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Improving Fruit Quality and Marketability of 'Balady'mandarin Fruits by Gibberellin and Copper Sulphate

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ABSTRACT

Obtaining 'Balady' mandarin fruits with fewer seeds is a valuable target for consumers as it is one of the most important cultivars in Egypt because of its high eating properties. So, a field experiment was conducted during 2016 and 2017 seasons at a private orchard situated in Dacult area, Kafr El-Sheikh governorate, Egypt, to study the effect of foliar spray with gibberellic acid (GA3) at 25 and 50 mg L^{-1} , copper sulfate (CuSO4) at 25 mg L^{-1} alone or in combination on yield, fruit quality , fruit seed number .and shelf life. The obtained results showed that the combination between gibberellic acid (GA3) and copper sulfate (CuSO4) treatment reduced the seed number per fruit ranged (4.66-7) and improved yield and fruit quality such as markedly increase in fruit weight, volume, SSC/acid ratio and ascorbic acid. Simultaneously, it reduced the weight loss % and decay loss % during shelf life in comparison to other treatments and control.

Keywords: mandarin – Foliar spray- seed number - shelf life

INTRODUCTION

The global market for fresh mandarin fruits, especially those seedless with easy-peeling and attractive orange-colored skin, has increased dramatically in the past decade. (Garmendia *et al*., 2019, Gambetta *et al*. 2013 and Garcia Neves . 2018).

Global production of mandarins increased by 30% (from 22 million tons in 2010 to 29 million tons in 2015) (FAO,2017) probably at least in part attributed to the fruit's consumer-friendly qualities. As well as higher peel convenience as opposed to other varieties of citrus. Furthermore, mandarins are primarily eaten as fresh fruits; they are a source of vitamins and fiber and also contain secondary metabolites such as ascorbic acid, phenolic compounds, flavonoids, and limonoids, which are essential for human nutrition and health. (Jayaprakasha and Patil, 2007). 'Balady' mandarin is one of the most important cultivated varieties in Egypt because of its beautiful shape, easy peeling, and yellow-orange when fully mature, thin and smooth. but, it has quite a large number of seeds, which is disadvantageous because the trade market prefers seedless fruit or less seed fruit.

In recent decades, it is possible to obtain new seedless varieties through sophisticated breading, triploid hybrids, gamma-induced mutations (Yamamoto *et al*., 1995; Shen, 1997; Vardi *et al.,* 2008). Additionally, net coverage considerably the most successful seed reduction activities, but high costs and reduced yield per tree are considered the major drawbacks (Gravina *et al*. 2016).

Furthermore, various attempts have been made to minimize Citrus fruit seeds; gibberellic acid (GA3) used in anthesis impairs fertilization either by improving the abortion of ovules or reducing the growth of pollen tubes in ' Clementine ' mandarin flowers under cross-pollination conditions (Mesejo *et al*., 2008).The role of gibberellic acid in parthenocarpy and fruit set has been illustrated (Pharis and King, 1985; Jacobsen and Olszewski, 1993 and Fos *et al*., 2001). It has been shown that exogenous GA_3 treatments increased fruit set in various citrus cultivars (García-Martínez and García-Papí,1979), but not in 'Satsuma' mandarin (Coggins *et al*., 1968) which had a high level of endogenous GA_3 at anthesis (Talon *et al*., 1992). Gambetta *et al.* (2013) attempted some GA_3 and $CuSO_4$ treatments to reduce the seed number in 'Afourer' mandarin the most efficient treatment was proved to be applications of GA_3 + $CuSO_4$, which increased the percentage of seedless fruit. Besides, Garmendia *et al*., (2019) studied treatments such as nets, copper sulfate (CuSO4) and gibberellic acid (GA_3)) in order to reduce the number of seeds in mandarin ' Afourer. ' fruit. Furthermore, Mesejo *et al*. (2006) suggested that 25 mg L^{-1} of copper sulfate applied at full bloom to the entire 'Afourer' trees significantly reduced the average number of seeds per fruit. Additionally, in numerous phonological and physiological stages of tree growth, plant growth substances are used to control crop loads, increase fruit size, enhance fruit quality or prolong fruit shelf life on the tree and/or after harvest. (El-Otmani, *et al* 2011). So, our study was carried out to evaluate the effectiveness of GA_3 and $Cuso_4$ on fruit quality by reducing the number of seeds, and their effects on the marketability of 'Balady' mandarin fruit.

