in both seasons. These results agree with those reported by Allan *et al.* (1997) on 'Fuyu' persimmon fruits. And, as indicated by can be explained by Yaman and Bayoindirli (2002) can be explained because the retention of firmness which occurred during storage could be due to the by retarded degradation of insoluble protopectins to the more soluble pectic acid and pectin. During fruit ripening depolymerization or shortening of chain length of pectin substances occurs with an increase in pectinesterase and polygalactronase activities

Concerning of the interaction, at the end of storage period the hot water at 60° C treatments had the highest fruit firmness in the both seasons. On the other hand, the least values of firmness were recorded with fruit treated by acetaldehyde vapor in the first season and hot water at 45°C in the second one.

TABLE 2. The effect of acetaldehyde vapor and hot water postharvest treatments on firmness (Lb/inch$^{2)}$ of persimmon 'Costata' fruits storedat 0°C and 90%RHduring 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	18.63	16.00	13.93	13.53	15.52
H.w at 55° C	18.63	14.67	14.10	12.77	15.04
H.w at 60° C	18.63	18.67	17.73	15.37	17.60
Acetaldehyde vapor	18.63	16.33	15.60	12.50	15.77
Control	18.63	16.80	15.50	15.17	16.53
Means B	18.63	16.49	15.37	13.87	
L.S.D. Value at 5%	A	B	A×B		
	0.9095	0.8135	1.819		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	18.93	16.30	13.70	13.03	15.49
H.w at 55° C	18.93	15.20	13.17	13.07	15.09
H.w at 60° C	18.93	18.93	15.13	18.43	17.86
Acetaldehyde vapor	18.93	17.57	16.13	13.33	16.49
Control	18.93	18.70	14.37	14.23	16.56
Means B	18.93	17.34	14.50	14.42	
L.S.D. Value at 5%	A	B	A×B		
	0.7875	0.7044	1.575		

Peel color

The data illustrated in Tables 3and 4 showed that tendencies of external color changes as hue angle (h°) and lightness (L^*) values of persimmon fruits.

As for lightness (L^* value), data showed that lightness (L^*) gradually decrease towards the end of the storage periods (6 weeks) with significant difference between them. Fruits treated by hot water at 60° C gave the highest values of L^*, while hot water at 45° C treatment recorded the lowest value in the two seasons.

Concerning the interaction no significant difference were recorded between them in the most cases. After 6weeks of storage, hot water at 60° C treatment recorded the highest value of L^*, while fruit treated by hot water at 45° C exhibited the least value in the two seasons.

Regarding to hue angle (h° value), data in Table 4 indicated that hue angle **(**h°) decreased (increase density of orange color) with the advance in cold storage periods. These results agreed with Wahba (2007).

Acetaldehyde vapor treatment gave the lowest value of h° (high density of orange color) in the two seasons. On the other hand, hot water at 60° C treatment recorded the highest value of h° in the two seasons. These results supported that of (Tiwari *et al.,* 2008) the fruit color is one of the main attributes of

persimmon fruits, which can determine the consumer acceptability and serving as an indicative of the harvest point of some fruits.

As for interaction after 6 weeks of storage, Acetaldehyde vapor treatment recorded the lowest value of h° (high density of orange color) in the two seasons.

TABLE 3. The effect of acetaldehyde vapor and hot water postharvest treatments on lightness (L^*) of persimmon 'Costata' fruits storedat 0° C and 90%RHduring 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	55.93	54.19	54.94	49.47	53.63
H.w at 55° C	55.93	55.08	53.72	51.56	54.05
H.w at 60° C	55.93	56.92	54.17	56.26	55.82
Acetaldehyde vapor	55.93	56.57	51.95	50.94	53.85
Control	55.93	58.08	58.90	47.32	55.06
Means B	55.93	56.17	54.74	51.09	
L.S.D. Value at 5%	A	B	A×B		
	2.764	2.473	5.529		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	57.03	58.31	50.26	50.87	54.12
H.w at 55° C	57.03	53.80	51.36	54.08	54.07
H.w at 60° C	57.03	53.76	56.24	58.19	56.31
Acetaldehyde vapor	57.03	53.91	52.51	52.12	53.89
Control	57.03	56.52	58.36	53.06	56.24
Means B	57.03	55.26	53.74	53.66	
L.S.D. Value at 5%	A	B	A×B		
	3.041	2.720	6.081		

