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Article

Effect of Pre-Postharvest Modified Atmosphere (MA) Treatments on Some Physical and Chemical Properties of Barhee Dates During Cold Storage

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Abstract: The present study has been conducted during 2024 season on ten years-old Barhee date palms (phonix dactylifera L.) grown in sandy soil under drip irrigation in a private orchard. Bunches of the palms were subjected to six spraying treatments as follow: (control) sprayed with water only ; GA3 and naphthalene acetic acid (NAA) each at 50, 100 and 50 ppm respectively; Salicylic acid at 50, 50 and 100 ppm respectively; Boric acid and Calcium / boron each at 2000, 1500 and 1000 ppm respectively. GA3 and NAA treatments achieved the highest values of almost all fruit physical Properties and the highest content of TSS% percentage and total sugars content. All pre-harvest treatments especially GA3 recorded significantly highest fruit firmness; juice TSS%; total sugars content and scoring evaluation values. While, significantly reduced fruit WL%; fruit decay. Passive modified atmosphere (PMA) treatment recorded the highest fruit firmness; juice TSS%; total sugars content and scoring evaluation values and lowest fruit WL%; fruit decay followed by both active modified atmosphere (AMA) treatments. Fruit WL%; decay %; juice TSS % and total sugars content were markedly increased as storage time increased. Whereas, fruit firmness (FF); and scoring evaluation was decreased as storage increased.

Keywords: Date palm, GA3, naphthalene acetic acid (NAA), calcium, boron, salicylic acid, postharvest

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Introduction

The date palm fruits (Phoenix dactylifera L.) are highly desire and consumed throughout the world, largely in the Middle East. Barhee of certain date cultivars which are harvested at the Khalal stage when they reach full maturity and are yellow in color, in this stage, these cultivars are less astringent than other cultivars that are only harvested when they are fully ripen. However, once ripened, these cultivars have a short shelf life {1} .In the meantime, dates consumers are looking for fruits with greater color and bigger size. The small fruit size of Barhee dates is another limiting factor that influences its marketing. Thus, it would be beneficial to improve quality characters and to prolong the Khalal stage of these cultivars in order to expand their shelf life and marketing and handling ability. Plant growth regulators play an important role in regulating fruit growth and development. Some of these substances were used in controlling ripening date (delayed ripening) as well as improving the fruit quality. The application of NAA (1-Naphthalene -acetic acid) was found to increase fruit size, weight and delayed ripening of dates {2}; {3}; {4}. Also, gibberellin (GA3) increased fruit weight, and delayed fruit ripening {5}; {6} and {7}. In addition, Salicylic acid (SA) is a simple phenolic compound and it is recognized as a plant growth regulator, because of its external practice effect on many plant growth physiological activity, as salicylic acid was apprise to retard ethylene synthesis {8}. Also, SA is required for inducing systemic resistance against some pathogenic infections {9}; {10}. {11} indicated that SA improved efficiency fruit quality during cold storage period of pomegranate fruits. In addition, boron levels were ranged between 3 and 8 mg kg−1 in soil specimens, and 1–6 mg kg−1 in fruits and leaves. Moreover, "off" tree have lower levels of boron in date leaves than in "on" tree in the Bisir stage of development. Also, the Ca/B ratios, in most cases, occurred between 700 and 1500 for leaves, and between 150 and 300 for fruit {12}. {13} found that, spraying date palm bunches twice; 2 h before pollination and 4 weeks after pollination, with boric acid (B) alone at1500 ppm get a positive effect on fruit set, yield, and fruit quality of "Mnifi" date palm. Calcium plays a fundamental role in plant growth and development. Many extracellular signals and environmental cues including light, abiotic and biotic stress factors, elicit change in the cellular calcium levels, termed as calcium signatures {14}. {15} found that the anti-salinity agents as calcium alleviated the adverse effects of salt stress on growth of Sewy, Zaghloul and Hayany date palm cultivars. For exporting 'Barhi' dates to foreign market, the producer's needs modern technology to handle and store 'Barhi' fruits at the full mature stage and to delay fruit ripening to obtain the highest competitive price in world markets. Many trials have been carried out to improve the storage period and maintain fruit quality throughout the storage period of date fruits. Some of the trials dialed with storage of fruits at relatively low temperatures {16}, coating fruits with polypropylene films {17} or storing them in polyethylene bags {18}. However, a very limited success has been achieved to maintain fruit quality throughout the storage period. As such, 'Barhi' date fruits, at full mature stage of development, initially have moisture content about 65%, this moisture content is comparatively much higher than the critical value of 23% for yeast fermentation and fungal attack {19}. At this range of moisture, the CO2 atmosphere had shown to be fungicidal. The use of modified atmosphere as a fungicidal agent is advantageous because it is economically competitive with chemical fumigation, and leaves no chemical residue on the fruit. In addition, date fruits at full mature stage are rich in antioxidants {20}; {21}; {22}; {23}; {24}; {25}; {26}; {27}. Tannins, which are the most dominant phenol compounds in date fruits, are closely associated with fruit ripening process. The more advanced stage of ripening, the lower is the fruit tannin content {19}; {28}. {29} reported that tannin values are high in the Khalal stage and gradually decrease to reach minimum concentration in the ripe stage (Rutab). Modified atmosphere (MA) has been used widely for many years, as such, elevated carbon dioxide during storage delays fruit ripening and reduces postharvest losses, which extends storage life and maintains quality {30}. Optimal MA combinations have been developed for different species, and even cultivars within the same species {31}. It is becoming a popular method for extending storage period of fruits and vegetables {32}. The use of elevated CO2 at storage atmosphere for preserving fruit quality and delaying fruit deterioration has been described {33}; {34}; {35}; {36}; {37}; {18}. In addition, elevated concentrations of CO2 inhibited decay and retarded softening without impairing the flavor of the strawberry {38}. Very little work has been done on the effect of modified atmosphere treatments on soft full mature date fruits to delay their ripening processes. In accordance to the previous mentioned, the present study was conducted to investigate the effect of spraying NAA, GA3, Ca + Boron (Ca+ B), Boron (B) and Salicylic acid (SA) on improving yield and fruit quality of Barhee dates after harvesting and during cold storage. And to determine the possible use of modified atmosphere (MA) postharvest treatments to extend the cold storage period without affecting fruit quality of full mature 'Barhee' date fruits.