MATERIALS AND METHODS

The experiment was conducted on 15-year-old trees of mandarin (*citrus reticulata* Blanco cv. 'Balady', grafted onto sour orange rootstock, and planted in 5x 5 m apart. The trees were grown on a private orchard located in Dacult area, Kafrelsheikh governorate, Egypt. All the agricultural practices were done as usual in the orchard. Physical analysis and soil chemicals are shown in Table 1

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Table 1. Physical analysis and soil chemical of the experimental soil.

Physical analysis				Chemical analysis										
				EC	pH	Soluble Cations (meql-1)				Soluble Anions (meql-1)				
Sand%	Silt%	Clay%	Soil texture	(ds.m1)		K^+	Na^+	Mg^{++}	Ca^{++}	Co_3^-	HCO_3^-	Cl^-	SO_4^-
11.30	36.34	52.36	clay	1.66	8.1	0.15	9.5	2.94	3.71	00	3.1	8.2	5.0

The experiment was consisted of six treatments as follow:

T1= Control trees without any chemical spray.

T2= Single foliar spray of GA_3 at 25 mg L^{-1}

T3= Single foliar spray of GA_3 at 50 mg L^{-1}

T4= Foliar spray of ($CuSO_4.7H_2o$) at 25 mg L^{-1}

T5= Combination foliar spray of GA_3 at 25 mg $L^{-1}$and ($CuSO_4.7H_2o$) at 25 mg L^{-1}

T6= Combination foliar spray of 1 GA_3 at 50 mg $L^{-1}$and ($CuSO_4.7H_2o$) at 25 mg L^{-1}

Treatments were applied 3 times throughout the flowering period (30%, 60%, and 90% opened flowers). The experiment was arranged with three replicate per treatment

During the ripening period, the following data was recorded:

Yield

At harvest time when SSC/acid ratio reached 10-12, then yield was calculated based on fruits number/tree, the average yield of fruits as kg per tree were calculated, and the average of fruit weight (g.) was determined.

Fruit seed number;

The number of developed and aborted (undeveloped) seeds per fruit were counted and the reduction percentage of developed seeds number per fruit over control was calculated and weight of 10 seeds.

Fruit quality

At harvest time,20 healthy fruits were taken at random from each replicate in both seasons and prepared for determination of physical characteristics such as fruit weight (g), fruit volume (ml), juice volume (ml), fruit height (cm), and diameter (cm). Fruit chemical characteristic as soluble solids content (SSC%) was determined by hand refractometer and total acidity as citric acid % was determined then SSC/acid ratio was calculated %. Vitamin C as ascorbic acid in mg/100ml juice was estimated by using 2, 6 dichlorophenol indophenol, according to (A.O.A.C., 2000), and carotenoids were determined according to the method of Wettestein (1957).

Weight loss during shelf life:

A sample of five fruits from each replicate was taken out and left at room temperature for 15 days, then, the fruits were weighted and the percentage of weighted loss during shelf-life was calculated

Percentage of decayed fruit:

The number of discarded fruits due to fungus or any microorganism infection, unmarketable fruits were recorded after 15 days shelf life at room temperature (18 - 20 C º, 60-65 % RH), and calculated as a percentage from the total number of fruits using the following equation:

Decay % = (Number of decay fruits/ total fruit number) * 100

Statistical analysis.

The experiment was designed in a completely randomized block design with three replicates for each treatment and each replicate was represented by one tree. The obtained data of both seasons were subjected to analysis of variance according to Clarke and Kempson, (1997) and the means were differentiated using Duncan multiple range test at 5% level (Duncan, 1955).

