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Improving Tommy Atkins Mango Resistance to Chilling Injury During Cold Storage and Marketing

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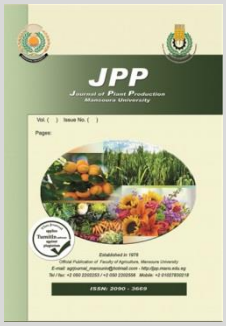

ABSTRACT

This work aimed to decrease the chilling injury (Cl) and fruit softness which limiting the quality marketing of mangoes stored at 5 °C. Putrescine (Put) and brassinosteroids (BRs) with packing in (EPE) foam net were examined during seasons 2017 and 2018 for 'Tommy Atkins' mango fruits during cold storage. Mango fruits were immersing into putrescine (Put) 50 ppm or (BRs)10 ppm with or without packing in (EPE) foam net. The treated fruits were stored at (5±1°C and 90 – 95% RH) for 30 days. Significantly all applied treatments decreased fruits weight loss, chilling injury and respiration rate, whereas delayed the decrease of titratable acidity and vitamin C. They have a good potential in delaying the increment in total soluble solids and total sugars with maintaining fruit firmness, skin color, total phenol, high rodent of antioxidant capacity and prolonged shelf-life of fruits than the control. It was presumed that aqueous solution of brassinosteroids (BRs) with (EPE) foam net packing being the most effective treatments in decreasing chilling injury, maintaining fruit quality under cold stress and has a good potential on improved shelf life of mango.

Keywords: Tommy Atkins Mango, Chilling injury (CI), Putrescine (Put),Brassinosteroids (BRs), (EPE) foam net packing.

INTRODUCTION

Mango (*Mangifera indica L.)* is an important climacteric tropical fruit, often harvested at the mature, hard green pre climacteric stage. Mango is having excellent export potential due to its appealing taste, aroma, and nutritional value **(**Sivakumar *et al.,* 2011). Cold storage of mango is utilized to delay shelf life by slowing the metabolic rate of fruits .Softening of the fruits, changes in color and development of decay were the limiting quality factors for the market life of mangoes after cold storage.

Mango is powerless to chilling injuries (CI) when stored at low temperature {underneath 12°C} after harvest, which diminishes fruit quality and storage life. Chilling injury (CI) in mango at postharvest storage appeared on the peel as red and dark spots, peel browning, abnormal ripening, reduced aroma and flavor, as well as expanded vulnerability to decay.

The mango peel is more helpless to CI than the pulp (Sivankalyani *et al.,* 2016).Typical CI symptoms may remember irregular increment for firmness, outside and inside tissue browning, poor smell and flavor, surface pitting, lopsided maturing, and expanded vulnerability to postharvest rot. Recently, the mango transcriptase's reaction to imperfect temperature storage was portrayed. Strangely, one of the primary pathwaysothat were raised was sugar digestion, where starch is processed to (mono-saccharides) and (di-saccharides). The high sugar content probably increases regularly as decreases the fruit's freezing point (Patil *et al.,* 2019).

Polyamines are natural mixes with aliphatic nitrogen structure, found in every single living creature, assume significant job in numerous physiological processes which identified with plant development, floral initiation, fruit development, mitosis division, maturation, ripening, and plant senescence as well as it reduces plant response to environmental stresses (Chen *et al.,* 2019 and Mustafavi *et al.,* 2018).The normal polyamines found in plant cells are putrescine, spermidine and spermine. Moreover, putrescine is the fundamental item in polyamine biosynthesis, and it synthetic precursor from spermidine and spermine (Reis *et al.,* 2016).Postharvest applications of PAs putrescine (PUT) efficient in reducing respiration rate, slow ethylene production, prevent senescence, hinder color changes, create mechanical resistance, maintain fruit firmness, and reduce the incidence of CI symptoms chilling injury of apricot fruits (Koushesh *et al.,* 2012). The upgraded resilience to CI in putrescine- treated fruits was related with diminished degrees of hydrogen peroxide which could be identified with changes in lipoxygenase (LOX) action by enacting the cell reinforcement framework by means of the collection of ascorbate and ferric reducing antioxidant power (FRAP) and by inducing the activities of ascorbate peroxidase (APX), catalaseg (CAT) and glutathionejreductase (GR)antioxidant enzymes (Valenzue la *et al.,* 2017).Moreover, pre storage (Put) treatment is widely mentioned to clearly inhibit ethylene causing and decelerate maturing in mango (Razzaq *et al.,* 2014).Plant hormones have significant role in production and postharvest management of fruits and horticultural produces. It is known that, there are five categories of plant hormones i.e. auxins, cytokinins, gibberellins, ethylene and abscisic acid (ABA) were known (Gray, 2004).Recently, another class of phytohormone namely brassinosteroids

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(BRs) are considered as the sixth group of plants hormones (Luan *et al.*, 2013).

Brassinosteroids (BRs) is a gathering of plant hormone, could be utilized in guideline of different formative procedures in plants. Critically, applied use of brassinosteroids and its analogous could alter the ripening process, quality, chilling tolerance and postharvest diseases in various fruits. BRs also regulate the activity of defense related enzymes which could develop strong defense mechanism against different micro organisms (Saini *et al.*, 2015).It is also indicated as hormones of the 21st century owing to active contribution of (BRs) in a large number of physiological processes, which regulates many growth and developmental processes in plants and fruits (Lima and Lobato, 2017). Exogenous application of (BRs) delays fruit senescence by decreasing ethylene evolution and respiration rate (Zhu *et al.*, 2010).Cold stress is an effective environmental factor that affects plant distribution and can strongly limit crop productivity. Chilling injury (CI) is one of the major physiological disorders of several tropical and subtropical fruits, such fruits are more sensitive to low temperature storage conditions and spoiled quickly affecting its quality (Han *et al.*, 2006).Shelf life of the fruits and vegetables can be extending by manipulating respiration which is affected by the ethylene and BRs.

In this respect, (Zaharah *et al.*, 2012) discovered that BRs application set off the ethylene advancement, respiration rate and senescence which decrease storage life of mango. Brassinosteroids had the ability to regulate plasma membrane proteins and genesiencoding which get up-managed under low temperature stress condition. Also, BRs application at 10 µM had the important capability in enhancing mango fruit resistance to cold temperature stress condition at 5°C (Li *et al.*, 2012).BRs are effective in delaying CI symptoms in fruits by mitigate the action of chilling injury CI by enhancing the activity of antioxidant enzymes such as{CAT and APX} and declining the accumulation of hydrogen peroxide (H_2O_2) and by instigating peroxidase (POD) activities, total phenolic , polyphenol oxidase (PPO) and phenylalanineiammonia lyase (PAL) (Valenzuela *et al.*, 2017).

