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The Impact of Spraying Ga_3 with Various Concentrations on Fruit Chemical Characteristics of Barhee Dates Palm Fruits Under Conditions of Humid or Semi-Dry Areas

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Abstract

The current Experiment was conducted to investigate the effects of foliar application of gibberellic acid (GA_3) on fruit chemical characters in 'Barhee' date palm carried out during the 2023 and 2024 seasons in a private orchard located at El-Mansoria district (Egypt - Alexandria Desert Road), El-Giza Governorate, Egypt. GA_3 at 0, 5, 10, 15, 20 and 25 ppm were applied to the date palms. Investigate were recorded on fruit chemical characters like total soluble solids (TSS), titratable acidity (%), TSS/acid ratio, total sugars, reducing sugars, non-reducing sugars, tannins (%), total phenols (mg g^{-1} Fw), total chlorophyll (mg/100 g Fw), total carotenoids (mg/100g Fw) and rutab (%). Results indicated that spray Barhee' date palm with GA_3 favorably influenced all fruit chemical characteristics.

Keywords: 'Barhee' Date palm, GA_3, Foliar spray, chemical characteristics.

1. Introduction

A popular kind of date palms (*Phoenix dactylifera* L.), Barhee cv. is prized for its very sweet, caramel-like flavor. Barhee dates, which come from Iraq, are known for their tender, amber flesh that turns golden brown when it ripens. Barhee dates are frequently eaten at three different stages of ripening-rub (soft and fully ripe), tamr (dry), and khalal (crunchy and semi-ripe), in contrast to many other date kinds. This kind does well in hot, dry conditions, especially in North Africa, the Middle East, and some U.S. states like California and Arizona [1,2]. Barhee date palms are a popular option for commercial production because of their great yield potential and quick fruit maturation. Rich in carbohydrates, fiber, and vital minerals like potassium and magnesium, the fruit is incredibly nutrient-dense [3]. Due to its unique texture and flavor, the Barhee variety is often used in fresh consumption rather than drying, distinguishing it from more commonly processed date cultivars such as Medjool and Deglet Noor. Due to their nutritional richness, Barhee dates are an important source of energy, fiber, and essential minerals [4].

Seasonal factors govern the global commerce of Barhee dates, with shipments peaking before Ramadan when Muslim populations around the world consume more dates. Barhee dates are supplied to worldwide markets in Asia, Europe, and North America by major exporting nations such as the United Arab Emirates, Saudi Arabia, and Egypt [5].

Barhee date cultivation provides significant economic benefits to date-producing regions, supporting thousands of farmers, laborers, and traders. In Gulf countries, date palm farming, including Barhee production, is a key agricultural sector, contributing to rural employment and food security. Additionally, government initiatives in countries like Saudi Arabia and the UAE have promoted date farming through subsidies, research, and sustainable farming techniques to boost economic returns. The global date market, valued at over $13 billion in 2023, continues to grow, with Barhee dates occupying a niche segment of the fresh fruit category [6]. As consumer interest in natural and organic foods rises, Barhee dates are expected to play a larger role in the expanding premium date market.

GA_3 application significantly affects sugar accumulation in Barhee dates by regulating carbohydrate metabolism. Increased total soluble sugars (TSS): Studies have shown that GA_3 treatment enhances TSS levels in Barhee dates, leading to increased glucose and fructose concentrations, which contribute to greater fruit sweetness [7]. GA_3 slows down starch hydrolysis, delaying the ripening process and prolonging the khalal stage, where the fruit remains firm and less sweet. As the fruit progresses to the rutab and tamr stages, sugar levels increase more gradually. GA_3-treated fruits exhibit an improved balance of sweetness and acidity, making them more palatable for consumers [8].