Materials and Methods

The present study has been conducted during 2024 season on 18 healthy, ten years-old of Barhee date palms (phoenix dactylifera L.) grown in private orchard. The experimental trees were selected to be healthy nearly similar in size its vigor and uniform, the palms received the normal horticulture practices which applied in the commercial orchard except for the tested treatments and used the same male pollen tree. The palms were grown in sandy soil under drip irrigation systems.

this experiment was carried out to study the effect of modified atmosphere (MA) treatments on some physical and chemical properties of Barhee dates during cold storage at 0◦C for 5 months. As such, fruits after harvesting were packed in carton boxes and transported directly to postharvest laboratory in Hort. Dept. Fac. Agric. Cairo University. Fruits with any insect infestation or defects were discarded. All fruits were dipped in aqueous solution of 0.1% imazalil for 2 minutes according to Spalding (1980) as a disinfectant, then, air dried. A final sorting was done to recheck the fruits for any defects which were not detected at first discarding. This study included 120 treatments arranged in a split split plot design with three replications. As the sex preharvest treatments were randomly distributed in the main plot, while the five storage periods were randomly distributed in the subplot and the four MA preharvest treatments were randomly distributed in the sub- subplot as follow:

A. Preharvest treatments were: 1. Spraying with water only (control). 2. Spraying with GA3 3. Spraying with NAA. 4. Spraying with Salicylic acid. 5. Spraying with Boric acid. 6. Spraying with Calcium / boron.

B. Postharvest modified atmosphere (MA) treatments were:

a. Storing fruits in carton box covered with net as control.
b. Storing fruits in carton box covered with sealed low-density polyethylene(LDPE) bags as passive modified atmosphere (PMA).
c. Storing fruits in carton box covered with(LDPE) bags injected with 10% CO2 + 10% O2.
d. Storing fruits in carton box covered with(LDPE) bags injected with 15% CO2 + 10% O2.

C. Storing periods: thirty Barhee date fruits (about 360 g) were placed in each carton box of the previous mentioned treatments and stored at 0ºC and 90-95%RH. Then, the observations samples were taken for five months at monthly intervals. The number of fruits required for this experiment = 6 preharvest treatments × 5 storing periods × 4 (MA) treatments × 3 replicates × 30 fruits per each replicates = 10800 fruit (about 130 kg). After each cold storage periods the fruits were subjected to the following measurements:

1. Fruit weight losses percentage (FWL): fruit samples were weighed individually before cold storage to obtain the initial weight, and then weighed after each period of cold storage. FWL % were calculated according to the following equation:

FWL%= $\frac{Wi-Ws}{Wi}x100$ Where: Wi=fruit weight at the initial date,

Ws= fruit weight at sampling date.

2. Fruit decay percentage. was estimated according to McCormack and Brown (1973) as the discarded fruits included all the injured or spoiled fruits resulting from fungus or bacteria, shriveling and other various defects, were calculated and expressed as decay percentage as follows:

Decay % = $\frac{No.of\ decayed\ fruits}{No.of\ initial\ fruits}x100$

3. Fruit firmness were measured as the maximum force required to penetrate the fruit to a puncturing depth of 10 mm as Ib/ inch2, using a 6-mm cylindrical tip of pressure tester. (A Push Pull Dynamometer Model FD101, Penetrometer). The values were expressed as Ib/ inch2.

4. Juice total soluble solids percentage (TSS %) was measured in fruit juice using a hand-held refractometer.

5. Total sugars were determined in the methanol extract using the phenol sulphoric acid and the percentage was calculated on dry weight basis according to {39}.

Results and Discussion

1. Weight Loss Percentage WL (%)

Data in Table 1 reveal that the control treatment showed significantly highest WL (6.05%), respectively, as compared with all other tested pre-harvest treatments which showed significant reductions in WL (%). Whereas, the lowest values of WL (3.71%) came from GA3 treatment. The other tested pre-harvest treatments recorded significantly intermediate values. Generally, all tested pre-harvest treatments showed significant reductions in WL (%) especially those treated by GA3 which recorded the lowest weight loss. Results in the same Table show that the control treatment recorded significantly highest WL (%) (6.12 %), as compared with all other tested post-harvest treatments which showed significant reductions in WL (%). Whereas, the lowest WL (%) values (3.64%) was recorded by passive modified atmosphere (PMA) treatment. While, both tested active modified atmosphere (AMA) treatments recorded intermediate values. It should be noted that the increase in the proportion of CO2 to 15% reduces WL (%) significantly compared to CO2 at 10%. Generally, all tested post-harvest treatments showed significant reductions in WL (%) especially those treated by passive modified atmosphere (PMA) treatment which recorded the lowest weight loss. Moreover, increasing the proportion of CO2 from 10 to15% in AMA treatment reduces fruit WL (%). Results in Table 1 also show that, fruit WL (%) was markedly increased as cold storage period increased. The highest values (6.58 %) resulted at 5 months' cold storage. Generally, fruit WL (%) was markedly increased as cold storage period increased.

In addition, data in Table 1 reveal that, the interaction between MA treatments and cold storage periods was significant. As such, the lowest WL (%) values (1.95 %) came from PMA × the first month (October) of cold storage. Whereas, the control treatment × the five month (February) of cold storage was recorded the highest WL (%) values (7.77 %). The other tested combinations came in between. Generally, the lowest WL (%) came from PMA × the first month (October) of cold storage. Whereas, the control treatment × the five month (February) of cold storage was recorded the highest WL (%).

Also, results in Table 1 show that, the interaction between pre-harvest treatments and cold storage periods was significant. As such, the lowest WL (%) values (1.98%) came from GA3 treatments × the first month (October) of cold storage. Whereas, the control treatment × the five month of cold storage (February) was recorded the highest WL (%) values (7.84 %). The other tested combinations recorded intermediate values.

Table 1. Effect of some pre-and post-harvest treatments; cold storage periods and their interactions on weight losses (WL %) of Barhee dates during (2024 season).

Pre-harvest treat.(T)	St Periods	(2024)				
		Storage treatments				
		Control	PMA	AMA 1	AMA 2	Av.
Control	1	5.59	2.50	4.16	4.95	4.30 k
	2	6.67	3.99	4.65	5.92	5.31 g
	3	7.37	4.31	5.57	6.44	5.92 f
	4	8.31	5.02	6.65	7.48	6.87 c
	5	9.06	6.25	7.52	8.53	7.84 a
Average		7.40 a	4.41 ij	5.71 f	6.66 c	6.05 A
GA3	1	3.28	0.84	1.46	2.32	1.98 p
	2	4.33	1.55	2.47	3.51	2.96 o
	3	5.32	2.34	3.17	3.93	3.69 m
	4	5.74	2.29	3.90	5.02	4.49 j
	5	6.70	4.11	4.93	5.93	5.42 g
Average		5.07gh	2.42 q	3.19 o	4.14 kl	3.71 F
NAA	1	3.42	1.08	1.81	2.09	2.10 p
	2	4.43	2.39	2.96	3.97	3.44 n
	3	5.11	2.62	3.50	4.60	3.96 l
	4	5.96	3.50	4.35	5.54	4.84 i
	5	7.06	4.34	5.42	6.43	5.81 f
Average		5.20 g	2.78 p	3.61 n	4.53 i	4.03 E
Ca + Boron	1	4.17	2.02	1.94	3.60	2.93 o
	2	5.03	2.91	2.38	4.55	3.97 l