Fruits packing (EPE) foam net is a new type of soft packing material which named as pearl cotton, also known as extended polyethylene. EPE foam comprised of non-cross linked closed-cell structures is a sort of new environmentally friendly packaging materials. It comprises of many single bubbles of low-density. EPE foam net is used for package the fruits in growing season to protect the fruits from damage, maintain the pretty color, as protection layer during transportation to extend the marketing period. EPE foam net has many advantages, such as excellent thermal insulation, resistance to moisture, heat preservation and high plasticity.

The objective of this research was to decrease the chilling injury and fruit softness which limiting the quality of mangoes stored at 5 °C to prolong the presence of mangoes whether in the local market or in export to foreign markets . The potentially enable in this respect of putrescine (Put) and brassinosteroids (BRs)with packing in (EPE) foam net were evaluated to improve the resistance of Tommy Atkins mango fruits during cold storage.

MATERIALS AND METHODS

"Tommy Atkins" mangoes were harvested at physiological maturity (more than 50% yellow or red) between 125 and 135 days of flowering (Costa, 2017) through seasons 2017 and 2018 from a commercial confidential orchard at El Salhia region Sharqia Government, Egypt. Fruits harvested from trees 8 years old grown in sandy soil , irrigated with drip irrigation system and planted at 2x5m space. The fruit were chosen uniform size, absence of defects, packed in plastic boxes. Fruits were removed from the field with minimal delay after harvest and transported to horticulture research institute postharvest laboratory (Mansoura branch) within approximately 6 h. At the start of the experiments, samples of 15 fruits were taken to establish the initial fruits properties.

The experiment was laid out in completely randomized design with three replicate, twenty fruits per replicate 60 fruits in each treatment. The fruits free from physical injure and diseases with related sizes, color and firmness were cleaned with tap water and air-dried, then received the following treatments:

1- Dipping fruits in 50 ppm putrescine (Put)
2- Dipping fruits in 50 ppm(Put) + packed in (EPE) foam net
3- Dipping fruits in 10 ppm Brassinosteroids (BRs)
4- Dipping fruits in 10 ppm Brassinosteroids (BRs) + packed in (EPE) foam net
5- Packed fruits in (EPE) foam net
6- Dipping fruit with tap water.

Fruits were immersed in an aqueous solution of putrescine (Put) and BRs for 10 min. A surfactant Tween 20® at the rate of 0.1% was added to obtain better retention and penetration. Tap water was used as a control. Fruits sample were air dried, spread on nylon net until dried, kept in one layer at carton boxes and stored at (5°C±1 and 90 – 95% RH) for 30 days. Afterward, all fruits were stored at (20°±2C) and 70-75% R.H. for 5 days as shelf life period to replicate a marketing period.

After conclusion of the respective storage duration fruits were analyzed for physical and chemical carectirestics as flows:

$$\textbf{1- Weigh loss Percentage} = \frac{\textbf{Initial fruit Weight - Final fruit weight}}{\textbf{Initial fruit weight}} \times \textbf{100}$$

$$\textbf{2- Decay percentage} = \frac{a \times 100}{b}$$

where:

a = No of decayed fruits at time of sampling (unmarketable fruit).

b = Initial fruits number.

3-Chilling Injury (CI) Index:- The chilling injury score was demonstrated by the CI index, as portrayed by Zhao *et al.*, (2006) with slight modifications. Browning, surface pitting and lenticels discoloration of fruits were used as indicators for chilling injury. It was evaluated on a range from 1-5 as, 1 = No chilling injury, 2 = 1-25%, 3 = 26-half, 4 = 51-75% and 5 = 76-100% chilling injury. The estimation of chilling injury score was completed by the accompanying equation.

$$\textbf{Chilling Injury Score} = \frac{\textbf{Injury level} \times \textbf{Number of fruits at the level}}{\textbf{Total number of fruits at the level}} \times \textbf{100}$$

4-Respiration Rate (ml CO_2 kg^{1-} hr^{1-}):

Respiration rate was calculated by gas analyzer (Model 1450 - Servomex 1400) according to (McCollum *et al*.1993) the airtight glass jars(4 liter) were used to fruit in cubs under the same storage conditions for 24 hr.

5- Skin color hue angle (h°):-:- The color of the peel was determined with (colorimeter Chroma Meter model CR-410®k) (Konica-Minolta, Japan). Measurements were made near the peduncle, in the middle of the fruit and in the pedicel. Conclusions were performed utilizing the arrangement of CIEL, a*, b *, and the color tone was predictable using the methods described by McGuire (1992) as the following equation:

$$(h°) = \tan^{-1}\frac{b}{a}$$

where :

***a* = interval of colors among green and red**

***b* = interval of colors among blue and yellow**

h° = Skin hue color.

6-Fruit firmness (lb $inch^{-2}$):- it was considered by a Magness Taylor penetrometer (pressure tester). Reading's were taken in three positions in leak tested fruit, averaged and recorded in lb/ $inch^2$.

A uniform sample was arranged from these five fruit per replicate to determine TSS, acidity, pH and vitamin C.

7-Totalisolublelsolid (TSS) %:- dissolved 1 mL of mango pulp juice in 40 mL double-distilled water. TSS (%) was measured at 22°C in each sample with hand refractometer Carl- Zeiss using 2 to 3 drops of juice obtained by squeezing the fruits and articulated as Brix (Ranganna, 1995).

8-Titratabl acidity (TA) %:- 10 g of pulp of each fruit were first diluted with sterile distilled water to get 50 ml. 10 ml of the dilution were then titrated with 0.1 N NaOH as indicated by the procedure detailed by the{ AOAC,2005}. The outcomes were conveyed as a fraction of citrus acid present in

(g citrus extract/100 g new weight).

9-Vitamin C (mg g^{-1}Fw): VC was determined by the oxidation of ascorbic acid with 2, 6-dichlorophenolkindophenol, the results expressed as mg g^{-1} on a fresh weight (FW) basis according to (AOAC,2005).