GA_3 influences organic acid metabolism in Barhee dates, affecting their acidity and pH: Reduced Acidity: GA_3-treated fruits tend to have lower titratable acidity the enhanced conversion of orgenic aceds (e.g., malic and citric acid) into sugars. This results in a smoother, less tangy taste. Higher pH: A slight increase in pH has been observed in GA_3-treated dates, making them less acidic and more appealing for fresh consumption.

GA_3 plays a key role in maintaining fruit hydration and firmness, especially in the fresh (khalal and rutab) stages. GA_3-treated fruits have a higher

moisture content, which contributes to improved juiciness and texture. This is beneficial for fresh date markets where soft, moist fruit is preferred. GA_3 treatment slows down the activity of cell-wall-degrading enzymes like pectinase and cellulase, which helps maintain fruit firmness for a longer period [9].

GA_3 influences the accumulation of phenolic compounds, which contribute to antioxidant properties and fruit quality. Some studies report that GA_3-treated Barhee dates exhibit higher levels of polyphenols, which enhance antioxidant activity and improve fruit resistance to oxidative stress [10]

GA_3 slows the enzyme invertase activity, delaying sugar accumulation and extending the khalal stage. Also, GA_3 can suppress amylase activity, slowing starch breakdown and delaying ripening. This is useful for prolonging fruit shelf life.

GA_3 application influences the vitamin and mineral composition of Barhee dates: Vitamin C Retention: GA_3-treated fruits show higher ascorbic acid (Vitamin C) content due to delayed ripening, which slows down oxidation processes. Enhanced potassium and magnesium levels: GA_3 has been linked to better mineral retention, particularly potassium and magnesium, which contribute to improved fruit texture and flavor.

In accordance with the previously mentioned, the present study was conducted to investigate the effect of different concentrations of spraying GA_3 on improving some fruit chemical charterers of Barhee date palm.

2. Materials and methods

This study was carried out during the 2023 and 2024 seasons in a private orchard located at El-Mansoria district (Egypt - Alexandria Desert Road), El-Giza Governorate, Egypt. 'Barhee' date palms of healthy, nearly homogenous in growth as well as fruiting ability were selected. according to the recommendation of the Ministry of Agriculture in the area subjected to the same horticultural practices (irrigation, fertilization, weed control, and pest control).

The present experiment included five treatments for each GA_3 concentration in addition to the control treatment (water spray) as follows.

T_1-Control (water spray)
T_2 -Foliar spray with GA_3 5 ppm.
T_3- Foliar spray with GA_3 10 ppm.
T_4- Foliar spray with GA_3 15 ppm.
T_5- Foliar spray with GA_3 20 ppm.
T_6- Foliar spray with GA_3 25 ppm.