	3	5.68	3.39	3.80	5.19	4.51 j
	4	6.36	4.43	4.81	6.19	5.45 g
	5	7.48	5.43	5.79	6.25	6.24 e
Average		5.75 f	3.64 n	3.94 m	5.16 g	4.62 D
Boron	1	4.74	2.32	2.57	4.15	3.45 n
	2	5.57	3.47	3.78	5.10	4.48jk
	3	6.53	3.87	4.39	5.64	5.11 h
	4	7.37	4.94	4.43	6.67	5.85 f
	5	7.78	5.93	6.32	7.51	6.89 c
Average		6.40 d	4.11lm	4.30jk	5.81 f	5.15 C
Salicylic acid	1	5.35	2.94	3.31	4.29	3.97 l
	2	6.20	3.77	3.96	5.26	4.80 i
	3	6.90	4.29	4.89	5.83	5.48 g
	4	7.54	5.37	5.82	7.09	6.45 d
	5	8.53	6.14	6.67	7.68	7.26 b
Average		6.90 b	4.50 i	4.93 h	6.03 e	5.59 B

Means in each column or rows which have the same letter(s) are not significantly different.

Table 1. (Count.) Interaction between storage treatments and periods.

Storage treatments	Periods (month)					
	1	2	3	4	5	S. av.
Control	4.43 i	5.37 f	6.15 e	6.88 c	7.77 a	6.12 A
PMA	1.95 n	3.01 l	3.47 k	4.42 i	5.37 f	3.64 D
AMA 1	2.54 m	3.53 k	4.22 j	4.99 g	6.11 e	4.28 C
AMA 2	3.57 k	4.72 h	5.27 f	6.33 d	7.06 b	5.38 B
P. av.	3.12 E	4.16 D	4.78 C	5.66 B	6.58 A	

Means in each column or rows which have the same letter(s) are not significantly different.

New-L.S.D. at 0.05	T	S	P	T x S	T x P	S x P	T x S x P
2024	0.07	0.07	0.08	0.18	0.19	0.16	0.40

T = Preharvest treatment S = Postharvest treatment P = Storage period PMA = Passive modified atmosphere

AMA 1 = Active modified atmosphere (CO_2 10 % + O_2 10 %) AMA 2 = Active modified atmosphere (CO_2 15 % + O_2 10 %)

Generally, the lowest WL (%) came from GA3 treatments × the first month (October) of cold storage. Whereas, the control treatment × the five month of cold storage (February) was recorded the highest WL (%).

Moreover, results in Table 1 also show that, the interaction between pre-harvest and post-harvest treatments was significant in both seasons. As such, the lowest WL (%) values (2.42 %) came from GA3 × PMA treatments. While, the control treatment for both pre-and post-harvest treatments was recorded the highest WL (%) values (7.40 %). The other tested combinations recorded intermediate values. Generally, the lowest WL (%) came from GA3 × PMA treatments. While, the control of pre-harvest × post-harvest treatments were recorded the highest WL (%). The effect of the interaction between the three tested factors on fruit WL (%) was significant. As such, control of both pre- and post-harvest treatments × five month (February) was recorded the highest WL (%) values (9.06 %). Whereas, the lowest WL (%) values (0.84 %) came from GA3 treatments × the first month (October) of cold storage × PMA treatment. The other tested combinations recorded intermediate values. Generally, the control of both pre- and post-harvest treatments × five month (February) was recorded the highest WL (%). While, GA3 treatments × the first month (October) of cold storage × PMA treatment recorded the lowest WL (%).

These results are generally in accordance with {40} who reported that prolonged cold storage often leads to a decrease in moisture content. {41} study the effect of cold storage at (0°C) of full mature 'Barhi' date fruits under modified atmosphere storage conditions with three carbon dioxide concentrations (5, 10 or 20%) and the common air conditions (0.03% CO2) as a control. He reported that highest fruit weight loss percent was observed in control fruits, followed by low CO2 concentrations (5% and 10%, respectively), whereas lowest fruit weight loss percent was recorded in fruits stored in 20% CO2. Also, {42} suggested that moisture content of date fruits packed in white polythene decreased from 14.1 to 9.7% over 5 months period. In addition, {43} Study the effects of some pre-harvest applications with growth regulators to improve fruit physical, chemical characteristics and storage ability of Barhee date palm cultivar. He found that the percentage of weight loss tended to decrease with the all spraying treatments (GA3; NAA and SA). Moreover, {44} and {45} studied fruit quality of two date cultivars, ''Khalas'' and ''Sukkary''under cold storage for 12 months at 5°C.They reported that fruit weight was reduced from 11.92 to 8.74% for cv. Sukkary and from 8.64 to 7.82% for cv. Khalas, respectively. {46} reported that pre-harvest application of „zaghloul" dates with GA3 and NAA decreased weight loss during cold storage than the control. The reduction of weight loss might be due to the effect of sprayed substances on maintaining and slowing down water loss {47}.

2. Fruit decay percentage (%)

Data in Table 2 reveal that pre-harvest control treatment recorded significantly highest fruit decay percentage (26.13 %) as compared with all other tested treatments which showed significant reductions in fruit decay percentage, as such, the lowest fruit decay percentage (18.35 %), came from GA3 treatment. The other tested treatments came in between.

Generally, all tested pre-harvest treatments showed significant reductions in fruit decay percentage as compared with the control, while, the lowest fruit decay percentage came from GA3 treatment.

As for the effect of post-harvest storage treatments, results in the same Table show that PMA treatment recorded significantly lowest fruit decay percentage (20.83%). Whereas, the control treatment was recorded the highest fruit decay percentage (24.23 %). Both AMA treatments recorded in between values. Generally, passive modified atmosphere (PMA) treatment recorded significantly lowest fruit decay percentage. In the second rank came both active modified atmosphere (AMA) treatments, whereas, the control treatment was recorded the highest fruit decay percentage.

Results in Table 2 also show that, fruit decay percentage was markedly increased as cold storage period increased. The highest fruit decay percentage (52.08 %), resulted after five months of cold storage. While after one month of cold storage has not recorded any decayed fruits, flowed by (11.18 %) after two months of cold storage. The percentage of decayed fruits did not exceed 35.58% after four months of cold storage.

Generally, fruit decay percentage was markedly increased as cold storage period increased. The highest fruit decay percentage resulted after five months of cold storage. While, after one month of cold storage has not recorded any decayed fruits. The percentage of decayed fruits did not exceed 35.58% after four months of cold storage.