10- Total sugar (%): It was approved using Lane and Eynon methods (James 1995). 5 grams of sample was taken into a beaker and100 ml of warm water was added. The solution was stirred until all the soluble matter was dissolved than filtered through Whatman filter paper into a 250 volumetric flask. After that, 100 ml of the solution set was pipette into a conical flask, added with 10 ml diluted hydrogen chloride (HCl) and boiled for 5 min. On cooling, the solution was neutralized to phenolphthalein with 10%0 NaOH and invented to volume in a 250 ml volumetric flask. This solution was used for titration against Fehling's solution and readings were considered by the follow formulas:

$$\text{Total sugar \%} = \frac{\text{Factor (4.95)} \times \text{dilution(250)} \times 2.5}{\text{Titrex weight of samplex} \times 10} \times 100$$

11-Total phenol content:-

Total phenols concentration was estimated according to Chun *et al.,* (2003). 50 µL of the methanol extract was mixed with 100 µL Folin-Ciocalteu reagent, 850 µL of methanol and allowed to stand for 5 min at ambient temperature. A 500 µL of 20% sodium carbonate was added and permitted to respond for 30 min. Absorbance was estimated at 750 nm. Total phenols was measured from a calibration curve acquired by estimating the absorbance of known fixations of gallic acid and the fallout communicated as mg g^{-1} FW gallic acid equivalent.

12- Antioxidant % (DPPH radical scavenging assay of fruit peel).

The DPPH free radical scavenging activity of methanol extract of fruit peel was deliberate using the 1, 1-diphenyl-2-picrylhydrazyl (DPPH) according to the methods of Ao *et al.,* (2008).A methanol remove (0.1 ml) was added to 0.9 ml of arranged DPPH methanol arrangement (0.1 M). An equivalent measure of methanol was utilized as a control. Later than, incubation for 30 min at room temperature in the dark, the absorbance (Abs), calculated at 517 nm using a spectrophotometer. Activity of scavenging percentage was determined utilizing the accompanying formula:

$$\text{DPPH radical scavenging \%} = \frac{\text{Absorbance of control} - \text{Absorbance of sample}}{\text{Absorbance of control}} \times 100$$

The inhibition absorption (IC_{50}) was defined as µg phenolic of the test sample that decreases 50% of initial radical. The IC_{50} values were measured from the dose responses curves.

Statistical analysis: Data were analyzed using analysis of variance (ANOVA) differences between treatments means were statistically compared using Duncan's multiple tests at a level 0.05, using (CoStatV6.4 program).

RESULTS AND DISCUSSION

Weight loss%:

The results in (Table 1) cleared that, weight loss percentage of Tommy Atkins mangoes enlarged after cold storage at 5°C and all through marketing at 20°C. Significantly all treatments used reduced weight loss percentage compared with control during both seasons. There was a significant increment in weight loss percent through cold storage of mango fruits. Significant reduction in weight loss values (3.83 and 3.73 %) were obtained at fruits immersing in 50 ppm putrescine (Put) and packed in (EPE) foam net after 30 days of cold storage through the two seasons. Whereas ranged 4.18 and 4.09 % after 5 days during marketing at 20°C. Conversely, the maximum weight loss was recorded from untreated control (6.75% and 6.61%) after 30 days of cold storage at 5°C and recorded 8.35 and 8.23% after 5 days during marketing at 20°C in both seasons, correspondingly.

It was informed that, the increased in weight loss is caused by reduced metabolic activity and moisture evaporation through skin (Wongmetha and Ke, 2012).

Brassinosteroids significantly reduced weight loss and delayed fruit senescence by decreasing ethylene production and maintained fruit quality (Zhu *et al.,* 2010).

Polyamine treatments led to decrease weight loss of fruits during storage, which could be attributed to relatively lower rates of respiration and constancy of both cell integrity and the permeability of the tissues. Thus, the lower weight loss in (Put) treated fruits may be due to the

integration and stabilization of cell solidity and permeability of the tissues as polyamine forms which linkage with cell membranes and preserves waxes of cuticle layer there by retard the removal of epicuticle waxes which play a very important role in water exchange through the skin (Mirdehgha *et al.,* 2007). In this regard, utilized putrescine on mango fruits significantly enhanced shelf life and quality characteristic (Jawandha *et al.,* 2012). The reduction of weight loss in pear fruits treated with putrescine can be attributed to coalition of polyamines to phospholipids and protein components of cell membranes, which resulting in consolidation of cell solidity and membrane permeability (Hosseini *et al.,* 2017).

Table 1. Effect of (Put), (BRs) and (EPE) packing on weight loss and decay percentage of Tommy Atkins mangos, through cold storage and marketing seasons 2017 and 2018.

Treatments	Weight loss%				Decay %			
	Season 2017							
	Storage period (days)							
	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C
50 ppm putrescine (Put)	0.00n	2.04lm	3.99h	5.19e	0.00m	0.00m	6.03i	8.84f
50 ppm putrescine (Put) + (EPE) packaging	0.00n	1.97m	3.83i	4.18g	0.00m	0.00m	5.50k	8.80d
10 ppm brassinosteroids (BRs)	0.00n	2.07l	3.97h	6.31c	0.00m	0.00m	5.65j	9.53e
10 ppm brassinosteroids (BRs)+ (EPE) packaging	0.00n	1.98m	3.95h	4.80f	0.00m	0.00m	5.00l	8.04g
(EPE) foam net packaging	0.00n	2.20k	4.79f	6.05d	0.00m	0.00m	6.55h	10.20c
Distilled water (control)	0.00n	3.38j	6.75b	8.35a	0.00m	0.00m	14.00b	32.90a
.Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								
Season 2018								
50 ppm putrescine (Put)	0.00o	1.97n	3.95hi	5.04e	0.00m	0.00m	5.89i	9.63d
50 ppm putrescine (Put) + (EPE) packaging	0.00o	1.96n	3.73j	4.09g	0.00m	0.00m	5.33k	8.60f
10 ppm brassinosteroids (BRs)	0.00o	2.05m	3.97h	6.22c	0.00m	0.00m	5.60j	9.36e
10 ppm brassinosteroids (BRs)+ (EPE) packaging	0.00o	2.02mn	3.90i	4.67f	0.00m	0.00m	4.80l	7.90g
(EPE) foam net packaging	0.00o	2.16l	4.75f	5.90d	0.00m	0.00m	6.40h	10.05c
Distilled water (control)	0.00o	3.15k	6.61b	8.23a	0.00m	0.00m	13.47b	30.80a
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								

Decay percentage:-

Results in (Table 1) demonstrated that, all the investigated postharvest treatments significantly influenced decay % of Tommy Atkins mango fruits through cold storage. In spite of storage period, all treatments didn`t record any decayed fruits through cold storage at (5±1°C) for 15 days. The minimum decay was recorded for mango fruits immersing in 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net (5.00% and 4.80 %) after 30 days of cold storage in the two seasons, respectively. However, the greatest decay was recorded for untreated mango fruits (14.00% and 13.47%) after 30 days of cold storage at 5°C in the two seasons, correspondingly. Otherwise, all treatments applied, significantly reduced decay contrasted with the untreated fruits. The lowest decay % recorded in mango fruits immersing in 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net(8.04% and 7.90 %) and during marketing after 5 days at((20 °C) in the two seasons, respectively. While, the maximum decay was recorded for untreated fruits (32.90% and 30.80%) through marketing at(20°C) in the two seasons, respectively.