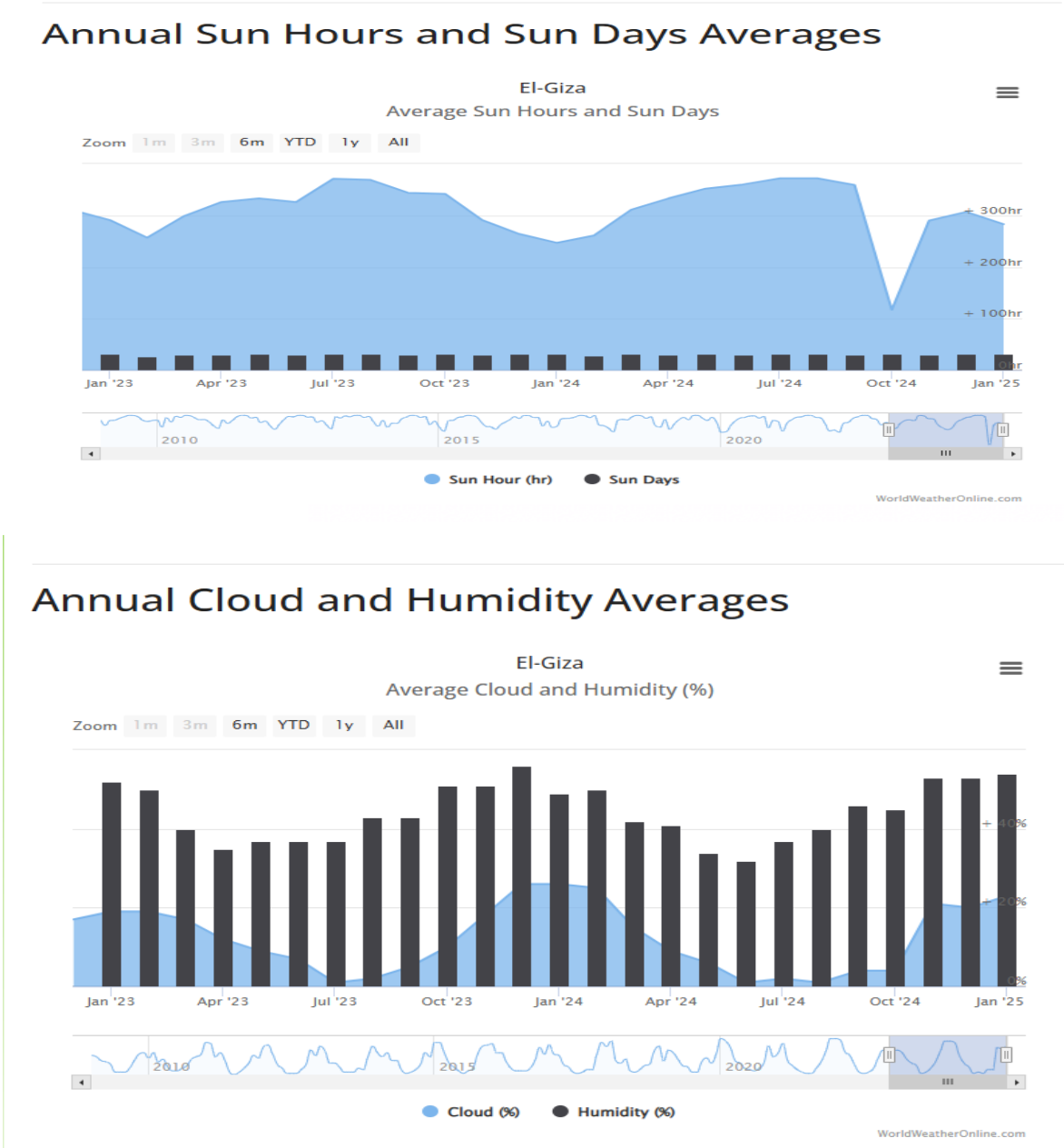

Fig. (1): The annual sun hours and sun days average, annual cloud and humidity data for the whole year as an average taken from 2023&2024 of historical data for Giza Governorate.

Experiments layout:

The complete randomized block design with three replications was employed for arranging the six investigated spraying treatments experimental seasons, whereas a single tree represented each replicate. Consequently, 18 healthy, fruitful Barhee date palm plants were carefully selected as being healthy, and disease-free.

Application time:

Taking into consideration that spray treatments were applied covering the whole different growth stages of Barhee dates of each palm, whereas 10 liters were found to be sufficient in this concern. Besides, periodically applied 5 times/season at the one-month interval in the 1st week of March, April, May, June and July.

Data and Measurements:

The response to spray treatments investigated was evaluated by determining changes exhibited in the following fruit chemical properties

Fruit chemical properties: The following fruit juice chemical properties were determined at harvest according to [11].

1. **Fruit juice total soluble solids (TSS %):** was determined using a Zesis hand refractometer.
2. **Total titratable acidity (%):** was determined as malic acid per 100 g flesh by titration against 0.10 N sodium hydroxide in the presence of phenol naphthalene indicator after method described according to [12].
3. **Total soluble solids/total acidity (TSS/acid ratio):** was calculated by dividing the total soluble solids percentage by total acidity percentage.
4. **Sugar content: -**

The water extract of the studied sample firstly was clarified by adding lead acetate to precipitate non-sugars, and then excess lead acetate was precipitated by adding potassium oxalate and filtrated to remove non-sugars. Reducing sugars and total sugars were estimated by Smogy method according to [13].