Moreover, data in Table 2 reveal that, the interaction between MA treatments and cold storage periods was significant in both seasons. As such, the highest fruit decay percentage (56.42 %), resulted from the control treatment × the five months of cold storage. While, all tested post-harvest treatments after one month cold storage did not recorded any decayed fruits(zero%), followed by (9.98 %), with PMA treatment × two months of cold storage. The other tested combinations came in between. Generally, the highest fruit decay percentage resulted from the control treatment × the five months of cold storage. While, all tested post-harvest treatments after one-month cold storage did not recorded any decayed fruits (zero%), followed by PMA treatment × two months of cold storage.

In addition, data in Table 2 show that, the interaction between pre-harvest treatments and cold storage periods was significant. As such, the highest fruit decay percentage (57.45 %), came from the control treatments × the five months of cold storage without significant differences with salicylic acid × the five months of cold storage in both tested seasons. While, the lowest fruit decay percentage (zero

%), came from the all tested pre-harvest treatments × the first month of cold storage. The other tested combinations recorded intermediate values.

Generally, the highest fruit decay percentage came from the control and salicylic acid treatments × the five months of cold storage, while, the lowest fruit decay percentage (zero %), came from all tested pre-harvest treatments × the first month of cold storage.

Also, data in Table 2 show that, the interaction between pre-harvest and post-harvest treatments was significant in both seasons. As such, the highest fruit decay percentage (27.32 %), came from the control for both pre-harvest and post-harvest treatments. While, the lowest fruit decay percentage (16.17 %), were recorded by GA3 treatment × PMA treatment. The other tested combinations recorded intermediate values.

Table 2. Effect of some pre-and post-harvest treatments; cold storage periods and their interactions on fruit decay percentage of Barhee dates during (2024 season).

Pre-harvest treat.	Periods	(2024)				
		Storage treatments				
		Control	PMA	AMA 1	AMA 2	Av.
Control	1	0.00	0.00	0.00	0.00	0.00 v
	2	15.73	13.75	14.99	15.35	14.96 o
	3	25.19	21.62	22.54	23.27	23.15 k
	4	35.51	34.19	34.98	35.76	35.11 e
	5	60.76	53.06	57.84	58.71	57.45 a
Average		27.32 a	24.53 d	26.07 c	26.62 b	26.13A
GA_3	1	0.00	0.00	0.00	0.00	0.00 v
	2	7.99	6.01	7.25	7.61	7.22 u
	3	15.56	10.33	12.14	13.92	12.99 q
	4	27.60	26.17	27.23	26.53	26.88 j
	5	52.45	38.31	43.15	44.75	44.67 d
Average		20.72 j	16.17 n	17.95m	18.56 l	18.35 F
NAA	1	0.00	0.00	0.00	0.00	0.00 v
	2	10.00	8.02	9.26	9.62	9.23 t
	3	16.59	13.2	14.65	17.37	16.20 n
	4	29.38	27.35	29.29	29.89	28.98 i
	5	54.46	43.96	56.54	48.59	48.14 c
Average		22.69 g	18.51 l	19.75 k	21.09 ij	20.51 E
Ca + Boron	1	0.00	0.00	0.00	0.00	0.00 v
	2	11.43	9.45	10.69	11.05	10.66 s
	3	20.83	14.46	19.51	20.10	18.73m
	4	31.01	29.10	30.28	31.34	30.43 h
	5	55.89 f	44.98	45.63	47.91	48.60 c
Average		23.83 e	19.60 k	21.22 i	22.08 h	21.68D
Boron	1	0.00	0.00	0.00	0.00	0.00 v
	2	12.29	10.31	11.55	11.91	11.52 r
	3	21.62	16.19	16.50	20.29	18.65m
	4	32.18	30.30	31.38	31.98	31.46 g
	5	56.75	54.22	56.23	55.91	55.78 b
Average		24.57 d	22.20 h	23.13 f	24.02 e	23.48C
Salicylic acid	1	0.00	0.00	0.00	0.00	0.00 v
	2	14.30	12.32	13.56	13.92	13.53 p
	3	24.09	18.17	21.54	23.42	21.80 l
	4	31.16	32.44	32.46	34.29	33.34 f

5	**58.76**	**57.05**	**56.93**	**58.65**	**57.85 a**
Average	**26.26bc**	**23.99 e**	**24.90 d**	**26.06 c**	**25.30 B**

Means in each column or rows which have the same letter(s) are not significantly different.

Table 2. (Count.) Interaction between storage treatments and periods.

Storage treatments	Periods (month)					
	1	2	3	4	5	St. av.
Control	0.00p	11.96 l	21.14h	31.64e	56.42a	24.23A
PMA	0.00 p	9.98 o	15.67k	29.92g	48.60d	20.83D
AMA 1	0.00 p	11.22m	17.81 j	30.94 f	50.89c	22.17C
AMA 2	0.00 p	11.58 m	19.72 i	31.63e	52.42b	23.07 B
Periods av.	0.00E	11.18 D	18.59C	31.03 B	52.08A	

Means in each column or rows which have the same letter(s) are not significantly different.

New- L.S.D. at 0.05	T	S	P	T x S	T x P	S x P	T x S x P
2024	0.33	0.10	0.15	0.25	0.38	0.23	0.65

T = Preharvest treatment S = Postharvest treatment P = Storage period PMA = Passive modified atmosphere
AMA 1 = Active modified atmosphere (CO2 10 % + O2 10 %) AMA 2 = Active modified atmosphere (CO2 15 % + O2 10 %)

Generally, the highest fruit decay percentage came from the control for both pre-harvest and post-harvest treatments. While, the lowest fruit decay percentage were recorded by GA3 treatment × PMA treatment.

The effect of the interaction between the three tested factors on fruit decay percentage was significant. As such, the highest fruit decay percentage (60.76 %), resulted from the control treatment for both pre-harvest and post-harvest treatments × five month of cold storage. While, all pre-harvest treatments × all post-harvest treatments × one month of cold storage recorded the lowest fruit decay percentage (zero%). The other tested combinations recorded intermediate values. Generally, the highest fruit decay percentage resulted from the control treatment for both pre-harvest and post-harvest treatments × five month of cold storage. While, all pre-harvest × all post-harvest treatments × one month of cold storage recorded the lowest fruit decay percentage (zero %).

These results confirm those reported by {41} working on mature 'Barhi' date fruits under cold storage (0°C) and MA conditions. He reported that the lowest fruit decay percent was observed in fruits stored under MA conditions at 20% CO2, as the decay percent did not exceed 7.4% after 180 days of storage. On the other hand, decayed fruits exceeded 10% in the control fruits during the second month of the experiment. Moreover, {48} revealed that modified atmosphere and cold storage treatments retarded effectively ripening and senescence of Barhee full mature dates. as such, fruits stored under modified atmosphere containing 20% CO2 at 0oC maintained their quality and showed longer storage ability achieving 173 days.