RESULTS AND DISCUSSION

Effect of treatments on the seed number per fruit: -

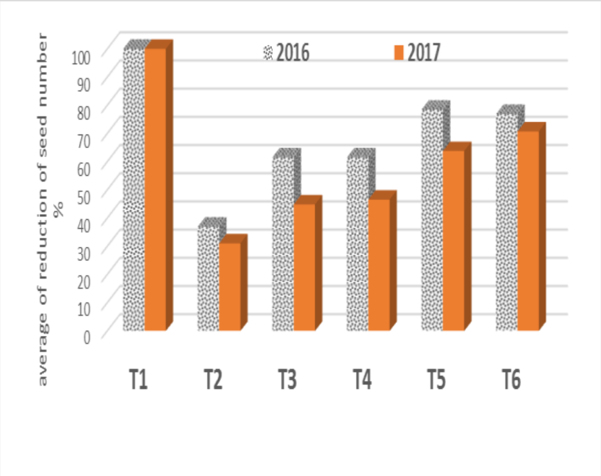
As is observed in Table 2 and Fig.1 , spraying trees through all treatments showed a significant reduction in the number of seeds / fruits produced compared to the control, in particular GA_3 (25 and 50 mg L^{-1}) combined with $CuSO_4$ sprays (25 mg L^{-1})in(T5and T6)which recorded a un upward tendency in the reduction of seed number percentage to (78.48% &63.78%) and (76.91% &70.71%) in both seasons respectively , while no significant reduction was observed between GA_3 at 50 mg L^{-1} (T3)and cuso4 at 25 mg L^{-1}(T4) in both seasons, which recorded (61.54% &44.85%) and (61.54% &46.55%) as compared with control during the two seasons (2016 and 2017), respectively. Simultaneously, concerning GA_3 (25 and 50 mg L^{-1}) combined $CuSO_4$ at 25 mg L^{-1} (T5 and T6) significantly increased the number of aborted seeds (16.66 &13.66)and (16 &15.66) in both seasons, respectively as shown in (Table 2).

Finding was proportionate with Garmendia *et al.*, *(*2019) in Citrus spp who considered that only the GA_3 and copper sulfate treatments reduced the seed number per fruit compared with the open pollination treatment. Also, Otero and Rivas (2017) on 'Afourer' mandarin found that reduction seedy fruits by between 33–40% compared to control with a single spray of GA_3 or combined with $CuSO_4$. While Mesejo *et al.* (2006) on 'Afourer' tangour indicated better efficiencies for the copper treatment of seed reduction and indicated that applying CuSO4, a pollen tube growth inhibitor, to avoid fertilization before pollination., and (Gambetta, *et al*. 2013) found that, during the flowering season,GA3 decreased the percentage of seed fruits and seeds per fruit on "Afourer" mandarin and the most successful treatment was three applications of GA_3(50 mg L^{-1})combined with $CuSO_4$ (25 mg $^{L-1}$), which increased seedless fruit from 19% to 31% and reduced the number of seeds per fruit from 3.7% to2.3% . Moreover, Okamoto and Miura (2005) and Mesejo, *et al*. (2008) reported that GA_3 was found to inhibit fertilization either by inducing seed abortion or reducing pollen tube in mandarin and grapes. In this regard, Cheng *et al*. (2013) stated that the mechanisms driving seedlessness of grapes caused by GA_3 are identical in both seeded and seedless cultivar ,and that the seed abortion observed may result at least in part from an increase in cell damage caused by reactive oxygen species caused by GA3, a decrease in enzymatic antioxidant activity, and a shift in the expression of seed-related gene .

Table 2. Effect of foliar application of GA_3 and $CuSO_4$ on seed number per fruit and weight of 10 seeds in 'Balady'mandarin during 2016and 2017 seasons.