Chilling injury percentage

Data in Table 5 clear that chilling injury percentage was increased gradually and significantly in both seasons with progress of storage period.Which results agreed with results obtained by Mousa and Orang (2014).

All treatments decreased the chilling injury percentage than control fruits.The lowest chilling injury percentage was recorded by hot water (55, 60° C) without significant difference between them. These results agreed with those obtained by Cristina *et al.* (2008) and Mousa & Orang (2014) on persimmon fruits. And can be explained because of that protection against chilling injury by heat treatment may be related to the accumulation of heat shock proteins (Fallik, 2004).

TABLE 4. The effect of acetaldehyde vapor and hot water postharvest treatments on hue angle (h °) of persimmon 'Costata' fruits stored at 0° C and 90%RH during 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	60.21	62.12	61.79	60.31	61.11
H.w at 55° C	60.21	64.56	61.31	59.34	61.36
H.w at 60° C	60.21	64.89	68.01	59.37	63.12
Acetaldehyde vapor	60.21	60.27	58.74	56.69	58.97
Control	60.21	53.58	63.25	63.61	62.66
Means B	60.21	61.08	62.62	59.87	
L.S.D. Value at 5%	A	B	A×B		
	1.880	1.681	3.759		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	63.47	66.66	60.73	58.88	62.44
H.w at 55° C	63.47	61.08	62.46	60.76	61.94
H.w at 60° C	63.47	61.54	68.63	62.76	64.03
Acetaldehyde vapor	63.47	61.19	62.10	56.37	60.78
Control	63.47	59.68	58.09	62.71	60.99
Means B	63.47	62.03	62.40	60.24	
L.S.D. Value at 5%	A	B	A×B		
	2.546	2.277	5.092		

As for the interaction after 6 weeks of storage, fruits treated by hot water at 55and 60° C were recorded the least percentage of chilling injury. On the contrary control fruit treatment gave the highest chilling injury percentage in the two seasons.

Chemical characteristics

Total Soluble solids percentage (TSS %)

Data in Table 6 cleared that totalsoluble solid (TSS%) of fruits gradually increased with the advance in cold storage. Significant differences between the treatments were obtained during storage periods at the most cases in the two seasons. These results agreed with Wahba (2007) and Dilawar *et al.* (2007) on persimmon fruits.

The highest percentages of TSS were obtained by the treatment with acetaldehyde vapor 10ml/kg for 30min (23.79 and 22.82%) in the two seasons, respectively. On the other hand, hot water at 60° C exhibited the lowest value of

TSS % (21.14 and 21.27%) in the first and second season, respectively. These results agreed with those obtained by Zisheng (2006) on persimmon fruits.

TABLE 5. The effect of acetaldehyde vapor and hot water postharvest treatments on chilling injury percentage of persimmon 'Costata' fruits stored at 0° C and 90% RH during 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	0	0	16	33	12.3
H.w at 55° C	0	0	5	16	5.3
H.w at 60° C	0	0	0	15	3.8
Acetaldehyde vapor	0	0	0	33	8.3
Control	0	0	16	75	22.8
Means B	0	0	7.4	34.4	
L.S.D. Value at 5%	A	B	A×B		
	1.608	1.439	3.217		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	0	0	16	33	12.3
H.w at 55° C	0	0	0	15	3.8
H.w at 60° C	0	0	0	16	4.0
Acetaldehyde vapor	0	0	0	33	8.3
Control	0	0	33	66	24.8
Means B	0	0	9.8	32.6	
L.S.D. Value at 5%	A	B	A×B		
	0.9587	0.8575	1.917		

The tendency of TSS to increase may be attributed to the quick conversion of insoluble solids to soluble ones beside the high rate of moisture loss Wahba (2007) on persimmon fruits. Moreover, Gouble *et al*. (2005) recorded that the increase in TSS during fruit development is normally linked to changes in fruit color and ethylene production.