3. Fruit Firmness (FF) (Lb./ inch 2)

Data in Table 3 reveal that pre-harvest GA3 treatment recorded significantly highest (FF) (14.39) without significant differences with those sprayed by NAA; Ca+ Boron and Boron. Whereas, the lowest (FF) values (12.43) came from the control treatment without significant differences with those sprayed by salicylic acid.

Generally, pre-harvest GA3 treatment recorded significantly highest fruit firmness without significant differences with those sprayed by NAA; Ca+ Boron and Boron.

As for the effect of post-harvest storage treatments, results in the same Table show that PMA treatment recorded significantly highest (FF) (13.91). In the second rank came both AMA treatments without significant differences among them. Whereas, the control treatment was recorded the lowest (FF) (13.40) .

Generally, passive modified atmosphere (PMA) treatment recorded significantly highest fruit firmness. In the second rank came both active modified atmosphere (AMA) treatments without significant differences among them.

Results in Table 3 also show that, fruit firmness (FF) was markedly decreased as cold storage period increased. The highest (FF) values (14.89) resulted at the first months of cold storage, without significant differences with those in the second month . The lowest (FF) values (12.26), were recorded after five-month cold storage. The other tested periods recorded intermediate values. Generally, fruit firmness (FF) was markedly decreased as cold storage period increased. The highest (FF) values resulted at the first months of cold storage, while, the lowest (FF) values were recorded after five-month cold storage. Moreover, data in Table 3 reveal that, the interaction between MA treatments and cold storage periods was significant. As such, the highest (FF) values (15.10) resulted from the PMA treatment × first months of cold storage, without significant differences with both AMA treatments × first months of cold storage and AMA (15% CO_2 +10% O_2) and PMA × second months of cold storage. While, the lowest (FF) values (12.02), were recorded by the control × five months of cold storage without significant differences with both AMA treatments × five months of cold storage in both tested seasons. The other tested combinations came in between.

Generally, the highest (FF) values resulted from the PMA treatment × first and second months of cold storage without significant differences with both AMA treatments × first months of cold storage and AMA (15% CO_2 +10% O_2) × second months of cold storage. In addition, data in Table 3 show that, the interaction between pre-harvest treatments and cold storage periods was significant. As such, the highest (FF) values (15.60 Lb. / $inch^2$) came from GA_3 treatments × the first month (October) of cold storage without significant differences with the same treatment × second month; NAA × first and second month; Ca + boron and boron × first and second month. While, the lowest (FF) values (11.02 Lb. / $inch^2$), were recorded by the control × five months of cold storage without significant differences with both treated by salicylic acid × five months of cold storage. The other tested combinations recorded intermediate values. Generally, the highest (FF) values resulted from GA_3 treatments × the first and second month of cold storage without significant differences with NAA × first and second month; Ca + boron and boron × first and second month, in both tested seasons, while, the lowest (FF) values were recorded by the control and salicylic acid treatments × five months of cold storage. Also, data in Table 3 show that, the interaction between pre-harvest and post-harvest treatments was significant. As such, the highest (FF) values (14.62 Lb. / $inch^2$) came from GA_3 treatment× PMA treatment without significant differences with GA_3 treatment × both AMA treatments; NAA treatment × all the three MA treatments and Ca + boron × PMA treatment. While, the lowest (FF) values (12.03 Lb. / $inch^2$), were recorded by the control for both pre- and post- harvest treatments without significant differences with control × AMA (15% CO_2 +10% O_2). The other tested combinations recorded intermediate values.

Generally, the highest (FF) values resulted from GA_3 treatment× PMA treatment without significant differences with GA_3 treatment × both AMA treatments; NAA treatment × all the three MA treatments and Ca + boron × PMA treatment. While, the lowest (FF) values were recorded by the control for both pre- and post- harvest treatments without significant differences with control × AMA (15% CO_2 +10% O_2). The effect of the interaction between the three tested factors on fruit (FF) values was significant. As such, the highest (FF) values (15.77 Lb / $inch^2$), resulted from GA_3 treatment × first month of cold storage × PMA treatment without significant differences with; GA_3 treatment × first month of cold storage × both AMA treatments; GA_3 treatment × second month of cold storage × all the three MA treatments; NAA treatment × first month of cold storage × all the three MA treatments; NAA treatment × second month of cold storage × PMA and AMA(15% CO_2 + 10% O_2); Ca + boron × first month of cold storage × PMA and AMA(10 % CO_2 + 10% O_2);and boron × first month of cold storage × AMA(10 % CO_2 + 10% O_2). While, the lowest (FF) values was (10.68 Lb / $inch^2$), for the control of both pre- and post- harvest treatments × five months' cold storage, without significant differences with; the control of both pre- and post- harvest treatments × four months' cold storage; control × five months cold storage × both AMA treatments; and Salicylic acid × five months cold storage × control and AMA (15% CO_2 + 10% O_2). The other tested combinations recorded intermediate values. Generally, the highest (FF) values resulted from GA_3 treatment × first and second months of cold storage × all the three MA treatments without significant differences with; NAA treatment × first month of cold storage × all the three MA treatments; NAA treatment × second month of cold storage × PMA and AMA(15% CO_2 + 10% O_2); Ca + boron × first month of cold storage × PMA and AMA(10 % CO_2 + 10% O_2);and boron × first month of cold storage × AMA (10 % CO_2 + 10% O_2).

Table 3. Effect of some pre-and post-harvest treatments; cold storage periods and their interactions on fruit firmness (lb) of Barhee dates during (2024 seasons).

Pre-harvest treat.	Periods	First season (2024)				
		Storage treatments				
		Control	PMA	AMA 1	AMA 2	Av.
Control	1	13.31	13.98	13.84	13.44	13.64 def
	2	13.29	13.89	13.48	13.22	13.47 e-h
	3	11.74	12.86	12.14	12.13	12.22 kl
	4	11.12	12.13	12.01	11.76	11.80 l
	5	10.68	11.35	11.08	10.97	11.02 m
Average		12.03 i	12.88 fg	12.51 gh	12.30 hi	12.43 B
GA_3	1	15.39	15.77	15.71	15.51	15.60
	2	15.32	15.61	15.61	15.55	15.52
	3	14.01	14.55	14.18	14.35	14.27
	4	13.20	14.04	13.70	13.34	13.57
	5	12.76	13.14	12.94	13.05	12.97
Average		14.14 bcd	14.62 a	14.43 abc	14.36 abc	14.39 A
NAA	1	15.36	15.73	15.72	15.48	15.57 a
	2	15.05	15.60	15.35	15.59	15.40 a
	3	13.97	14.06	13.97	14.25	14.06 cd
	4	13.17	13.91	13.52	13.31	13.48 e-h
	5	12.73	13.10	12.93	13.02	12.95 hij
Average		14.06 b-e	14.48 ab	14.30 a-d	14.33 abc	14.29 A
Ca + Boron	1	15.33	15.60	15.60	15.22	15.44 a
	2	15.11	15.25	15.71	15.24	15.08 ab
	3	13.70	13.98	13.83	14.02	13.88 cde
	4	13.14	13.44	13.41	13.05	13.26 f-i
	5	12.70	13.96	12.82	12.76	12.81 ij
Average		13.99 cde	14.25 a-d	14.07 b-e	14.06 b-e	14.09 A
Boron	1	14.92	15.42	15.42	15.19	15.23 ab
	2	14.65	15.23	14.16	15.22	14.82 b
	3	13.39	13.90	13.76	13.78	13.71 def
	4	12.73	13.26	13.23	13.02	13.06 g-j
	5	12.29	12.79	12.64	12.73	12.61 jk
Average		13.60 e	14.12 bcd	13.84 de	13.99 cde	13.89A
Salicylic acid	1	13.60	14.07	14.01	13.71	13.85 cde
	2	13.55	14.01	13.99	13.76	13.83 cde
	3	13.34	13.79	13.57	13.65	13.59 d-g
	4	11.41	12.29	12.00	11.55	11.81 l
	5	10.97	11.44	11.25	11.23	11.22 m
Average		12.57 gh	13.12 f	12.97 fg	12.78 fgh	12.86 B