Treatments	Developed seeds		Aborted seeds		Weight (10 seeds) g	
	2016	2017	2016	2017	2016	2017
T1	21.66 a	19.33 a	2 .00 c	3.33 d	1.41 e	1.51 f
T2	13.66 b	13.33 b	11.33 b	10.33 c	1.51 d	1.61 d
T3	8.33 c	10.66 c	12.00 b	10.66 c	2.07 b	2.22 b
T4	8.33 c	10.33 c	11.66 b	11 .00 c	1.42 e	1.54 e
T5	4.66 d	7.00 d	16.66 a	13.66 b	1.98 c	2.13 c
T6	5.00 d	5.66 d	16 .00 a	15.66 a	2.27 a	2.31 a

Means followed by different letter are significantly different within columns by Duncan's multiple range test, $P \leq 0.05$
T1= Control; T2= GA3 at 25 mg L^{-1}; T3=GA3 at 50 mg L^{-1}; T4= $CuSO_4$ at 25 mg L^{-1};
T5= GA3 at 25 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}; T6= GA3 at 50 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}



T1= Control; T2= GA3 at 25 mg L−1; T3=GA3 at 50 mg L−1; T4= CuSO4 at 25 mg L−1;
T5= GA3 at 25 mg L−1 + CuSO4 at 25 mg L−1; T6= GA3 at 50 mg L−1 + CuSO4 at 25 mg L−1

Fig. 1. Averages of reduction (%) of seed number / fruit in 'Balady' mandarin as affected by GA_3 and $CuSO_4$ foliar application during 2016 and 2017 seasons.

Previews results suggested that the reduction of developed seed number per fruit is associated with increasing of gibberellins or both gibberellins and auxins content in the seeds (Mohamed and Elgamma 2018).

Besides, exogenous application of GA_3 induce parthenocarpic fruit development (Olimpieri, *et al*., 2007 and Dorcey, *et al*., 2009). Furthermore, as observed in Table (2) spraying trees through all treatments showed a significant increasing in the weight of ten seeds / fruits produced compared to the control, in particular all treatments including GA_3 application. This observed trend reflected the positive effect of GA in enhancing cell division and enlargement in ovary tissues (Mesejo *et al*., 2016).

yield data

Data in (Tables 3) showed average fruit weight (g), yield as a number of fruit / tree and productivity kg / tree.

The results indicated that, all GA_3 treatments resulted significant increase in fruit weight and yield compared with control treatment in both experimental seasons ,especiallyGA3 at 50 mg L^{-1} alone(T3) or both concentration of GA_3 combined with $CuSO_4$ (T5 and T6)which recorded the highest fruit weight (141.66 &139.66and145.33) in the first seasons, respectively , and the same trend was true in the second season .In addition , despite of reducing number of fruits was recorded from GA_3 treatments in both seasons ,but the yield was higher with all GA_3 treatments in both seasons.in this respect, the highest yield (80.56 and 83.04) was observed fromGA3 at 50 mg L^{-1} alone(T3) and combined $CuSO_4$ at 25 mg L^{-1} (T6) was recorded (83.04 and 85.51) in both seasons, respectively.

Findings are harmony with Hifny, et al., (2017) who recorded that foliar spraying with GA3 resulted the highest values of yield (kg) /tree , and consistent with the studies of , Pal et al. (1977) & Kaur et al. (2008) &Rokaya, et al (2016) & Mohamed and Elgamma (2018) in Citrus , and Singh et al. (2003) in pear, who recorded that the improvement in fruit weight by foliar application of GA3 may be due to hormones targeted at transporting and accumulating photosynthesis, resulting in enhanced fruit production and acceleration of cell division, elongation and enlargement.

Table 3. Effect of foliar application of GA_3 and $CuSO_4$ on average fruit weight, fruit number per tree and yield in 'Balady' mandarin during 2016 and 2017 seasons.

Treatments	Av. Fruit weight (g)		Yield Fruit No./tree		Yield (kg/tree)	
	2016	2017	2016	2017	2016	2017
T1	104.66c	115.83d	630.00a	651.66a	65.95d	75.48c
T2	123.33b	129.80c	580.00b	595.00b	71.35c	77.17bc
T3	141.66a	145.43ab	569.33bc	571.00cd	80.56a	83.04a
T4	106.00c	115.33d	626.66a	653.33a	66.44d	75.48c
T5	139.66a	141.30b	550.00c	558.33d	76.77b	78.90b
T6	145.33a	148.03a	563.66bc	577.66bc	83.56a	85.51a