Non-reducing sugars are calculated as;

Non-reducing sugars = Total sugars – Reducing sugar.

5. **Soluble tannins content (%):** The soluble tannins were measured by the Folin–Denis method [14].
6. **Total phenols content (mg g^{-1} Fw):** Five grams of fruit tissue were dissolved in fifteen milliliters of 95% ethanol and then heated for fifteen minutes. Whatman No. 1 filter paper was used to filter the homogenate. Five minutes after adding 0.5 ml of Folin-Denis reagent to 1 ml of the alcoholic extract, 7 ml of saturated sodium carbonate solution was added, mixed, and allowed to sit for half an hour. At 750 nm, optical density was measured, and total phenols were computed using a gallic acid reference curve. The mg gallic acid equivalents per gram of fresh weight basis were used to express this data in accordance with [15].
7. **Total chlorophyll (mg/100 g Fw) and total Carotenoids (mg/100g Fw):** total chlorophyll and total carotene contents (mg /100 g peel fresh weight) were achieved by the method of [16].
8. **Rutab (%):** after 10 days at room storage. The Rutab stage in date palms can be determined through color change, texture softening, moisture loss, sugar accumulation, and enzymatic activity. fruits go through four distinct ripening stages: Kimri (unripe, green), Khalal (mature, firm, yellow or red), Rutab (partially ripe, soft, brown), and Tamr (fully ripe, dry, dark brown or black). The Rutab stage is crucial for determining fruit quality, harvest timing, and market value, particularly in soft and semi-dry cultivars like Barhee. Identifying Rutab fruits involves visual [3], textural [17], biochemical [18], and physiological parameters [19].

Statistical analysis:

The obtained data were subjected to an analysis of variance according to [20]. Duncan's multiple range test [21] at the 5% level was used to c0mpare the mean values.

3. RESULTS AND DISCUSSION

3.1. Effect of spraying GA_3 with different concentrations on TSS (%), titratable acidity (%) and TSS/acid ratio of Barhee date palm fruits

Table (1) showed that data revealed that treatments with different concentrations of GA_3 induced significant effects in TSS%, TSS/acid ratio of Barhee date palm fruits in dates extract in 2023 and 2024 seasons while not inducing significant effects in Titratable acidity (%). Concerning the effect of spraying GA_3 (10 ppm), it could be noticed that resulted in the highest level of TSS% at the, in comparison with untreated (control) palms during the two studied seasons. While not inducing an increase in Titratable acidity (%) in dates at both seasons, all in compared with untreated (control) palms.

The results gained from this investigation differ from those published by [22] on date palm Seewy cv and [22,24] on date palms Zaghloul and Samani cvs , where they discovered that spraying GA_3 resulted in a modest decrease in TSS% and total sugars%. They concluded that the results they obtained might be because GA_3 delays the ripening of fruit and increases its moisture content.

However, [25] concluded that the TSS% in date fruits was not consistently impacted by GA3, while [26] found that the chemical qualities of the fruits were enhanced by bagging Zaghloul date bunches.

Table (1): Effect of spraying GA_3 with different concentrations on TSS, titratable acidity (%) and TSS/acid ratio of Barhee date palm fruits during 2023 and 2024 seasons.