Regarding of interaction significant differences were noticed in the most cases in the two seasons. After 6 weeks of storage, the highest values of TSS % were noticed by hot water at 45° C in the first season and acetaldehyde vapor in the second one. On the other hand control fruits treatments gave the least percentage of TSS in the two seasons.

Titratable acidity %

Data in Table 7 revealed that titratable acidity (TA %) increased with progress in storage period until 4 weeks and decreased after that. All treatments decreased TA% than the control, with significant differences between the treatments were obtained during storage periods at the most cases in the two seasons. This result agreed with those reported by Wahba (2007) and Abdel – Hafeez (2005) on Costata persimmon.

Changes in TA percentage with advanced of storage periods which could be due to the increase of its consumption in respiration activities as an organic substrate, Wahba (2007).

The least titratable acidity % was recorded by acetaldehyde vapor and hot water at 55°C treatments in both seasons. This is agreement with Zisheng (2006) and Tiwari *et al.* (2008) on persimmon fruits.

As for interaction, significant differences were noticed in the most cases in the two seasons.

TABLE 6. The effect of acetaldehyde vapor and hot water postharvest treatments on total soluble solids percentage of persimmon 'Costata' fruits stored at 0° C and 90%RH during 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	20.00	21.67	25.43	26.03	23.28
H.w at 55° C	20.00	21.00	22.60	23.47	21.77
H.w at 60° C	20.00	18.00	22.27	24.30	21.14
Acetaldehyde vapor	20.00	24.33	25.30	25.53	23.79
Control	20.00	22.00	24.23	22.30	22.13
Means B	20.00	21.40	23.97	24.33	
L.S.D. Value at 5%	A	B	A×B		
	1.105	0.9882	2.210		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	20.30	20.17	22.90	24.10	21.87
H.w at 55° C	20.30	21.73	23.23	25.47	22.68
H.w at 60° C	20.30	18.33	23.40	23.03	21.27
Acetaldehyde vapor	20.30	22.67	22.73	25.57	22.82
Control	20.30	22.33	21.80	22.57	21.75
Means B	20.30	21.05	22.81	24.15	
L.S.D. Value at 5%	A	B	A×B		
	1.316	1.177	2.632		

Total tannins content %

Data tabulated in Table 8 indicated that tannins content was decreased gradually towards the end of storage periods with significant difference between them, which agreed with results obtained by Del Bubba *et al.* (2009) and Wahba

(2007) also on persimmon fruits. The decrease in total tannins percentage with storage may be due to increasing the polymerization of tannins (Wahba, 2007).

Fruits treated by acetaldehyde vapor had the lowest tannins content compared to other treatments during two seasons. On the other hand, fruits treated by hot water at 45° C recorded the highest tannins percentage in both seasons. These results are agreement with Satoshi *et al.* (1999) and Satoshi *et al.* (2001) on persimmon fruits.

TABLE 7. The effect of acetaldehyde vapor and hot water postharvest treatments on acidity percentage of persimmon 'Costata' fruits stored at 0° C and 90 % RH during 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	0.26	0.28	0.32	0.08	0.24
H.w at 55° C	0.26	0.35	0.21	0.08	0.22
H.w at 60° C	0.26	0.30	0.17	0.11	0.21
Acetaldehyde vapor	0.26	0.21	0.21	0.13	0.20
Control	0.26	0.20	0.35	0.13	0.23
Means B	0.26	0.27	0.25	0.10	
L.S.D. Value at 5%	A	B	A×B		
	0.0738	0.0606	0.1476		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	0.28	0.22	0.29	0.12	0.23
H.w at 55° C	0.28	0.30	0.19	0.01	0.20
H.w at 60° C	0.28	0.30	0.19	0.14	0.23
Acetaldehyde vapor	0.28	0.23	0.19	0.09	0.20
Control	0.28	0.20	0.38	0.16	0.26
Means B	0.28	0.25	0.25	0.12	
L.S.D. Value at 5%	A	B	A×B		
	0.0369	0.0330	0.0738		

Regarding of interaction, after 6 weeks of storage, fruits treated by hot water at 60 ° C and acetaldehyde vapor recorded the least percentage of tannins while hot water at 45° C and 55° C gave the highest percentage in the both seasons.