Means followed by different letter are significantly different within columns by Duncan's multiple range test, $P \leq 0.05$
T1= Control; T2= GA3 at 25 mg L^{-1}; T3=GA3 at 50 mg L^{-1}; T4= $CuSO_4$ at 25 mg L^{-1};
T5= GA3 at 25 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}; T6= GA3 at 50 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}

Fruit physical and chemical characteristics:

A- Fruit physical characteristics:

It is obviously shown from Table.4 that fruit volume increased with the application of all treatments especially GA_3 at 50 mg L^{-1} alone (T3) which recorded (146.00 &149.67) in both seasons respectively or combined with $CuSO_4$ at 25 L^{-1} mg (T6)which the values were (149.00 and 154.67) in 2016 and 2017 respectively .And this trend was true with fruit juice.

Additionally, the effect of treatments on fruit diameter showed significant differences among treatments (Table 4).The highest average diameter was obtained in the fruits from the GA_3 at 50 mg L^{-1} (7.42 cm)(T3), followed by its combined with $CuSO_4$25 mg L^{-1} (7.30 cm)(T6), while the lowest average (6.32 cm) from the control treatment, with substantial differences in the first season. The fruits from the trees treated withGA_3 + copper sulfate had an intermediate average diameter (7.20 cm) rather than control. Furthermore, the increase in the length of the fruits showed significant where the height value (6.94 cm) from the treatment $GA_3$50 + $CuSO_4$25 mg L^{-1} as compared to the control (5.56 cm) in the first season. In comparison, no substantial length differences were found among the fruits of the second season for both treatments and control.

These results are in agreement with those of Marzouk and Kassem (2002) on orange, who stated that fruit dimension was increased significantly as affected by GA_3 as compared with the control. Besides, it was reported by El-Shobaky and Mohamed (2000) and Samman *et al*., (2001) on orange, they stated that juice volume was greatly increased by GA_3 treatment compared with the control.

Our previous results showed a positive effect of GA_3 in increase average fruit weight, volume and dimension although it decreased the number of seeds produced per fruit as a result of foliar spray of different treatments in the 'Balady' mandarin fruit. Such findings are in line with those obtained by Guardiola *et al*. (1993) who found that applying gibberellins and cytokinins during or early flower opening improves the growth of early fruit, the overall increase in fruit size is mainly due to a temporary increase in the ovary wall's cell division .These results are contrary with Eshghi,*et al*., (2010) and Takei (1990) indicated that its negative effects such as decrease in berry size with reduction in seed number .So, GA_3 is often applied to table grapes to increase berry size. (Ziv *et al.*, 1981).

Table 4. Effect of foliar application of GA_3 and $CuSO_4$ on Fruit physical properties of 'Balady' mandarin during 2016 and 2017 seasons.

Treatments	Fruit volume (ml)		Juice volume (ml)		Fruit diameter (cm)		Fruit length (cm)	
	2016	2017	2016	2017	2016	2017	2016	2017
T1	117.10c	123.30d	32.56 c	25.56 e	6.23d	6.26b	5.56d	5.21
T2	122.33c	124.87d	42.58 b	29.46 d	7.17c	6.95a	6.53ab	5.21
T3	146.00ab	149.67b	46.52 a	44.53 ab	7.42a	7.30a	6.45abc	5.59
T4	117.66c	123.83d	41.78 b	39.60 c	6.25d	6.39b	5.67cd	5.52
T5	141.66b	144.33c	46.85 a	42.43 b	7.26bc	7.36a	5.93bcd	5.68
T6	149.00a	154.67a	47.14 a	45.13 a	7.30b	7.03a	6.94a	5.57

Means followed by different letter are significantly different within columns by Duncan's multiple range test, $P \leq 0.05$
T1= Control; T2= GA3 at 25 mg L^{-1}; T3=GA3 at 50 mg L^{-1}; T4= $CuSO_4$ at 25 mg L^{-1};
T5= GA3 at 25 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}; T6= GA3 at 50 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}

B-Fruit chemical characteristic:

Concerning SSC, acidity and SSC/acid ratio (Table 5) It could be observed clearly that all GA3 treatments significantly increased SSC and SSC/acid ratio in the two studied seasons. As for acidity % data revealed that, all treatments increased acidity except cuso4 and control in both seasons. These obtained results are in agreement with that, Kaur *et al.*, (1997) &Ladaniya (2001)and Rokaya *et al*.,(2016) in mandarin and Hikal (2013) on Washington navel orange who found that SSC/acid ratio of fruits was improved by foliar spraying with GA3 ,beside Khan, *et al*., (2014) and Hifny, *et al*., (2017) in orange fruit found that application with GA3 enhanced the chemical properties. Besides, Sharma *et al.*, (2002) on lime fruit who reported that spraying GA_3 increased acidity of juice citrus fruit.

Table 5. Effect of foliar application of GA_3 and $CuSO_4$ on fruit chemical properties of 'Balady' mandarin trees 2016 and 2017 seasons.

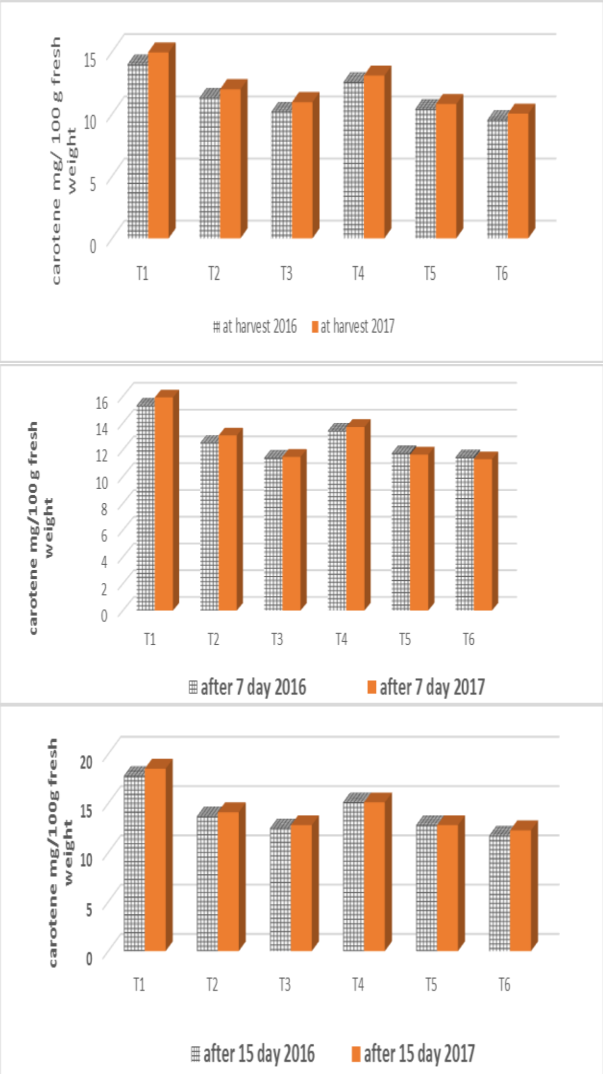
Treatments	SCC%		Acidity %		SCC/acid ratio		Vitamin C (mg/100ml juice)	
	2016	2017	2016	2017	2016	2017	2016	2017
T1	9.30e	9.30f	0.74d	0.83f	12.54bc	11.25c	39.66 e	35.66 d
T2	11.24c	11.24d	0.84bc	0.88d	13.44ab	12.77b	40.66 de	37.66 c
T3	12.93a	12.85b	0.94a	0.94b	13.76a	13.63a	42.00 bc	37.83 c
T4	9.74d	9.66e	0.81c	0.85e	11.98c	11.41c	41.66 cd	37.46 c
T5	12.49b	12.42c	0.90ab	0.92c	13.92a	13.55a	42.93 ab	39.32 b
T6	13.15a	13.54a	0.93a	0.98a	14.15a	13.77a	43.16 a	40.66 a