Parameters	TSS (%)		Titratable acidity (%)		TSS/acid ratio	
Treatments	**1st season**	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**

T1- Control	30.13D	31.59D	0.136A	0.139A	221.0D	227.9D
T2- GA_3 5 ppm	31.22C	32.33C	0.128A	0.131A	243.3C	247.5C
T3- GA_3 10 ppm	35.36A	36.15A	0.128A	0.126A	277.0A	286.9A
T4- GA_3 15 ppm	34.01B	34.35B	0.131A	0.135A	259.6B	253.8B
T5- GA_3 20 ppm	29.39E	31.09E	0.137A	0.140A	214.0E	222.7E
T6- GA_3 25 ppm	28.18F	30.22F	0.140A	0.142A	201.8F	212.4F

Means followed by the same letter/s within each column didn`t significantly differ at 5 % level.

3.2. Effect of spraying GA_3 with different concentrations on total sugars, reducing sugars and non-reducing sugars of Barhee date palm fruits

Data presented in **Table (2)** showed that all treatments with different concentrations of GA_3 increased in total sugars and reducing sugars content % based on the bunch weight of dates during the both seasons. Regarding to effects of spraying GA_3 (10 ppm), it could be noticed that was more effective of date palm Barhee cv during 2023 and 2024 seasons compared with control.

Additionally, Table (2) showed that all treatments with GA_3 decrease in non-reducing sugars content % in Barhee date palm during the first season, while all treatments caused a significant increase in non-reducing sugars content % based on fresh weight of dates during the both seasons in comparison with untreated palms.

Table (2): Effect of spraying GA_3 with different concentrations on total sugars, reducing sugars and non-reducing sugars of Barhee date palm fruits during 2023 and 2024 seasons.

Parameters / Treatments	Total sugars %		Reducing sugars %		Non-reducing sugars %	
	1st season	**2nd season**	**1st season**	**2nd season**	**1st season**	**2nd season**
T1- Control	26.18D	26.40D	21.02D	21.10D	5.17F	5.31C
T2- GA_3 5 ppm	27.11C	27.21C	21.54C	21.42C	5.57D	5.80B
T3- GA_3 10 ppm	31.00A	30.75A	24.07A	24.20A	6.94A	6.55A
T4- GA_3 15 ppm	29.03B	29.21B	22.94B	23.02B	6.09B	6.19AB
T5- GA_3 20 ppm	24.98E	25.12E	19.14E	19.20E	5.84C	5.92B
T6- GA_3 25 ppm	24.17F	24.91E	18.74F	18.80F	5.43E	6.11AB

Means followed by the same letter/s within each column didn`t significantly differ at 5 % level.

3.3. Effect of spraying GA_3 with different concentrations on tannins (%) and phenols (mg g^{-1} Fw) of Barhee date palm fruits.

In this regard, two fruit chemical characteristics dealing with tannins (%) and phenols (mg g^{-1} Fw) in response to spraying with GA_3 were investigated. Data obtained during 2023 & 2024 seasons are presented in **Table (3)**.

It is quite evident that two of these investigated fruit chemical characteristics indeed tannins (%) and phenols (mg g^{-1} Fw) typically didn't follow the same trend previously detected with both yield/tree and average bunch weight. That did not induce an increase in tannins (%) in dates at both seasons compared with control (untreated palms). The data presented in **Table (3)** showed that all treatments with different concentrations of GA_3 increased in phenols (mg g^{-1} Fw) of dates during the 2023 and 2024 seasons of this research. It could be noticed that GA_3 as concentration GA_3 (25 at ppm) spraying was more effective at Barhee date during both seasons compared with untreated (control) palms.

Table (3): Effect of spraying GA_3 with different concentrations on tannins (%) and total phenols (mg g^{-1} Fw) of Barhee date palm fruits during 2023 and 2024 seasons.

Parameters / Treatments	Tannins (%)		Phenols (mg g^{-1} Fw)	
	1st season	**2nd season**	**1st season**	**2nd season**
T1- Control	0.237A	0.237A	0.420C	0.433C
T2- GA_3 5 ppm	0.222A	0.224A	0.403C	0.407D
T3- GA_3 10 ppm	0.220A	0.222A	0.347E	0.333F
T4- GA_3 15 ppm	0.227A	0.228A	0.383D	0.367E
T5- GA_3 20 ppm	0.232A	0.230A	0.460B	0.470B
T6- GA_3 25 ppm	0.239A	0.240A	0.500A	0.513A

Means followed by the same letter/s within each column didn`t significantly differ at 5 % level.

