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Improving Fruit Quality, Marketability and Storagability of Barhee Date Palm

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Abstract: The present study was conducted during 2008 and 2009 seasons in order to extend harvest date and maintain fruit quality for better marketability of Barhee date palms growing in Riyadh, Saudi Arabia. Palms sprayed at the hababouk stage and at the beginning of fruit color break with N-(2-chloro-4-pyridinyl)-N'-phenyl urea (CPPU), putrescine (Put), gibberellic acid (GA_3), naphthalene acetic acid (NAA), benzyl adenine (BA) and salicylic acid (SA). Harvest date was delayed one month with NAA and GA_3, three weeks with putrescine and SA and two weeks with CPPU and BA compared to the commercial harvest date. All treatments retarded skin carotenoids content and increased acidity as compared with control. The postharvest rutab stage during cold storage at 0°C and 85-90% RH reduced by all treatments. The incidence of postharvest fruit decay during cold storage did not significantly differ among all sprayed growth regulators. The GA_3, NAA and putrescine treatments had significant higher effect in extending shelf life and decreasing fruit weight loss percent than the other treatments. The sprayed growth regulators had positive influence on extending harvest season and shelf life of Barhee dates without any deterioration in fruit characteristics before and during cold storage.

Key words: Date palm · Preharvest sprays · Harvest date · Rutab · Marketability

INTRODUCTION

The date palm fruits (*Phoenix dactylifera* L.) are highly demanded and consumed throughout the world, especially in the Middle East. According to FAO [1], Saudi Arabia is considered the third country of the top ten date producers (982546 tones). A small quantity of certain date cultivars (such as Barhee) are harvested and consumed at the khalal stage when they reach full maturity (partially-ripe) and are yellow, pink, or red in color (according to the cultivar). In this stage these cultivars are less astringent than other cultivars that are only harvested when they are fully ripen and are yellow, pink, or red in color. However, once ripened, these cultivars have a short shelf life [2]. In the mean time, 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 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, which act for increasing the income and the revenues of farmers. NAA was found to increase fruit size, weight and delayed ripening of dates [3-6]. Also, GA_3 increased fruit weight and delayed fruit ripening [7-9]. Benzyl adenine (BA) and a new cytokinin related substance (CPPU or N-(2-chloro-4-pyridinyl)-N'-phenyl urea), known as cytofex increased fruit size and delayed chlorophyll breakdown and fruit aging [10]. Polyamines such as putrescine (PUT) have been reported as anti-senescence agents [11]. They were found to retard color change, decrease firmness loss, delay ethylene production, decrease respiration rate and, induce mechanical resistance [12-15], which resulted in reducing senescence rate after harvest [15,16]. Salicylic acid (SA) is a simple phenolic compound. It is recognized as a plant growth regulator, because of its external application effect on many plant growth physiological processes [17]. In addition, salicylic acid was reported to retard ethylene synthesis [18] and reduced weight loss, decay and increased firmness [19]. Also, it has been recognized that salicylic acid is required in the signal transduction for inducing systemic acquired resistance against some pathogenic infections [20, 21]. Sayyari *et al.*, [22] indicated that salicylic acid improved fruit quality

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during cold storage of pomegranate. Preharvest application of salicylic acid has induced resistance against pathogens in pear [23] and decreased disease development in cherry [24]. Salicylic acid at 2 mM effectively increased strawberry fruit total antioxidant potential, ascorbic acid content, total soluble solids and prevented fungal contaminations [25]. They also reported the reversible effect of SA and suggested plant SA treatment in all different growth stages like vegetative, fruit development and postharvest stage. Salicylic acid also prevented softening of banana and kiwifruit during ripening [26, 27].

In accordance to the previous mentioned, the present study was conducted in order to investigate the effect of spraying NAA, GA_3, CPPU (cytofex), putrescine (Put), benzyl adenine (BA) and salicylic acid (SA) on improving fruit quality of Barhee dates before and during cold storage.