Means followed by different letter are significantly different within columns by Duncan's multiple range test, $P \leq 0.05$
T1= Control; T2= GA3 at 25 mg L^{-1}; T3=GA3 at 50 mg L^{-1}; T4= $CuSO_4$ at 25 mg L^{-1};
T5= GA3 at 25 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}; T6= GA3 at 50 mg L^{-1} + $CuSO_4$ at 25 mg L^{-1}

Vitamin C is the most effective antioxidant water-soluble which directly reduces ROS damage, and the most important source of vitamin C is citrus (Mditshwa, *et al*., 2017). Concerning fruit vitamin C. content, results in Table (5) indicate that GA3 combined $cuso_4$ treatments(T5&T6) significantly increased vitamin C in the two studied seasons, which recorded the highest values were (42.93 & 39.32) and (43.16 & 40.66) in the first and second seasons, respectively. Funding results are consistent with Kassem and El-Sabrout (2002) on orange and Rokaya *et al*.,(2016) on mandarin who reported that GA3 spraying resulted in increased vitamin C concentration of fruit.

Carotene content in fruit peel

As clear in Fig (2) Carotene content of mandarin fruit peel was significantly affected by treatments at harvest and after shelf life period (7 and14 days). Both GA_3 at 50 mg L^{-1} alone(T3) or combination with $cuso_4$ at 25 mg L^{-1} (T5&T6), which significant delay in the peel color development, and exhibited the lowest values (10.17 ,10.95), (10.38 .10.80) and (9.49 and 10.02) in both seasons, while the control treatment exhibited the highest values in both seasons. As well as the values gradually increased during shelf life. Similarly, the same trend was observed in the end of shelf life period. These results are in harmony with the findings of Ladaniya (2001) and Rokaya *et al*.,(2016) in mandarin who stated that GA_3 treatments significantly delayed the color change in fruit peel mandarin, which GA_3 play a role in delaying chlorophyll-degradation and the fruits senescence (Garcia-Luis *et al*.,1992).



T1= Control; T2= GA3 at 25 mg L–1; T3=GA3 at 50 mg L–1; T4= $CuSO_4$ at 25 mg L–1;
T5= GA3 at 25 mg L–1 + $CuSO_4$ at 25 mg L–1; T6= GA3 at 50 mg L–1 + $CuSO_4$ at 25 mg L–1

Fig. 2. Effect of foliar application of GA_3 and $CuSO_4$ on carotene content in fruit peel of 'Balady' mandarin during 2016 and 2017.

Weight loss% during shelf life

Weight loss percentage increase with extending the shelf life period. All treatments reduced the percentage of weight loss during shelf life than control fruits,(Table 6)the same trend has been obvious throughout the period and during both seasons, where both concentrations of GA3 combined with cuso4(T5&T6) recorded high significant weight loss reduction, for instance, after 15 days shelf life, fruits treated by the aforementioned concentrations exhibited the least weight loss percentage (5.84 &6.17)and(5.88 &5.89) in both seasons respectively.

Water loss is the main cause of fruit weight loss, which can result in significant economic losses, facilitating shriveling, softening and spoiling, as well as increasing fruit senescence). Furthermore, metabolic activity, evaporation of moisture through the skin, and respiration is mostly removed from the flavedo layer in citrus fruit, addition, mandarin fruit loses water more easily than grapefruit and oranges (El-Otmani *et al*., 2011) .Hence, the possible reason for reduction in weight loss by GA3 could be due to its ability to retain more water against force of evaporation, could be attributed to the gibberellins ' anti-senescence properties with improved resistant potential in the fruit, and consequently reduced the weight loss during shelf life (Rokaya *et al*., 2016).