3.4. Effect of spraying GA_3 with different concentrations on total chlorophyll (mg/100 g Fw) and total Carotenoids (mg/100g Fw) of Barhee date palm fruits

Data in **Table (4)** reveal also that, spraying bunches of date palms with GA_3 significantly increased total chl0rophyll (mg/100 g Fw) and total carotenoids (mg/100g Fw) content in the fruit in the 1st and 2nd seasons, respectively. But in two different trends.

Generally, GA_3 (25 at ppm) treatments achieved the highest content of total chlorophyll (mg/100 g Fw) and the lowest content of total Carotenoids (mg/100g Fw) in the two seasons. While the control and GA_3 (5 at ppm) treatments achieved the highest values of total carotenoids (mg/100g Fw) within both experimental seasons.

Table (4): Effect of spraying GA_3 with different concentrations on total chlorophyll (mg/100 g Fw) and total carotenoids (mg/100g Fw) of Barhee date palm fruits during 2023 and 2024 seasons.

Parameters	Total chlorophyll (mg/100 g Fw)		Total carotenoids (mg/100g Fw)	
Treatments	**1st season**	**2nd season**	**1st season**	**2nd season**
T1- Control	2.75D	2.87E	5.69A	5.72AB
T2- GA_3 5 ppm	2.73E	2.87E	5.73A	5.82A
T3- GA_3 10 ppm	2.92C	2.91D	5.36B	5.57B
T4- GA_3 15 ppm	2.95B	2.93C	5.21C	5.15C
T5- GA_3 20 ppm	2.97B	2.97B	5.10D	5.09C
T6- GA_3 25 ppm	3.04A	3.02A	4.99E	4.93C

Means followed by the same letter/s within each column didn`t significantly differ at 5 % level.

3.5. Effect of spraying GA_3 with different concentrations on Rutab (%) of Barhee date palm fruits

Data in **Table (5),** Rutab (%) the trend of response to various spray solution treatments took the other way around to that previously detected with the above-discussed characteristics. Herein, the fruit of control (water-sprayed) showed statistically the highest value i.e., its rutab trended to be less control during both experimental seasons. Since the rate of decrease in Rutab over control to each treatment was separately concerned.

Table (5): Effect of spraying GA_3 with different concentrations on Rutab (%) of Barhee date palm fruits during 2023 and 2024 seasons.

Parameters	Rutab (%)	
Treatments	**1st season**	**2nd season**
T1- Control	9.02A	9.05A
T2- GA_3 5 ppm	5.19E	5.21E
T3- GA_3 10 ppm	5.11F	5.15E
T4- GA_3 15 ppm	6.05D	6.09D
T5- GA_3 20 ppm	7.22C	7.31C
T6- GA_3 25 ppm	8.74B	8.82B

Means followed by the same letter/s within each column didn`t significantly differ at 5 % level.

4. Discussion

Gibberellic acid (GA_3), a plant growth regulator, is widely used in horticultural crops to manipulate growth, development, and fruit quality. In Barhee date palm (*Phoenix dactylifera* L.), the application of GA_3 has shown notable effects on the chemical composition and quality parameters of the fruits.

GA_3 influences the chemical composition of Barhee date palm fruits by altering sugar content, acidity, and ripening patterns. While it may reduce TSS and delay ripening, it can also lead to improved sugar accumulation and reduced acidity over time. However, the outcomes largely depend on timing, concentration, and environmental conditions, suggesting that GA_3

must be used judiciously for optimal fruit quality enhancement.