It clear that, both fruits weight loss and decay occurrence significantly increased during cold storage (Table 1). Mangos are climacteric fruits with a fairly high rate of metabolic activity such as high ethylene production and respiration rate that hasten the ripening processes after harvest. These processes are corresponded with the enlarge of weight loss, quick softening, peel browning, and decay that abbreviate fruit storability and storage (Zaharah *et al.,* 2012).

Exogenous application of epibrassinolide (EBR) increased phenylalanine ammonia lyase (PAL) and peroxidase (POD) enzymes activities that posteriorly suppressed *Botrytis cinerea* induced grey mold disease of table grapes through postharvest storage (Liu *et al.,* 2016). Furthermore, Zhu *et al.,* (2015) declared that the BRs treatment reduced disease incidence, which was regarding with H_2O_2 accumulation .It can be assumed that the innovative postharvest BRs treatment not only relieves postharvest CI along with minimizing decay but also enhancing quality of fruits.

Chilling Injury (CI) Index:-

Results available in (Table 2 and fig 1) cleared that, all the investigated treatments significantly decreased chilling injury percentage of Tommy Atkins mango fruits through cold storage.. Treatment with 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net was more effective for delaying the raise in CI symptoms, since the CI index was fewer (61–65%) compared with the control fruits through 30 days of cold storage (Table. 2 and Fig.1). While, chilling injury in this treatment range (0.75 and 0.69) during the two seasons, respectively. CI symptoms for instance skin pitting, scalding, uneven ripening, loss of color and increased decay were clear in mango stored for 5 days at 20°C.Consequently,immersing fruits 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net showed a minor to direct pitting or burning rate of (1.70 and 1.62) during both seasons, respectively. While, the untreated fruits showed higher indications of CI after 5 days at 20°C ranged (4.20 and 4.10) during both seasons respectively.

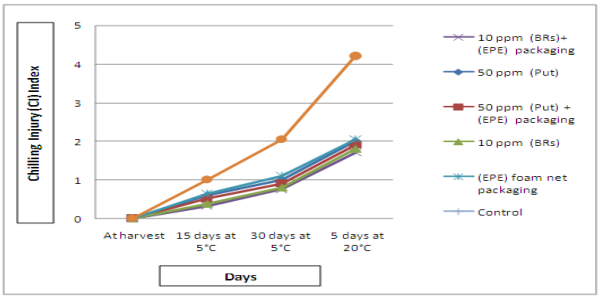

Fig. 1. Chilling injury in Tommy Atkins mango through cold storage at 5°C and marketing 5 days at 20°C as a mean of 2017 – 2018 seasons.

Low temperature is an alternate technique for horticultural crops to increase chilling tolerance. This includes holding cold-sensitive tissue at temperatures simply above essential temperature to induce chilling tolerance. CI leads to quality disintegration and limits postharvest storage life which negatively affects safety of cell membranes. Furthermore, accretion of CI symptoms was correlated to severe lipid peroxidation. BRs as an environmentally and safely regulator can be used for minimizing postharvest losses by decreasing CI and maintaining quality of fruits.

Accordingly, application of brassinosteroids led to substantially higher alleviation of CI in Washington Navel oranges during storage at 3 °C (Ghorbani and Pakkish, 2014). In addition application of brassinolide significantly reduced chilling injury in lime fruits during cold storage by decreasing oxidative damage (Rezakhani and Pakkish, 2017). Membrane damage and reactive oxygen species (ROS) production are multifarious adverse effects of chilling in fruits during cold storage. Thus, the extenuation of chilling in fruits treated with BRs could be attributed to enhancing membrane solidity by reducing phospholipase D (PLD) and lipoxygenase (LOX) enzyme activities and enhancing antioxidant system activity (Li *et al.*, 2012). Otherwise, PAs plays as anti-senescent agents, reduce respiration rate, delay ethylene production, delay color changes, increase fruit firmness, stimulate mechanical resistance, and reduce chilling symptoms (Valero *et al.*, 2002).

Respiration Rate (mg CO2 kg^{1-} hr^{1-}):

As shown in (Table 2 and Fig 2), significant differences were registered in respiration rates in reaction to storage periods and treatments examined under the study. Despite storage period, all treatments applied in both seasons significantly prevented respiration rate compared with the untreated. The results refined that respiration rates were declined after 15 days of cold storage furthermore, trailed by increase at the end of the storage period. Consequently, immersing fruits in 10 ppm brassinosteroids (BRs)and packed in (EPE) foam net showed a higher delay in respiration rate (11.96 and 11.87 mg CO_2 kg^{-1} h^{-}) after 30 days of cold storage in the two seasons, respectively. While, respiration rate was slightly decrease after 5 days during marketing at 20 °C for all treatments applied in both seasons. Since, immersing fruits in 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net produced lower respiration rate ranged (0.20 and 10.08 mg CO_2 kg^{-1} h^{-1}) through marketing in both seasons, respectively. Respiration plays an important job in diverse physiological processes till the senescence phase and is vitally involved in diverse postharvest losses. In this respect, Zaharah *et al.*, (2012) reported that BRs application aroused the ethylene evolution, respiration rate and senescence which reduce storage life of mango. Likewise, application of putrescine (Put) on mango fruits reduce the respiration rate under storage conditions and resulted in lowered synthesis of ethylene (Malik and Singh, 2006).

Table 2. Effect of (Put), (BRs) and (EPE) packing on chilling injury and respiration rate (mg CO_2 $kg^{1-}hr^{1-}$) of Tommy Atkins mangos through cold storage and marketing seasons 2017 and 2018.