MATERIALS AND METHODS

The present study was conducted during 2008 and 2009 seasons at the Research and Agricultural Experimental Station at Dirab, King Saud University, Saudi Arabia on Barhee date palms (*Phoenix dactylifera* L.).The palms were planted at 10x10 m apart and subjected to common cultural practices. Organic manure, calcium super phosphate and potassium sulfate were applied in December of each season at the rate of 15 kg, 1 kg and 1.5 kg per palm, respectively. Also, ammonium nitrate at the rate of 3kg/palm was applied at three equal doses; mid-February, mid- April and mid- May of each season. Eleven palms were selected as uniform as possible and bunches were pollinated from the same male palm tree. Bunches were sprayed at both hababouk and the beginning of fruit color break stages with gibberellic acid (GA_3), naphthalene acetic acid (NAA), putrescine (Put), salicylic acid (SA), N-(2-chloro-4-pyridinyl)-N'-phenyl urea (CPPU, 'cytofex') and benzyl adenine (BA). Palms were subjected to seven foliage treatments with three replicates per treatment and three bunches for each replicate (i.e., 7 treatments x 3 replicates x 3 bunches = 63 bunch on 11 palm tree): Treatments arranged in a complete randomized design were as follow:

- Water only (control)
- NAA (100 ppm at hababouk stage and 50 ppm at the beginning of fruit color break).
- GA_3 (100 ppm at hababouk stage and 50 ppm at the beginning of fruit color break).
- CPPU (10 ppm at hababouk and 10 ppm at beginning of fruit color break stage).
- Put (8 mM at hababouk and 8 mM at beginning of fruit color break stage).
- BA (100 ppm at hababouk stage and 50 ppm at the beginning of fruit color break).
- SA (100 ppm at hababouk stage and 50 ppm at the beginning of fruit color break).

The surfactant Nourfilm (produced by Alam Chemica Co.) at the rate of 40 cm^3/100L water was added in tankmix to all sprayed substances in order to obtain best penetrating results and bunches were sprayed once in the early morning. In both seasons, at full maturity and yellow colour, a sample of ten strands were randomly collected from each bunch/replicate for determination the fruit physical and chemical characteristics. To study effect of treatments on fruit storagability and shelf life, a second fruit sample of twenty five strands was randomly collected from each replicate when every treatment reached full maturity and yellow color and harvest date for each treatment in both seasons was recorded. Strands were kept at 0°C and 85 -90% relative humidity for 45 days and the incidence percentages of fruit rutab, decay and weight loss were determined every 15 days during the cold storage period.

Physical Properties: Fruit physical properties were determined at harvest; fruit and pulp weight (g), fruit diameter and length (cm), fruit volume (cm^3). Also, ground fruit color (assessment of color change) was estimated by giving five degrees of color stage as follow; (1) = 100% green, (2) = 25% yellow (3) = 50% yellow, (4) = 75% yellow and (5) =100% yellow. Fruit skin color in the Barhee cultivar was assessed visually and recorded on a scale from 0 (no color change) to 5 (complete change).

Chemical Properties: Fruit chemical properties were determined at harvest; total soluble solids (%) was measured by a hand refractometer, acidity (%) was determined by titration according to AOAC [28], carotenoids and total chlorophyll contents (mg/100 g peel fresh weight) were achieved by the method of Moran and Prorate [29], as 80% acetone extract was calorimetrically assayed at 650 nm, for total chlorophyll and 440 nm for carotene using Spectrophotometer and the percent of reducing, non- reducing and total sugars were determined [30].

Statistical Analysis: Data obtained were subjected to analysis of variance (ANOVA) to detect treatment effect. Mean separation were performed using least significant difference (LSD) at the p= 0.05 level. The data were analyzed using statistical analysis system [31] version 8.02.