Percentages of decay fruits

Post-harvest deterioration is one of the main problems affecting the quality of citrus resulting in significant economic loss. Therefore, methods need to be found to reduce citrus decay. As observed in Table 6 the percentage of decay fruits after 15 days shelf life was significantly decreased by applied treatments compared to control in both seasons. It is clear that treated trees with GA3 at 25 or 50 mg L^{-1} combined cuso4 at 2 mg L^{-1} (T5&T6) ,and GA3 at 50 mg L^{-1}(T3)showed the lowest percentage of discarded fruits (11.16%) in the first season, and the same trend in the second season, where the percentages of decay fruits were 11.57,11.53 and 11.53 %, respectively. This reduction in the percentage of samples handled is possibly due to increased protection of surface fruit treatments and their effects on preventing pathogenic infection could be due to anti senescence properties of the gibberellins which prevent the cellular disintegration with enhancing resistant ability in the fruit. (Rokaya *et al*., 2016). Additionally, chlorophyll content in citrus peel is not directly involved in photosynthetic operations, but acts as an antioxidant to defend citrus fruit against oxidative stress (Hasanuzzaman *et al*., 2013).

Table 6. Effect of foliar application of GA_3 and $CuSO_4$ on Weight loss% during shelf life and decay % of 'Balady' mandarin fruit 2016 and 2017 seasons.

Treatments	Weight loss %						Decay %	
	Shelf life after five days		Shelf life after ten days		Shelf life after 15 days			
	2016	2017	2016	2017	2016	2017	2016	2017
T1	3.56a	3.53a	7.15a	3.53a	7.46a	8.24a	21.77a	21.11a
T2	3.16ab	2.48c	6.20c	2.49c	7.08a	7.34b	19.66a	19.33a
T3	2.56c	2.41c	6.11c	2.41c	6.61ab	7.23b	11.16b	11.53b
T4	3.33ab	3.12b	6.64b	3.12b	7.42a	7.71b	20.11a	20.55a
T5	2.88bc	2.35c	5.82d	2.35c	5.84b	6.17c	11.16b	11.57b
T6	2.85bc	2.36c	5.59e	2.36c	5.88b	5.89c	11.16b	11.53b

Means followed by different letter are significantly different within columns by Duncan's multiple range test, P ≤ 0.05
T1= Control; T2= GA3 at 25 mg L–1; T3=GA3 at 50 mg L–1; T4= $CuSO_4$ at 25 mg L–1;
T5= GA3 at 25 mg L–1 + $CuSO_4$ at 25 mg L–1; T6= GA3 at 50 mg L–1 + $CuSO_4$ at 25 mg L–1

CONCLUSION

Our findings concluded that GA3 was more effective to increase fruit weight and overall fruit quality whereas both concentrations of GA3 combined with $cuso_4$ remained the best for improve yield, fruit quality and prolonging the shelf life and minimizing the loss in weight and decay of 'Balady' mandarin fruit.

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تحسين جوده ثمار اليوسفي البلدي وقابليتها للتسويق بواسطه الرش بحمض الجبريلين وكبريتات النحاس

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يعد الحصول على ثمارمن اليوسفي "البلدي" ، ذات العدد القليل من البذور من الاهداف الهامة للمستهلكين ، حيث يعتبر اليوسفي "البلدي أحد أهم اصناف اليوسفى المنزرعة في مصر نظرًا لخصائصة الأكلية. لذلك تم إجراء تجربة حقليه خلال موسمي 2016 و 2017 في مزرعة خاصة في منطقة د قلت ، بمحافظة كفر الشيخ ، مصر ، لدراسة تأثير الرش الورقي بحمض الجبريليك و كبريتات النحاس على المحصول والجودة وعدد البذور بالثمار وفترة حياة الثمرة بعد الحصاد(فترة الرف) حيث استخدم الجبرلين بتركيزات 25 أو 50 ملجم /لتر، بينما استخدمت كبريتات النحاس بتركيز 25 ملجم /لتربصوره منفرده او مركبه .وأظهرت النتائج التي تم الحصول عليها أن المعامله المركبه بكل من الجبرلين وكبريتات النحاس ادى الى تقليل عدد البذور لكل ثمرة تراوحت مابين (4.66-7) كما حسنت المحصول و بعض صفات الجودة مثل (الزيادة الملحوظة فى وزن وحجم الثمار ونسبة المواد الصلبه الذائبه الي الحموضه وحمض الأسكوربيك ،فى الوقت نفسة قللت نسبة الفاقد في وزن الثمار ونسبة التالف خلال فترة مابعد الحصاد وذلك بالمقارنة بالمعاملات الاخرى والكنترول.