Treatments	Chilling injury Score				Respiration rate (mg CO_2 $kg^{1-}hr^{1-}$)			
	Season 2017							
	Storage period (days)							
	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C
50 ppm putrescine (Put)	0.00r	0.59n	1.00i	2.00d	11.80i	6.80p	13.00e	11.20j
50 ppm putrescine (Put) + (EPE) packaging	0.00r	0.51o	0.90j	1.90e	11.80i	6.60q	12.90f	11.0k
10 ppm brassinosteroids (BRs)	0.00r	0.38p	0.80k	1.80f	11.80i	6.50r	12.40g	10.50l
10 ppm brassinosteroids (BRs)+ (EPE) packaging	0.00r	0.32q	0.75l	1.70g	11.80i	6.00s	11.96h	10.20m
(EPE) foam net packaging	0.00r	0.63m	1.10h	2.10b	11.80i	7.00o	14.00c	13.60d
Distilled water (control)	0.00r	1.00i	2.04c	4.20a	11.80i	10.00n	17.40a	15.00b
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								
Season 2018								
50 ppm putrescine (Put)	0.00s	0.56o	0.95j	1.94d	11.70i	6.71p	12.88e	11.11j
50 ppm putrescine (Put) + (EPE) packaging	0.00s	0.50p	0.86k	1.84e	11.70i	6.52q	12.73f	10.85k
10 ppm brassinosteroids (BRs)	0.00s	0.36q	0.76l	1.73f	11.70i	6.41r	12.32g	10.44l
10 ppm brassinosteroids (BRs)+ (EPE) packaging	0.00s	0.29r	0.69m	1.62g	11.70i	5.90s	11.87h	10.08m
(EPE) foam net packaging	0.00s	0.62n	1.06h	2.18b	11.70i	6.90o	13.90c	13.53d
Distilled water (control)	0.00s	1.00i	2.02c	4.10a	11.70i	9.95n	17.25a	14.84b
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								

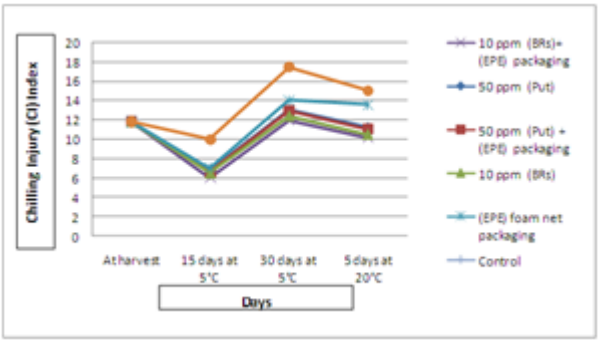

Fig. 2. Respiration rate in Tommy Atkins mango through cold storage at 5°C and marketing 5 days at 20°C as a mean of 2017 – 2018 seasons

Skin hue Color (h°):

Data in (Table 3) showed that, all utilized treatments belated the evolution of fruits skin color as compared with the untreated fruits. Besides, green color in mango fruits decreased with storage period progressive either during cold storage or marketing. While, the values of green color during shelf life were almost lower than those obtained at cold storage through the both seasons of study. In control fruit, hue color decreased quickly during storage indicating a losing green color, neither after 30 days of cold storage (80.00 and 79.00 h°) nor through marketing after 5 days (69.00 and 68.00 h°). Moreover, 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net maintained a higher skin hue color (h°) than all treatments or the control after 30 days of cold storage and 5 days during marketing in both season. The increment due using these treatment reached about 105.00 and 104.00 h° after 30 days of cold storage during both seasons, respectively. While, after 5 days during marketing the values averaged 92.00 and 91.00 h° in both seasons, respectively.

Brassinosteroids and putrescine treatments appeared to delay fruit skin color development, as obvious from the data. Yet, the loss of color led to decrease visual quality and market possibility of the fruits. In this respect, vacuum infiltration of 'Tahiti' and 'Persian lime' fruits by 10 µmol L^{-1}epibrassinolideexhibited higher hue angle and reduced chrome values. Moreover, it reduced chlorophyll degradation and showed conserved green color due to inhibited yellowing (Tavallali, 2018). Also, polyamines may inhibit chlorophyll degradation in skin tissues by inhibition of peroxidase activity (Jawandha *et al.*, 2012).

Fruit firmness (lb $inch^{-2}$) :

As shown in (Tablex3), fruit firmness was considerably influenced by storage period and treatments applied at the two seasons. Despite of storage period, all treatments preserved firmness significantly compared to control fruits. Conversely, significant declines in fruit firmness were recorded as storage time prolonged.

In this respect, the maximum firmness was obtained at fruits treated with 10 ppm brassinosteroids (BRs)and packed in (EPE) foam net after cold storage at 5°C (12.40 and 12.26 lb $inch^{-2}$) and through marketing at 20 °C (9.80 and 9.73 $lbinch^{-2}$)in the two seasons, respectively.

Brassinosteroids and putrescine treatments appeared to preserve fruit firmness, as evident from the data. Since, the changes in mango texture during ripening have been previously referred to the degradation by pectic enzymes, which activity significantly increases as the fruit ripens (Razzaq *et al.*, 2014).

Table 3. Effect of (Put), (BRs) and (EPE) packing on skin hue color h° and fruit firmness (lb $inch^{-}$) of Tommy Atkins mangos through cold storage and marketing seasons 2017 and 2018.

Treatments	Skin hue color h°				Fruit firmness $lbinch^{-2}$			
	Season 2017							
	Storage period (days)							
	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C
50 ppm putrescine (Put)	118.00a	110.00e	93.00j	82.00n	18.10a	15.00d	11.50j	8.10p
50 ppm putrescine (Put) + (EPE) packaging	118.00a	112.00d	97.00i	85.00m	18.10a	15.20c	11.83i	8.30o
10 ppm brassinosteroids (BRs)	118.00a	114.00c	100.00h	87.00l	18.10a	15.30c	12.20h	9.00n
10 ppm brassinosteroids (BRs)+ (EPE) packaging	118.00a	116.00b	105.00g	92.00j	18.10a	16.00b	12.40g	9.80m
(EPE) foam net packaging	118.00a	107.00f	89.00k	77.00p	18.10a	14.70e	10.90k	7.20q
Distilled water (control)	118.00a	100.00h	80.00o	69.00q	18.10a	13.00f	10.10l	5.30r
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								
Season 2018								
50 ppm putrescine (Put)	117.00a	109.00e	92.66j	81.00o	17.90a	14.91e	11.41k	7.98q
50 ppm putrescine (Put) + (EPE) packaging	117.00a	111.00d	96.33i	84.00n	17.90a	15.06d	11.66j	8.21p
10 ppm brassinosteroids (BRs)	117.00a	113.00c	99.00h	86.33m	17.90a	15.16c	12.06i	8.93o
10 ppm brassinosteroids (BRs)+ (EPE) packaging	117.00a	115.00b	104.00g	91.00k	17.90a	15.86b	12.26h	9.73n
(EPE) foam net packaging	117.00a	106.00f	88.00l	76.00q	17.90a	14.56f	10.76l	7.06r
Distilled water (control)	117.00a	98.66h	79.00p	68.00r	17.90a	12.90g	9.93m	5.19s
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								

In this respect, brassinosteroids played a suitable role in inhibiting pectin methyl esterase and polygalacturonase enzymes, which play an important role in cell wall degrading and fruit softening .Moreover, postharvest treatment with brassinosteroids restrained softening of persimmon fruits which significantly achieved higher cellulose, pectin content and acid-soluble pectin (He *et al.*, 2018).