RESULTS AND DISCUSSION

Fruit Physical Characteristics: Data obtained in both seasons are presented in Table 1. All sprayed substances (except SA) significantly increased fruit weight, diameter, length and volume and pulp weight when compared with the control.GA_3 and PUT treatments resulted in a significant effect in increasing fruit weight, length and volume and pulp weight than NAA in the first season with no significant difference between them. However, in the second season no significant differences were obtained among the NAA, GA_3, CPPU, PUT and BA treatments. In the mean time, fruit diameter did not significantly differ among the previously mentioned compounds in both seasons. In addition, data of both seasons showed a remarked delay in the fruit green color break by growth regulators treatments as compared with the control. Fruit green color break was significantly lower by NAA than BA and CPPU sprays in the first season. Moreover, no significant difference between BA and CPPU as well as between NAA, GA_3, PUT and SA treatments. In the second season, the NAA and SA had a significant higher effect on retarding fruit green color break than BA, PUT and CPPU.

In general, our data showed that the growth regulators had positive influences in increasing fruit weight, diameter, length and volume and pulp weight and retarded fruit green color break of Barhee dates. The increment in fruit physical characteristics was also reported by numerous investigations working on different fruit trees [3-5, 10, 32]. The improvement in fruit physical properties as a resulted of growth regulators treatments might be due to their influence in enlarging the cells size and enhancing the strength of carbohydrate sink, thus increasing fruit size and weight. In this connection, Valero *et al.* [33] reported that polyamines are essential for cell growth and differentiation and their intracellular concentrations increase during periods of rapid cell proliferation. Also, the role of putrescine in delaying fruit color break was reported by Valero *et al.* [15], Martinez-Romero *et al.* [16] and Serrano *et al.* [34]. Benzyl adenine and cytofex (CPPU) sprays were found to delay chlorophyll breakdown and fruit aging [10].

Fruit Chemical Characteristics: The effect of the various treatments on fruit chemical parameters at harvest are presented in Table 2.The data showed that fruit acidity was significantly increased by spraying NAA and SA (in both seasons), putrescine (in the first season) and GA_3 (in the second season) when compared with the untreated palms. No significant difference was obtained among the previously mentioned treatments in both seasons. In addition, fruit chlorophyll was increased significantly with all treatments in both seasons. Spraying SA had a significant effect in increasing the fruit chlorophyll

Table 1: Effect of different growth regulators treatments on the physical characteristics of Barhee fruits during 2008 and 2009 seasons

Treatments	Fruit weight (g)	Fruit volume (cm^3)	Fruit length (cm)	Fruit diameter (cm)	Pulp weight (g)	Ground color
			2008			
Control	9.21	8.80	2.48	2.04	8.54	5.00
NAA	12.68	12.17	3.07	2.60	11.38	3.60
GA_3	14.86	14.63	3.53	2.65	13.75	4.00
CPPU	13.90	13.50	3.42	2.72	12.67	4.22
Put	14.47	14.00	3.48	2.63	13.83	4.04
BA	13.84	13.33	3.18	2.47	12.70	4.40
SA	10.80	10.45	2.80	2.45	9.81	4.00
L.S.D 0.05	1.61	1.74	0.37	0.48	1.76	0.46
			2009			
Control	9.97	9.87	2.93	2.30	8.98	5.00
NAA	13.60	13.17	3.37	2.60	12.61	4.02
GA_3	13.86	13.83	3.33	2.65	12.84	4.12
CPPU	14.90	14.50	3.42	2.72	13.67	4.24
Put	14.17	14.00	3.60	2.63	12.83	4.24
BA	15.34	14.83	3.38	2.67	14.03	4.36
SA	10.85	10.85	2.98	2.45	9.81	4.06
L.S.D 0.05	2.16	1.80	0.30	0.26	1.46	0.18

Table 2: Effect of different growth regulators treatments on the chemical characteristics of Barhee fruits during 2008 and 2009 seasons