TABLE 8. The effect of acetaldehyde vapor and hot water postharvest treatments on tannins percentage of persimmon 'Costata' fruits stored at 0° C and 90%RH during 2013 and 2014 seasons.

Storage periods (weeks) season 2013					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	1.90	1.75	1.70	1.05	1.60
H.w at 55° C	1.90	1.40	1.40	1.20	1.48
H.w at 60° C	1.90	1.45	1.40	0.50	1.31
Acetaldehyde vapor	1.90	1.10	1.15	0.50	1.16
Control	1.90	1.10	1.10	0.90	1.25
Means B	1.90	1.36	1.35	0.83	
L.S.D. Value at 5%	A	B	A×B		
	0.09039	0.08084	0.1808		
Storage periods (weeks) season 2014					
Treatments	**0**	**2**	**4**	**6**	**Means A**
H.w at 45° C	2.10	1.95	1.65	1.25	1.74
H.w at 55° C	2.10	1.50	1.25	1.15	1.50
H.w at 60° C	2.10	1.45	1.10	0.65	1.33
Acetaldehyde vapor	2.10	1.10	1.35	0.70	1.32
Control	2.10	1.05	1.05	0.95	1.29
Means B	2.10	1.41	1.28	0.94	
L.S.D. Value at 5%	A	B	A×B		
	0.1278	0.1143	0.2556		

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تاثير معاملات ما بعد الحصاد ببخار الاسيتالدهيد والماء الساخن على الجودة و تقليل اضرار البرودة لثمار الكاكى (صنف كوستاتا)

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اجريت الدراسة خلال موسمى ٢٠١٣و٢٠١٤ على ثمار الكاكى صنف كوستاتا بهدف دراسة تاثير معاملات مابعد الحصاد بغمر الثمار فى الماء الساخن على درجات (٤٥ و٥٥ و٦٠ درجة مئوية) لمدة ١٥ دقيقة و معاملة الثمار ببخار الاسيتالدهيد (١٠مل / كجم ثمار) .خزنت ثمار كل المعاملات على الصفر المئوى ورطوبة نسبية ٩٠ ٪ وذلك للتقليل اضرار البرودة والمحافظة على جودة الثمار وتم تقدير كلا من نسبة المئوية لاضرار البرودة والفقد فى الوزن واللون وكذلك صلابة الثمار ومحتواها من المواد الصلبة الذائبة الكلية ونسبة الحموضة ومحتوى التانينات .

واشارت النتائج انه بالتقدم فى فترات التخزين المبرد زادت معنويا نسبة الفقد فى الوزن واضرار البرودة ونسبة المواد الصلبة الكلية بينما قلت الصلابة و الحموضة واللون ومحتوى التانينات مع فترات التخزين خلال موسمى التجربة. وهناك فروق معنوية بين كل المعاملات. ووجد ان الثمار المعاملة ببخار الاسيتالدهيد ١٠مل /كجم والثمار المعاملة بالماء الساخن (٥٥درجة مئوية) لمدة ١٥ دقيقة أعطت معنويا افضل النتائج حيث انهم سجلو أعلى نسبة فى الصلابة واللون ومحتوى الثمار من المواد الصلبة الذائبة وأقل محتوى فى الثمار من التنينات و الحموضة الكلية واقل نسبة للفقد فى الوزن وأضرار البرودة وذلك بدون فروق معنوية بين هاتين المعاملتين.