On the other hand, PAs combined with pectin and cell wall components with anions for example,

phospholipids of the cell membranes. The role of PUT in reducing the softening of fruit was described because of its inhibitory effects on the enzymes implicated in degradation of cell wall (Razzaq *et al.,* 2014). Also, fruits of Kensington Pride mango become firmer after being exogenously treated with putrescine (Malik and Singh, 2006).

Total soluble solid TSS %:-

As shown in (Table 4) all treatments and storage periods had a significant result on TSS % during both seasons also, significant increases in TSS % have been recorded all along the periods of storage. TSS percentage was lesser at all treatments used than the control. As well, TSS % increased as storage advanced to all treatments in both seasons. In this respect, the activity of enzymes answerable for starch hydrolysis to soluble sugars may be led to increase TSS %. Also, during the respiration process, it occurs a decline in carbohydrates, pectin,, and partial hydrolysis of protein which led up to increase TSS percentage (Woolf, *et al*. 2003).

TSS % was higher for control fruits than all treatments neither after 30 days of cold storage at 5°C (14.30 and 14.16 %) nor after 5 days of marketing at 20 °C (15.60 and.15.43 %) in both seasons, respectively. The smallest significant TSS.% was recorded for mango fruits immersingin10 ppm brassinosteroids (BRs) and packed at (EPE) foam net(12.50 and 12.33 %) after cold storage at 5°C and during marketing at 20 °C (13.80 and 13.73%) in the two seasons, respectively.

Table 4. Effect of (Put), (BRs) and (EPE) packing on TSS and titratable acidity % of Tommy Atkins mangos during cold storage and marketing seasons 2017 and 2018.

Treatments	TSS%				Titratable Acidity (%)			
	Season 2017							
	Storage period (days)							
	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C
50 ppm putrescine (Put)	8.90p	10.40m	13.03h	14.70c	1.36a	1.24d	0.96j	0.81n
50 ppm putrescine (Put) + (EPE) packaging	8.90p	10.30mn	13.00h	14.40d	1.36a	1.24d	0.99i	0.83m
10 ppm brassinosteroids (BRs)	8.90p	10.20n	12.80i	14.20e	1.36a	1.29c	1.01h	0.85l
10 ppm brassinosteroids (BRs)+ (EPE) packaging	8.90p	10.00o	12.50j	13.80f	1.36a	1.33b	1.08g	0.88k
(EPE) foam net packaging	8.90p	10.80l	13.30g	14.90b	1.36a	1.16e	0.89k	0.78o
Distilled water (control)	8.90p	11.30k	14.30de	15.60a	1.36a	1.14f	0.86l	0.68p
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								
Season 2018								
50 ppm putrescine (Put)	8.70r	10.26o	12.93i	14.56c	1.31a	1.18d	0.90i	0.75n
50 ppm putrescine (Put) + (EPE) packaging	8.70r	10.25o	12.83j	14.31d	1.31a	1.18d	0.93h	0.77m
10 ppm brassinosteroids (BRs)	8.70r	10.06p	12.70k	14.06f	1.31a	1.22c	0.95g	0.79l
10 ppm brassinosteroids (BRs)+ (EPE) packaging	8.70r	9.86q	12.33l	13.73g	1.31a	1.25b	1.02f	0.81jk
(EPE) foam net packaging	8.70r	10.63n	13.13h	14.76b	1.31a	1.09e	0.82j	0.72o
Distilled water (control)	8.70r	11.13m	14.16e	15.43a	1.31a	1.08e	0.80kl	0.62p
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								

Starch degraded to sugar in mango fruits stored at Inappropriate temperature. Degradation of starch to mono- and di-saccharides for example sucrose, fructose, and glucose increases the osmolality, and these compounds act as cryo - protectants to decrease the freezing point. Application of (Put) on Kensington Pride mango at 1.0 mM, led to significant increase in TSS.% as compare to the control (Malik and Singh, 2006). In another study, treated "Langra" mango fruits with 2.0 mM (Put) prompted the highest acidity and provided mixture of good taste of sugar and acidity under storage (Jawandha *et al.,* 2012). Moreover, (Xi *et al.,* 2013) demonstrated that, spraying grapevine with (BRs) increase berry total soluble solids while reduced titratable acidity content.

Titratable acidity TA :-

Results in (Table 4) showed that, TA % in cold stored mango fruits was significantly influenced because of expanded cold storage periods and investigated postharvest treatments. Control treatment led to significant decrement in TA. % relative to all treated in both seasons moreover after cold storage at 5 °C (0.86 and 0.80 %) or after 5 days during marketing at 20 °C (0.68 and 0.62 %) in the two seasons, respectively.

Perversely, treated mango with 10 ppm brassinosteroids (BRs) and packed at (EPE) foam net led to remained higher TA % (1.08 and 1.02 %) after cold storage at 5°C and during marketing at 20 °C (0.88 and 0.81 %) in the two seasons, respectively. BRs treatments inhibited respiration rates and ethylene production which led to preserve higher TA % during cold storage (Zhu *et al.,* 2010). In addition, the role of putrescine on maintaining TA in treated fruits would be attributed to the synthesis and subsequently retarding the ripening process (Barman *et al.,* 2011).

Vitamin C mg 100g^{-1} FW :-

All applied treatments significantly slow down the decrease of vitamin C than the control until the end of storage as showed in (Table 5) either after 30 days of cold storage or 5 days during marketing. While, the amount of vitamin C significantly declined as the storage advanced. The contents of vitamin C in control treatments declined (21.30 and 21.20 mg g^{-1} FW.) after cold storage at5°C and (16.00 and 15.90 mg g^{-1} FW.) through marketing at 20 °C in both seasons, respectively

Table 5. Effect of (Put), (BRs) and (EPE) packing on vitamin C mg/g^{-1} FW and Total sugar % of Tommy Atkins mangos during cold storage and marketing seasons 2017 and 2018.