Treatments	Acidity (%)	TSS (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Total Chlorophyll (mg/100g)	Carotene mg/100g
				2008			
Control	0.31	33.4	21.6	8.53	30.2	2.94	8.47
NAA	0.49	30.3	18.4	9.97	28.4	5.74	4.04
GA_3	0.43	31.8	18.5	9.68	28.2	4.86	3.75
CPPU	0.38	32.2	18.7	9.69	28.4	4.68	3.19
Put	0.48	29.4	18.5	9.48	28.0	5.38	3.74
BA	0.38	33.6	19.9	8.67	28.6	4.28	4.23
SA	0.53	30.4	17.5	10.78	28.2	6.03	3.29
L.S.D 0.05	0.13	1.7	2.7	0.86	1.6	1.26	3.43
				2009			
Control	0.39	32.8	20.3	9.23	29.4	2.18	7.83
NAA	0.58	30.0	17.6	10.83	27.5	7.37	4.76
GA_3	0.61	27.6	17.6	10.93	28.4	6.15	3.28
CPPU	0.48	31.9	17.5	9.74	27.2	4.83	4.14
Put	0.42	28.4	17.1	10.37	27.5	4.87	4.76
BA	0.42	31.6	18.2	9.93	28.1	4.43	5.48
SA	0.63	28.4	14.9	10.83	25.8	7.86	4.63
L.S.D 0.05	0.17	2.7	2.5	1.13	1.8	2.08	2.08

Table 3: Effect of different growth regulators treatments on the harvesting date of Barhee fruits during 2008 and 2009 seasons

Treatments	2008 season	2009 season
Control	1/8	27/7
NAA	8/9	4/9
GA_3	30/8	2/9
CPPU	18/8	14/8
Put	21/8	18/8
BA	10/8	12/8
SA	24/8	22/8

Table 4: Effect of different growth regulators treatments on the fruit rutab percentage during storage for 45 days at 0° C and 85% RH of Barhee fruits during 2008 and 2009 seasons.

Treatments	After 45 days	After 30 days	After 15 days
		2008	
Control	12.43	32.65	86.98
NAA	0.00	0.00	12.76
GA_3	1.32	4.65	16.25
CPPU	4.34	13.54	22.34
Put	1.23	5.87	12.43
BA	6.65	14.43	37.33
SA	2.67	5.33	24.33
		2009	
Control	16.65	28.53	95.00
NAA	0.00	0.00	11.32
GA_3	2.33	7.67	18.46
CPPU	5..67	12.76	31.38
Put	1.67	6.72	19.45
BA	3.21	18.65	33.33
SA	4.67	4.42	20.33

Table 5: Effect of different growth regulators treatments on the fruit weight loss percentage during storage for 45 days at 0°C and 85% RH of Barhee fruits during 2008 and 2009 seasons

Treatments	After 45 days	After 30 days	After 15 days
		2008	
Control	3.63	6.76	13.24
NAA	2.00	3.42	9.45
GA_3	2.23	4.06	8.21
CPPU	2.82	4.79	12.22
Put	2.35	4.04	10.80
BA	2.76	5.32	12.55
SA	2.17	5.12	9.30
L.S.D 0.05	0.48	1.89	3.76
		2009	
Control	3.84	8.5	13.46
NAA	2.21	4.42	8.45
GA_3	2.33	5.07	9.21
CPPU	2.76	5.39	10.22
Put	1.95	4.74	8.80
BA	2.75	5.08	10.55
SA	2.21	4.28	9.30
L.S.D 0.05	0.82	2.74	4.27

content than BA and cytofex in the first season only, whereas, no significant difference was obtained among the SA, NAA, GA_3 and Put. In the second the SA and NAA had similar higher effect in increasing peel chlorophyll content than BA, cytophex and putrescine with no significant differences were obtained among the BA, cytophex and putrescine treatments. A significant increase in the fruit non- reducing sugars was obtained by NAA,GA_3, SA and Put sprays (in both seasons) and CPPU (in the first season),with no significant differences was found among the previously mentioned treatments during both seasons. Total soluble solids content was decreased by NAA, SA and putrescine sprays (in both seasons) and GA_3 (in the second season) as compared with the control, with no significant difference was obtained among the previously mentioned treatments during both seasons. Moreover, the fruit reducing sugars were also decreased with all treatments (except BA) in both seasons with no significant differences obtained among them in the first season. However, in the second season the highest decrease of reducing sugars content was obtained by salicylic acid sprays. In addition the NAA, Put, GA_3 and CPPU treatments showed insignificant difference among them in the second season. Fruit total sugars were decreased by spraying NAA, SA, CPPU and Put in both seasons and by GA_3 in the first season. In the mean time, all sprayed substances decreased the fruit carotene content in both seasons as compared with the water sprayed control.