Means in each column or rows which have the same letter(s) are not significantly different.

Table 3. (Count.) Interaction between storage treatments and periods

Storage treatments	Periods (month)					
	1	2	3	4	5	St. av.
Control	14.65 bc	14.49 c	13.36e-g	12.46ij	12.02k	13.40C
PMA	15.10 a	14.93 ab	13.86 d	13.21fg	12.46ij	13.91A
AMA 1	15.05 a	14.55 bc	13.58def	12.98gh	12.28jk	13.69B
AMA 2	14.76 bc	14.76abc	13.70 de	12.67hi	12.30ijk	13.64B
Periods av.	14.89 A	14.69 A	13.62 B	12.83C	12.26 D	

Means in each column or rows which have the same letter(s) are not significantly different.

New-L.S.D. at 0.05	T	S	P	T x S	T x P	S x P	T x S x P
2024	0.63	0.17	0.21	0.48	0.53	0.38	1.07

T = Preharvest treatment S = Postharvest treatment P = Storage period PMA = Passive modified atmosphere
AMA 1 = Active modified atmosphere (CO_2 10 % + O_2 10 %) AMA 2 = Active modified atmosphere (CO_2 15 % + O_2 10 %)

These results are in agreement with those reported by {41} who study the effect of cold storage at (0°C) of full mature 'Barhi' date fruits under modified atmosphere storage conditions with three carbon dioxide concentrations (5, 10 or 20%) and the common air conditions (0.03% CO_2) as a control. He reported that lowest fruit firmness values were observed in control fruits, which totally collapsed after 60 days of storage. Moreover, fruit firmness was closely associated with fruit ripening process during the storage period, the more advanced stage of ripening, the lower the fruit firmness. Also, fruit firmness showed directly proportional values to CO_2 concentration used in the MA treatments. Fruits stored at MA supplied with 20% CO_2 showed significantly higher fruit firmness compared to all other treatments, which clearly indicated the positive effect of CO_2 treatment in retarding the fruit ripening process and subsequently maintain fruit quality and firmness without causing fruit injury. Moreover, Cold storage delayed fruit ripening and extend the shelf life of „Barhee" dates compared with store at ambient condition {49}. In addition, {50} reported that the CO_2 duration treatments on "Medjool" date fruits did not show any significant changes of firmness. Also, {45} observed that the main reason for the change of firmness of date fruits during storage period was probably due to the increase in cell rigidity and subsequent strengthening of cell wall bonding. Low temperature storage could therefore be used to effectively strength the firmness of date fruits. Moreover, Infiltration of calcium can delay the overall softening process during ripening {51}; and {52}. Also, pre-harvest spray of GA3 or NAA at 50 or 100 ppm reduced rutab%; weight loss; delayed fruit maturation and ripening of Barhee dates during cold storage {53}.

4. Juice total soluble solids percentage (TSS %)

Data in Table 4 reveal that pre-harvest GA3 treatment recorded significantly highest juice TSS (28.87 %) While, the lowest juice TSS (24.33 %) came from the control treatment. The other tested treatments came in between. Generally, pre-harvest GA3 treatment recorded significantly highest juice TSS%. While, the lowest juice TSS came from the control treatment. As for the effect of post-harvest storage treatments, results in the same Table show that PMA treatment recorded significantly highest juice TSS (27.43 %) . Whereas, the control was recorded the lowest juice TSS (26.57 %). Generally, passive modified atmosphere (PMA) treatment recorded significantly highest juice TSS. In the second rank came both active modified atmosphere (AMA) treatments, whereas, the control treatment was recorded the lowest juice TSS. Data in Table 4 also show that, juice TSS percentage was markedly increased as cold storage period increased. The highest juice TSS (28.01 %), resulted after five months of cold storage. While, the lowest juice TSS (25.40 %), came after one month of cold storage. The other tested cold storage periods came in between. Generally, fruit juice TSS percentage was markedly increased as cold storage period increased. The highest juice TSS percentage resulted after five months of cold storage. While, the lowest juice TSS percentage was recorded after one month of cold storage. Moreover, data in Table 4 reveal that, the interaction between MA treatments and cold storage periods was significant. As such, the highest fruit juice TSS (28.39 %), resulted from the passive modified atmosphere (PMA) treatment × the five months of cold storage. While, the lowest juice TSS (24.82 %), was recorded by the control × one month cold storage. The other tested combinations recorded intermediate values.

Table 4. Effect of some pre-and post-harvest treatments; cold storage periods and their interactions on fruit TSS percentage of Barhee dates during (2024 season).