Treatments	Vitamin C mg g^{-1} FW				Total sugar %			
	Season 2017							
	Storage period (days)							
	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C
50 ppm putrescine (Put)	43.20a	37.10e	26.90k	20.10q	6.38q	7.65n	9.40i	10.98d
50 ppm putrescine (Put) + (EPE) packaging	43.20a	37.60d	27.60j	20.7p	6.38q	7.50o	9.38i	11.22c
10 ppm brassinosteroids (BRs)	43.20a	38.10c	27.90i	21.00o	6.38q	7.33p	8.75k	10.56f
10 ppm brassinosteroids (BRs)+ (EPE) packaging	43.20a	38.90b	29.70h	22.00m	6.38q	7.72m	9.25j	10.83e
(EPE) foam net packaging	43.20a	32.30f	24.50l	19.50r	6.38q	8.04l	9.50h	11.40b
Distilled water (control)	43.20a	29.90g	21.30n	16.00s	6.38q	7.50o	9.75g	11.50a
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels..								
	Season 2018							
50 ppm putrescine (Put)	42.00a	37.03e	26.80k	20.03q	6.50r	7.42q	9.48j	11.35c
50 ppm putrescine (Put) + (EPE) packaging	42.00a	37.50d	27.50j	20.60p	6.50r	7.74o	9.51i	11.08d
10 ppmbrassinosteroids (BRs)	42.00a	38.00c	27.80i	20.90o	6.50r	7.62p	8.87l	10.49f
10 ppm brassinosteroids (BRs)+ (EPE) packaging	42.00a	38.80b	29.60h	21.80m	6.50r	8.13m	9.62h	10.96e
(EPE) foam net packaging	42.00a	32.20f	24.40l	19.30r	6.50r	7.85n	9.37k	11.50b
Distilled water (control)	42.00a	29.80g	21.20n	15.90s	6.50r	7.64p	9.87g	11.66a
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								

The extreme rate (lower IC 50 value) of antioxidant capacity were noticed by immersing fruits in 10 ppm brassinosteroids (BRs) and packed in (EPE) foam net (7.05 and 7.18 µg) after cold storage whereas, after 5 days (6.20 and 6.39 µg) during both seasons, respectively.

The advanced amount of vitamin C contents were obtained in 10 ppm brassinosteroids (BRs) and packed at (EPE) foam net treated fruits during the whole storage period. The contents of vitamin C in this treatment (29.70 and 29.60 mg g^{-1} FW) after cold storage at5°C and (22.0 and 21.80 mg g^{-1} FW) after 5 days during marketing at 20 °C in both seasons, respectively.

Vitamin C significantly declined as the storage prolonged because of the activities of phenol oxides and ascorbic acid oxides enzymes through cold storage (Woolf, *et al.* 2003). Zhu *et al.,* (2015) observed an increase in ascorbic acid in fruits treated with brassinosteroids which relating to the fruit quality maintenance. Also, this trend was slower in putrescine treated mango fruits. The putrescine treatments retard the activity of ascorbate oxidase, this led to maintain fruits vitamin C content (Razzaq *et al.,* 2014).

Total sugar mg/100g FW :-

Regarding to the effect of total sugar confirmed data in (Table 5) that, total sugars were increased progressively awarded to the progress of cold storage through both seasons. As, fruits of the control had significantly the maximum level of total sugars values after 30 days of cold storage at 5°C (9.75 and 9.87%) and ranged (11.50 and 11.66 %) during marketing at 20 °C in the first and second seasons, respectively. Conversely, 10 ppm brassinosteroids (BRs) presented the lower significant sugar percent (8.75 and 8.87%) after 30 days of cold storage and (10.56 and 10.49 %) during marketing at 20 °C under the two seasons, respectively.

Postharvest application of brassinosteroids was effective in delaying the increment of sugars percentage. In this respect, treated kiwifruit with 5 µmol L-1 EBR delayed degradation of starch and activities of acid invertase, sucrose synthase, sucrose phosphate synthase, also hexokinase and fructokinase enzymes. The activities of these enzymes posteriorly lead to decrease the increase in glucose, sucrose and fructose contents (Lu *et al.,* 2019).

Total phenolic contents:

Data in (Table 6) showed the interaction effects among treatment and storage period on total phenols. In this respect, all applied treatments significantly delayed the reduction in total phenolic content of Tommy Atkins mango during storage .The data also revealed that, during the entire storage period phenol compounds register highest significant values in fruits treated with 10 ppm brassinosteroids (BRs). The contents of total phenolic compounds in this treatment reached (19.85 and 19.88 mg^{-1}) after cold storage at5°C and were 17.87 and 17.89 mg g-1after5 days during marketing at 20°C in both seasons, correspondingly.

In additions, control treatment produced the lower phenol content ranged (17.60 and 17.88 mg g^{-1}) after cold storage at 5°C (15.40 and 15.56 mg g^{-1}) 5 days through marketing at 20 °C in both seasons, respectively. Furthermore, phenolic compounds progressively decreased in mango fruits at cold storage. The decrease of these phenols might be due the action of polyphenol oxidase which led to breakdown of cell structure during ripening. Phenolic compounds are affected by different biotic and abiotic stress included chilling injury (Lattanzio *et al.,* 2008).

In this respect, Zhu *et al.,* (2010) observed that BRs treatment improved the activity of phenylalanine ammonia-lyase, which responsible to synthesis free phenolic.

Moreover, PAs play an important role for maintaining TPC in fruits under cold storage (Table 6). Therefore, the breakdown of cell texture during storage lead to decrease TPC because of the activity of PPO. So,

the decrease in activity was owing to reduced respiration rate by PAs treatment. Also, the results showed the impact of PAs of responsible for antioxidant activity, various pigments of plant origin, phenols and diverse vitamins (Davarynejad *et al.,* 2013).

Table 6. Effect of (Put), (BRs) and (EPE) packing on total phenolic contents and antioxidant capacity% of Tommy Atkins mangos during cold storage and marketing seasons 2017 and 2018.