The increments in fruit acidity, non-reducing sugars and total chlorophyll and the decrements in fruit TSS and carotene contents obtained with NAA, GA_3 and CPPU application might translate their influence in retarding fruit ripening process as mentioned before by Aljuburi *et al.* [4], Hussein *et al.* [7], Moustafa and Seif [8] and Moustafa *et al.* [9], working on date palm fruit. Similarly, the role of putrescine and salicylic acid in delaying fruit ripening was indicated. The main effect of putrescine is lowering ethylene production and respiration rate as well as inducing mechanical resistance [6, 15]. Salicylic acid was reported to activate the metabolic consumption of soluble sugars to form new cell constituents as a mechanism for stimulating plant growth and might be assumed to inhibit polysaccharide-hydrolyzing enzyme system and /or accelerate the incorporation of soluble sugars into polysaccharides [35]. The previous mentioned might be leading factors to the role of salicylic acid in retarding fruit ripening.

Harvest Date: Ripening period was prolonged by 38, 30, 21 and 24 days for NAA and GA_3, SA and Put sprays, respectively as compared with the water sprayed control (Table 3). Cytofex had a moderate effect on delaying fruit ripening, whereas, BA delayed fruit ripening by 10 days only, in comparison with the control.

Fruit Quality During Storage: The effect of the different spray treatments on fruit storage ability determined as

the percent of rutab incidence of fruits and weight loss in both seasons is presented in Tables 4 and 5. The obtained data showed that rutab percent during 45 days of storage at 0 °C and 85-90% RH was significantly reduced by all treatments. NAA application resulted in the lowest rutab percent, followed by GA_3, Put, SA, cytofex and BA sprays. The storage life of Barhee dates treated with NAA was extended 30 days without incidence of fruit rutab, while, after at 45th day the fruit rutab percentage reached 12.8 and 11.3 in 2008 and 2009 seasons, respectively. Regarding the effect of the different treatments on fruit weight loss during storage, the data in Table 5 revealed that the percentage of fruit weight loss tended to decrease with all sprayed substances in comparison to the control. Weight loss is an important factor that limits postharvest storage life of fruit [36].

Fruits going into ripening and senescence are mainly characterized by disintegration of organelle structures, intensive loss of chlorophyll and proteins, membrane leakage and breakdown of cell wall components leading to loss of tissue structure [37, 38]. Ethylene is known to have primitive effect on ripening and senescence processes [39]. From the results above, decreasing fruit deterioration (reduction of rutab incidence and weight loss) might be due the effect of the sprayed substances on regulating ethylene production or action and thus, slowing down fruit senescence. Polyamines are well-known regulators of growth and differentiation and may compete directly with ethylene for their common precursor S-adenosylmethionine, thus reduce or even nullify ethylene emission in the final days of fruit growth [31]. Also, putrescine application was found to reduce the activities of fruit softening enzymes in the skin and pulp tissues [40]. SA significantly maintained fruit firmness and lowered fruit decay during cold storage [41].

CONCLUSION

In general, all preharvest substances tested had a role on Barhii date palm fruit quality, but SA, NAA, Put or GA_3 treatments were better than CPPU or BA treatments. The preharvest NAA, GA_3 and SA treatments prevented fruit rutab (softening) and decreased weight loss and TSS. These treatments can be easily used instead of laborious postharvest treatments to extend or increase the storagability life and improve Barhii date palm fruit quality.

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