Pre-harvest treat.	Periods	First season (2024)				
		Storage treatments				
		Control	Passive	MA 10+10	MA 15+10	Av.
Control	1	21.98	22.80	22.88	22.46	22.53 v
	2	23.70	24.33	24.22	24.46	24.18 u
	3	24.02	24.99	24.29	24.45	24.44 t
	4	24.58	25.26	25.40	25.20	25.11 s
	5	25.35	25.90	25.24	25.12	25.40 r
Average		23.93 s	24.66 p	24.41q	24.34 r	24.33F
GA_3	1	26.44	27.40	27.53	27.07	27.11 k
	2	28.47	29.18	29.07	29.32	29.01 c
	3	28.64	29.65	28.90	29.02	29.05 c
	4	28.87	29.50	29.53	29.63	29.38 b
	5	29.98	30.12	29.42	29.72	29.81 a
Average		28.48 e	29.17 a	28.89 c	28.95 b	28.87A
NAA	1	26.03	26.57	26.75	26.36	26.43m
	2	27.58	28.99	28.14	28.34	28.26ef
	3	27.72	29.43	27.93	28.14	28.30 e
	4	28.16	28.93	28.86	28.97	28.73 d
	5	29.12	29.64	28.57	28.87	29.05 c
Average		27.72 h	28.71 d	28.05 g	28.14 f	28.15 B
Ca + Boron	1	24.96	26.36	26.04	25.62	25.75 p
	2	26.64	27.54	27.35	27.56	27.27 j
	3	27.10	28.11	27.42	27.58	27.55 i
	4	27.37	27.87	28.03	28.07	27.84 g
	5	28.36	28.43	27.90	28.15	28.21 f
Average		26.89 k	27.66 h	27.35 i	27.40 i	27.32C
Boron	1	24.96	25.82	25.97	25.38	25.53 q
	2	25.64	27.22	26.30	26.40	26.39mn
	3	26.300	27.72	26.78	26.79	26.90 l
	4	27.12	27.78	27.75	27.84	27.62hi
	5	27.94	28.25	27.61	27.74	27.89 g
Average		26.39 n	27.36 i	26.88 k	26.83 k	26.87D
Salicylic acid	1	24.53	25.41	25.38	24.90	25.06 s
	2	25.46	27.14	26.13	26.15	26.22 o
	3	25.86	26.87	26.18	26.39	26.33 n
	4	26.46	27.56	27.61	27.38	27.25 j
	5	27.76	27.99	27.44	27.57	27.69 h
Average		26.02 o	26.99 j	26.55 l	26.48m	26.51 E

Means in each column or rows which have the same letter(s) are not significantly different.

Table 4. (Count.) Interaction between storage treatments and periods.

Storage treatments	Periods (month)					
	1	2	3	4	5	St. av.
Control	**24.82**	**26.25**	**26.61**	**27.09**	**28.09**	**26.57**
PMA	**25.73**	**27.40**	**27.80**	**27.82**	**28.39**	**27.43**
AMA 1	**25.76**	**26.87**	**26.91**	**27.86**	**27.70**	**27.02**
AMA 2	**25.30**	**27.04**	**27.06**	**27.85**	**27.86**	**27.02**
Periods av.	**25.40**	**26.89**	**27.10**	**27.66**	**28.01**	

Means in each column or rows which have the same letter(s) are not significantly different.

New-L.S.D. at 0.0 5	T	S	P	T x S	T x P	S x P	T x S x P
2024	0.06	0.02	0.03	0.06	0.07	0.05	0.14

T = Preharvest treatment S = Postharvest treatment P = Storage period PMA = Passive modified atmosphere

AMA 1 = Active modified atmosphere (CO_2 10 % + O_2 10 %) AMA 2 = Active modified atmosphere (CO_2 15 % + O_2 10 %)

Generally, the highest fruit juice TSS percentage resulted from the passive modified atmosphere (PMA) treatment × the five months of cold storage. While, the lowest juice TSS percentage was recorded by the control × one-month cold storage. In addition, data in Table 4 show that, the interaction between pre-harvest treatments and cold storage periods was significant. As such, the highest fruit juice TSS (29.81 %), came from GA3 treatment × the five month of cold storage. While, the lowest fruit juice TSS (22.53 %), came from the control treatments × one month of cold storage. The other tested combinations recorded intermediate values. Generally, the highest fruit juice TSS percentage came from GA3 treatment × five month of cold storage, while, the lowest fruit juice percentage came from the control × one month of cold storage. Also, data in Table 4 show that, the interaction between pre-harvest and post-harvest treatments was significant. As such, the highest fruit juice TSS (29.17 %), came from GA3 treatment × PMA treatment. While, the lowest fruit juice TSS (23.93 %), were recorded by the control for both pre- and post-harvest treatments. The other tested combinations recorded intermediate values. Generally, the highest fruit juice TSS percentage came from GA3 treatment × PMA treatment. While, the lowest fruit juice TSS percentage were recorded by the control for both pre- and post-harvest treatments. In addition, data in Table 4 show that, the effect of the interaction between the three tested factors on fruit juice TSS percentage was significant. As such, the highest fruit juice TSS (30.12 %), resulted from GA3 treatment × PMA treatment × five month of cold storage. While, the lowest fruit juice TSS (21.98 %), were recorded by the control for both pre- and post-harvest treatments × one-month cold storage. The other tested combinations recorded intermediate values. Generally, the highest fruit juice TSS percentage resulted from GA3 treatment × PMA treatment × five month of cold storage. While, the lowest fruit juice TSS percentage were recorded by the control for both pre- and post-harvest treatments × one-month cold storage. These results are in agreement with those reported by {54}, and {55} reported that TSS content in date increased gradually with the increase of storage time. This significant increase in TSS content could be due to the degradation in insoluble compounds present in date fruit into soluble compounds (such as the conversion of proto pectin into pectin). In addition, {48} working on mature 'Barhy' date fruits stored under different storage temperatures (0, 2, 4, 6°C) and under modified atmosphere conditions with 0.03, 5, 10, or 20% carbon dioxide concentrations. He found that a slight increase in SSC% occurred in most treatments under investigation. This increase could be due to the conversion of some insoluble compounds into soluble compounds (such as the conversion of protopectin into pectin), or as a result of the water loss from the fruits.as such, decreasing moisture contents during storage could affect positively SSC% as shown by {17}. Moreover, {45} studied fruit quality of two date cultivars, ''Khalas'' and ''Sukkary''under cold storage at 5°C for 12 months they reported that TSS is a parameter significantly correlated with the perception of sweetness, date flavor and aroma intensity. TSS of Sukkary date was significantly increased from 82.96 to 85.10% according to the packing type. This difference could be due to the different conversion of some insoluble compounds into soluble compounds in date samples. TSS of Khalas date significantly increased from 77.85 to 83.85% under the same storage conditions.