Treatments	Total phenolic contents Mg g^{-1} FW.				Antioxidant % DPPH IC50 value.			
	Season 2017							
	Storage period (days)							
	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C	Initial at harvest	15 days at 5 °C	30 days at 5 °C	5 days at 20°C
50 ppm putrescine (Put)	22.40a	19.80e	18.90i	16.90n	21.00a	12.95e	8.07k	7.20m
50 ppm putrescine (Put) + (EPE) packaging	22.40a	19.90d	19.25h	17.16m	21.00a	13.80d	7.85l	6.90o
10 ppm brassinosteroids (BRs)	22.40a	20.40c	19.68f	17.60l	21.00a	12.26f	7.15m	6.40p
10 ppm brassinosteroids (BRs)+ (EPE) packaging	22.40a	20.77b	19.85de	17.87k	21.00a	12.35f	7.05n	6.20q
(EPE) foam net packaging	22.40a	19.57g	17.97j	16.09o	21.00a	14.80c	9.00i	8.40j
Distilled water (control)	22.40a	18.90i	17.60l	15.40p	21.00a	19.00b	12.80g	9.60h
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								
	Season 2018							
50 ppm putrescine (Put)	23.00a	20.10e	19.43i	17.16n	22.00a	13.16e	8.26k	7.46m
50 ppm putrescine (Put) + (EPE) packaging	23.00a	20.66d	19.56h	17.26m	22.00a	13.98d	8.00l	7.05p
10 ppm brassinosteroids (BRs)	23.00a	20.73c	19.66g	17.36l	22.00a	12.38g	7.38n	6.56q
10 ppm brassinosteroids (BRs)+ (EPE) packaging	23.00a	20.80b	19.88f	17.89f	22.00a	12.48f	7.18o	6.39r
(EPE) foam net packaging	23.00a	19.89f	18.29j	16.19o	22.00a	15.13c	9.18i	8.68j
Distilled water (control)	23.00a	19.66g	17.88k	15.56p	22.00a	19.36b	13.16e	10.26h
Means followed by the same letters are not significantly different by Duncan multiple range test at 0.05 levels.								

Antioxidant %:-

The primary antioxidant % of fruit scaled by the DPPH method (IC_{50} values) ranged (21.00 and 22.00 µg) phenolic concentration during both seasons, respectively (Table 6). It was lower rate (higher IC_{50} values) for control fruits after cold storage (12.80 and 13.16 µg) while, after 5 days (9.60 and 10.26 µg) during both seasons, correspondingly.

Over ripening, the total antioxidant activity increases and this increase are mostly due to change into the lipophilic antioxidant activity. Likewise, then increase in the antioxidant capacity (lower IC_{50} values) through storage confirm those of (Kondo *et al.,* 2005) where DPPH-radical scavenging activity (IC_{50} values) of mangoes increased through 10 days storage at 6 and 12 °C.

Total antioxidant activity during ripening, increments and this expansion are for the most part because of progress into the lipophilic cell reinforcement action. In like manner, the expansion in the antioxidant capacity (lower IC_{50} values) during storage affirm those of (Kondo*et al.,*2005) wherever DPPH-radical rummaging action (IC_{50} values) of mangoes expanded during 10 days storage at 6 and 12 °C.

Furthermore, ascorbate peroxidase (APX), peroxidase (POD) and superoxide dismutase (SOD) as antioxidant enzymes are critical to mitigate the impeding impacts of oxidative worry during postharvest storage (Valenzuela *et al.,* 2017). It is necessary to maintain antioxidants in fruits under storage by keeping the overall attributes required for fruit quality. The decrease in antioxidant agents under colder temperatures prompts the concealment of dynamic oxygen species (AOS) contents. Also, under chilling temperature the lipid peroxidation of the susceptible membranes occurs followed by their degradation and senescence (Kondo *et al.,* 2005).In this respect, exogenous application of epibrassinolide (EBR) showed higher activities of phenylalanine ammonia lyase (PAL) and peroxidase (POD) enzymes activities caused increased biosynthesis of phenolic which eventually resulted in reduced accumulation of H_2O_2 and O^{-2} contents and indicated extensive marketability of table grapes during postharvest storage (Liu *et al.,* 2016).As well, BRs application led to accumulate total phenolic, tannin, flavonoids, and anthocyanins which contributed to enhance antioxidant capacity of grapes berry (Xi *et al.,* 2013).Moreover, treated apricot cultivars {Lasgerdi and Shahrodi} with putrescine (Put) at 4 mM produced highest antioxidant activity, whereas control possessed lowest antioxidant activity

In addition, applications of approved postharvest brassinosteroids (BRs) or putrescine (Put) is recommended to preventing chilling injury and enhance cold tolerance to maintain quality marketing of mangoes.

CONCLUSION

Cold storage is the mainly popular method to prolong postharvest fruit life. Conversely, chilling injury limits the utilization of cold storage to mango fruits. In conclusion, putrescine (Put) or brassinosteroids (BRs) promoted CI tolerance in Tommy Atkins mangoes by maintaining membrane solidity which associated with antioxidant activity. Application of dipping with brassinosteroids (BRs) 10 ppm plus EPE foam net packing to mango fruits by cold storage beneficial in controlling postharvest chilling injury. PAs, being biodegradable and environmentally natural compound, will advance maintainability by decline the postharvest losses of fruits.

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تحسين مقاومة المانجو تومي أتكينز لأضرار البرودة أثناء التخزين البارد والتسويق

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أجرى البحث بهدف تقليل أضرار البرودة (Cl) و الطراوة الناشئة أثناء التخزين البارد التى تقلل الجودة التسويقية لثمار المانجو تومى أتكنز المخزنة عند 5 م° بإستخدام Putrescine (Put)و Brassinosteroids (BRs) مع التعبئة في شبكة من الفوم (EPE) خلال موسمى 2017و 2018 وقد تم غمر ثمار المانجو في Putrescine ((Put) 50جزء في المليون أو Brassinosteroids (BRs) 10جزء في المليون مع أو بدون التعبئة في شبكة من الفوم(EPE) . تم تخزين الثمار المعاملة عند 5 ± 1 درجة مئوية و 90-95٪ رطوبة نسبية لمدة 30 يومًا. و أوضحت النتائج أن جميع المعاملات المستخدمة أدت إلى خفض الفقد فى وزن الثمار مع تقليل أضرار البرودة ومعدل التنفس كما أدت إلى تأخير الإنخفاض فى الحموضة الكلية وفيتامين .C كما كان للمعاملات المستخدمة تأثير جيد فى في تأخير الزيادة في المواد الصلبة القابلة للذوبان والسكريات الكلية مع الحفاظ على صلابة الثمار ، ودرجة التلوين، والفينولات الكلية ، والحفاظ على معدل مرتفع من مضادات الأكسدة مع إطالة الفترة التسويقية مقارنة بالكنترول. و خلصت النتائج إلى أن المعاملة بالمحلول المائي لمادة Brassinosteroids (BRs) مع التعبئة فى شبكة من الفوم (EPE) هي أكثر المعاملات فاعلية في تقليل أضرارالبرودة ، والمحافظة على جودة الثمار تحت ظروف درجات الحرارة المنخفضة كما أثرت بشكل جيد فى تحسين و إطالة الفترة التسويقية لثمار المانجو.