GA_3 treatments have been reported to influence TSS levels, which are closely associated with sugar content and overall fruit sweetness. Some studies suggest that GA_3 can delay fruit ripening, leading to lower TSS values, especially when applied at early developmental stages. This delay in maturity might be due to GA_3's role in inhibiting the synthesis of ripening-related hormones like ethylene. [27] reported that application of GA_3 at 100 ppm reduced TSS in Barhee dates compared to untreated controls, indicating a delay in sugar accumulation. [28] also observed that GA_3 treatments resulted in fruits with relatively lower TSS, particularly when applied at the Kimri or Khalal stage.

GA_3 tends to influence organic acid metabolism, thereby affecting fruit acidity and pH. Some studies report that GA_3 treatments can lead to a reduction in titratable acidity, resulting in sweeter-tasting fruits. [29] found that Barhee dates treated with GA_3 showed decreased acidity, especially during the Rutab stage.

GA_3 treatments often affect sugar metabolism. While TSS might decrease initially due to delayed ripening, sugar content may increase later as ripening progresses. The effects, however, depend on application timing and concentration. According to [30] GA_3 applied at moderate levels (e.g., 50–100 ppm) can increase reducing sugars and improve the sugar profile in later stages of fruit development.

GA_3 may also affect secondary metabolites such as phenolics, Tannins, chlorophyll and Carotenoids. However, the effect on phenolic content in date fruits is not consistently reported and may depend on environmental factors and cultivar response. Limited studies, such as those by [31], indicate minimal or inconsistent changes in phenolic content following GA_3 treatment in Barhee and other cultivars.

Plant growth regulators like gibberellic acid (GA_3) play a significant role in the biochemical and physiological development of fruits, including pigment biosynthesis and degradation. In Barhee date palm, GA_3 application has been shown to influence chlorophyll and carotenoid concentrations, which are crucial pigments affecting fruit color, maturity, and nutritional quality. Application of GA_3 is known to delay chlorophyll degradation, thereby prolonging the green color retention in fruits. This effect is attributed to GA_3's ability to delay senescence and ripening, likely by suppressing ethylene production or activity. [28] reported that spraying Barhee palms with GA_3 (75–100 ppm) increased chlorophyll a and b concentrations in fruits during early development stages compared to control, indicating a retarded transition to the Khalal stage. [29] also observed higher chlorophyll content in GA_3-treated Barhee dates, suggesting delayed pigment degradation during fruit maturation.

GA_3 often shows a suppressive effect on carotenoid biosynthesis, especially when applied at higher concentrations or early in development. This is due to the delayed chlorophyll breakdown, which consequently slows the onset of carotenoid accumulation. [27] found that GA_3 application resulted in lower carotenoid content in Barhee fruits during early ripening stages, likely due to the delayed onset of chloroplast-to-chromoplast transition. Similarly, [32] reported a decrease in carotenoid levels in date fruits treated with GA_3, suggesting that gibberellins may interfere with the expression of genes responsible for carotenoid biosynthesis pathways. The higher chlorophyll and lower carotenoid contents observed in GA_3-treated Barhee fruits suggest a delay in ripening and color development, which can be both advantageous and disadvantageous depending on the intended harvest time and market preferences:

5. Conclusion

It can be concluded from the above results that different concentrations of GA_3 sprays, had a positive effect on fruit chemical characteristics like TSS (%), titratable acidity (%), TSS/acid ratio, total sugars, reduc1ng sugars, Non-reducing sugars, tannins (%), phenols (mg g^{-1} Fw), total chlorophyll (mg/100 g Fw), total carotenoids (mg/100g Fw) and Rutab (%) compared with control. Therefore, it could be recommended that spraying Barhee date palms with GA_3 it has been used to improve the fruit's chemical properties of date palm grown under similar environmental conditions (humid or semi-dry).

Photo (1): **Effect of spraying GA_3 with different concentrations on chemical characters of Barhee date palm fruits.**

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