5. Total sugars content

Data in Table 5 reveal that pre-harvest GA3 treatment recorded significantly highest total sugars content (26.23 %). While, the lowest total sugars content (22.12 %) came from the control treatment. The other tested treatments came in between. Generally, pre-harvest GA3 treatment recorded significantly highest juice total sugars content. While, the lowest juice total sugars content came from the control treatment. As for the effect of post-harvest storage treatments, results in the same Table show that PMA treatment recorded significantly highest juice total sugars content (25.00%). Whereas, the control was recorded the lowest juice total sugars content (23.53%). Both AMA treatments recorded in between values. Generally, passive modified atmosphere (PMA) treatment recorded significantly highest juice total sugars content. In the second rank came both active modified atmosphere (AMA) treatments, whereas, the control treatment was recorded the lowest juice total sugars content. Data in Table 5 also show that, juice total sugars content was markedly increased as cold storage period increased. The highest juice total sugars content (26.41%), resulted after five months of cold storage. While, the lowest total sugars content (22.95%), came after one month of cold storage. The other tested cold storage periods came in between. Generally, fruit juice total sugars content was markedly increased as cold storage period increased. The highest juice total sugars content resulted after five months of cold storage. While, the lowest total sugars content was recorded after one month of cold storage. Moreover, data in Table 5 reveal that, the interaction between MA treatments and cold storage periods was significant. As such, the highest fruit juice total sugars content (26.97%), resulted from the passive modified atmosphere (PMA) treatment × the five months of cold storage. While, the lowest total sugars content (22.05%), was recorded by the control × one-month cold storage. The other tested combinations recorded intermediate values. Generally, the highest fruit juice total sugars content resulted from the passive modified atmosphere (PMA) treatment × the five months of cold storage. While, the lowest juice total sugars content was recorded by the control × one-month cold storage. In addition, data in Table 5 show that, the interaction between pre-harvest treatments and cold storage periods was significant. As such, the highest fruit juice total sugars content (27.99%) came from GA3 treatment × the five month of cold storage. While, the lowest fruit juice total sugars content (20.81%), came from the control treatments × one month of cold storage. The other tested combinations recorded intermediate values. Generally, the highest fruit juice total sugars content came from GA3 treatment × five month of cold storage, while, the lowest fruit juice percentage came from the control × one month of cold storage. Also, data in Table 5 show that, the interaction between pre-harvest and post-harvest treatments was significant. As such, the highest fruit juice total sugars content (27.02%), came from GA3 treatment × PMA treatment. While, the lowest fruit juice total sugars content (21.40%), were recorded by the control for both pre- and post-harvest treatments. The other tested combinations recorded intermediate values. Generally, the highest fruit juice total sugars content came from GA3 × PMA treatment. While, the lowest fruit juice total sugars content was recorded by the control for both pre- and post-harvest treatments. In addition, data in Table 5 show that, the effect of the interaction between the three tested factors on fruit juice total sugars content was significant. As such, the highest fruit total sugars content (28.72%), resulted from GA3 treatment × PMA treatment × five month of cold storage. While, the lowest fruit juice total sugars content (19.43%), were recorded by the control for both pre- and post-harvest treatments × one-month cold storage. The other tested combinations recorded intermediate values. Generally, the highest fruit juice total sugars content resulted from GA3 treatment × PMA treatment × five month of cold storage. While, the lowest fruit juice total sugars content was recorded by the control for both pre- and post-harvest treatments × one-month cold storage.

Table 5. Effect of some pre-and post-harvest treatments; cold storage periods and their interactions on fruit total sugars percentage of Barhee dates during (2024 season).

Pre-harvest treat.	Periods	First season (2024) Storage treatments: Control	PMA	AMA1	AMA2	Av.
Control	1	19.43	21.79	21.19	20.83	20.81A
	2	20.93	21.82	21.66	21.37	21.45 z
	3	20.84	22.70	21.73	21.63	21.73 y
	4	22.46	23.30	22.74	22.93	22.86 v
	5	23.35	24.31	21.31	23.07	23.76 q
Average		21.40 v	22.79 r	22.33 t	21.97 u	22.12 F
GA_3	1	23.96	26.15	25.46	24.71	25.07 i
	2	25.09	25.92	25.55	25.49	25.51 h
	3	25.20	27.05	26.26	25.81	26.08 f
	4	25.91	27.27	26.34	26.35	26.47 d
	5	27.51	28.72	28.49	27.26	27.99 a
Average		25.54 e	27.02 a	26.42 b	25.93 d	26.23A
NAA	1	23.24	25.09	24.02	23.48	23.96 o
	2	23.80	24.91	24.91	24.07	24.42 l
	3	23.68	26.27	25.11	23.99	24.77 k
	4	23.62	26.78	25.35	23.98	24.93 j
	5	27.44	28.09	28.14	27.05	27.68 b
Average		24.36 j	26.23 c	25.51 e	24.52 i	25.15 B
Ca + Boron	1	22.30	24.27	23.77	22.94	23.31 t
	2	23.03	24.31	24.44	23.63	23.85 p
	3	23.59	25.00	24.17	23.67	24.11 n
	4	23.51	25.30	24.60	23.85	24.32m
	5	26.10	27.32	27.47	25.92	26.70 c
Average		23.71 n	25.23 f	24.89 g	24.00m	24.46C
Boron	1	22.19	23.35	22.98	22.35	22.72w
	2	23.14	23.65	23.79	23.24	23.46 s
	3	22.93	24.72	23.65	23.10	23.60 r
	4	23.35	24.61	23.90	23.78	23.91op
	5	25.92	26.75	26.93	25.69	26.32 e
Average		23.51 p	24.62 h	24.25 k	23.63 o	24.00D
Salicylic acid	1	21.19	22.40	22.06	21.55	21.80 y
	2	21.43	23.23	23.15	22.45	22.57 x
	3	22.13	24.10	23.38	23.00	23.15 u
	4	23.22	24.33	23.63	23.71	23.72 q
	5	25.62	26.62	26.52	25.28	26.01 g
Average		22.72 s	24.14 l	23.75 n	23.20 q	23.45 E

Means in each column or rows which have the same letter(s) are not significantly different

Table 5. (Count.) Interaction between storage treatments and periods.

Storage treatments	Periods (month): 1	2	3	4	5	St. av.
Control	22.05 r	22.90 p	23.06 o	23.68 k	25.99 b	23.53 D

PMA	**23.84 j**	**23.97 h**	**24.98 e**	**25.27 d**	**26.97 a**	**25.00 A**
AMA 1	**23.25 n**	**23.92 i**	**24.05 g**	**24.43 f**	**26.98 a**	**24.52 B**
AMA 2	**22.64 q**	**23.37 m**	**23.54 l**	**24.10 g**	**25.71 c**	**23.87 C**
Periods av.	**22.95 E**	**23.54 D**	**23.91 C**	**24.37 B**	**26.41 A**	

Means in each column or rows which have the same letter(s) are not significantly different.

New-L.S.D. at 0.05	T	S	P	T x S	T x P	S x P	T x S x P
2024	0.03	0.02	0.03	0.06	0.07	0.05	0.13

T = Preharvest treatment S = Postharvest treatment P = Storage period PMA = Passive modified atmosphere
AMA 1 = Active modified atmosphere (CO_2 10 % + O_2 10 %) AMA 2 = Active modified atmosphere (CO_2 15 % + O_2 10 %)

Conclusions

These results are in agreement with those reported by Coggins and; {56}; {41} and {48} working on various date cultivars comprised mature 'Barhy' date fruits, they all found a clear relationship was observed between fruit stage of development and total sugar content. The more advanced stage of fruit development and ripening, the higher the sugar content. In general, there was a slight increase in fruit total sugar content as the fruits passed from the Khalal to Rutab (full ripen fruits) stage.

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