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Pre Storage Application of 1- Methylcyclopropane on Quality and Extending Storability of Tommy Atkins Mango Fruits

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Abstract

1-Methylcyclopropane (1-MCP) is an ethylene inhibitor tested for maintaining fruit quality and extending storability of Tommy Atkins mango fruits as an export variety. The fruits were harvested at maturity stage in July 2019 and 2020, immersed in (1-MCP) water solution at 750, 1500 and 2250 ppb for 5 minutes besides control fruits were soaked in tap water for the same period. Fruits were air dried then cold stored at 8°C and relative humidity (RH) 85-90% for 15,30,45and 60 days. After each storage period fruits were holding to ripe at 20°C for 7 days, At the end of storage period either 8°C and 20°C, fruit quality characteristics (weight loss, decay percentage, firmness, respiration rate ,TSS % and total acidity %) were evaluated. The results revealed that (1-MCP) at 1500 ppb and storage at 8°C for 45 days was the best treatment for maintaining fruit quality after cold storage and the following ripening period at 20°C.

Key words: 1-Methylcyclopropane, Storability ,Fruit Quality, Mango, Ripping

1. Introduction

Mango (*Mangiferaindica L.*) belongs to the *Anacardiaceae* family and is the most important tropical and climacteric fruit. It is considered as one of the choicest fruit having heavy demand in world market due to its attractive color, delicious taste and excellent nutritional properties as a source of antioxidants [12].The total world mango harvested area increased from 13.225.188 to 13.773.100 acres with mango production increased substantially from 53.4 tons to 55.8 tons in (2018-2019). Meanwhile, the total Egyptian mango harvested area is 322.676 acres with fruit production 1.47 million tons as [6].

Mango is generally highly perishable fruit with a short and limited shelf life ripen after harvest when held at ambient temperatures. Meanwhile, [13] and [21] reported that post-harvest treatments play an important role in managing mango affecting agents, the deterioration in post-harvest permanence is critical in maintaining mango fruit quality. Soft texture of mango fruit limits the postharvest life quality and increases its susceptibility to rapid deterioration and various pathogenic infections which were the major problems of mango fruit that restricts its transportation to distant markets [27].

Tommy Atkins fruits are very perishable with a short postharvest life which depends on harvest maturity stage and storage conditions [22]. Tommy Atkins mango cultivar comes from a relatively developed group of cultivars originated in Florida USA , from the high yielding mono-embryonic cultivar 'Mulgoba' imported from India to the USA in 1910 [6].

Previous studies of [15] have demonstrated that 1-Methylcyclopropene (1-MCP) has great benefit in controlling ripening, maintaining quality and extending the shelf life of mango fruit. Furthermore, 1-MCP is a cyclic alkene that can bind to ethylene

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receptors and inhibit the action of ethylene and preventing its activation of ageing and maturity-related genes, Hence (1-MCP) has been examined as an ethylene inhibitor to identify its effective use to provide the consumer quality demands, and also to understand its role of ethylene development processes [9] Moreover, the beneficial effect of 1-MCP is a potent ethylene antagonist bindings to ethylene receptors, blocking ethylene action in modulating ripening processes [19],[20],[11] the use of 1-MCP as postharvest treatments of mango fruit to extend shelf-life depend upon its concentrations and exposure time [26].

Recently, [9],[26] showed that the response to 1-MCP applications were better on fruit quality characteristics as well as control fruits at lower storage temperature than at higher one with contrary with 1-MCP concentrations. However, [8] concluded that probably inhibited the activities of the enzymes effect through ripening processes. Furthermore, the effect of gaseous application of 1-methylcyclopropene with different concentrations and exposure times showed the best results in terms of physicochemical quality dramatically delayed in respiration speed increasing trends over the storage of all fruits [4],[14].

This study aims to investigate the effect of 1-MCP with different concentrations on Tommy Atkins mango fruits, in order for maintain fruit quality during cold storage and extend its storability during shelf life to meet the market and customer demands.

2. Materials and Methods

Plant materials: Mango fruit of Tommy Atkins cultivar was carefully harvested at the maturity stage as reported by [10], when Mango fruit with the flesh turned to yellow color with a soluble solids concentration (TSS) of 5.5% and flesh firmness around 17 (Ib/inch^2) of the two consecutive seasons of July 2019 and 2020 was collected from a private orchard of Alexandria Desert Road (Cairo-Alexandria Road, km 62) at Giza Governorate. The trees are 15-year-old, grafted white sugary stock, grown in sandy soil, 3.5 X 3.5 m apart, irrigated with a drip irrigation system and received common horticultural management as recommended. Mango fruits were chosen to be uniform in size, shape, and color without any pathological or mechanical injuries. Fruits were picked by using secateurs and cutting the stem 3-5 cm away from the fruit (this technique reduces latex and fungal infection). [14] Mango fruits were instantly transported carefully to the laboratory of Agricultural Development Systems (ADS), Faculty of Agriculture, Cairo University. Upon the arrival, all fruits were washed in chlorinated water (100 ppm free chlorine) for 10 min, air dried, and randomly distributed for postharvest treatments with 1-MCP.

1-Methylcyclopropane (1-MCP) Treatments:

The selected Tommy Atkins mango fruits (128 fruits/treatment) were dipped in aqueous solution of 1-Methylcyclopropane (1-MCP), dissolved in distilled water, at three concentrations (750, 1500 and 2250 ppb) for 5 minutes, then fruits were dried in air. Control fruit were treated only with tap water.

Treated and control fruits were packed in corrugated cardboard boxes and then stored at 8^{o}C±2^{o}C in controlled temperature rooms with 85-90% relative humidity (as shipping simulation) for 8 weeks (60 days). Four replicates for each treatment and sampling time were used. Each replicate consists of 8 fruits throughout storage period and ripening duration. At each storage period (15 days), intervals at 8oC mango fruits in the end of each storage date were holding to ripe at 20^{o}C for 7 days. All treated and untreated fruits were examined for quality assessment either at storage at 8^{o}C or after ripening at 20^{o}C at each sampling intervals [9].

Fruit Physical Quality Measurements:

1- ***Decay percentage:*** Fruits, decayed by different physiological and pathological factors, were periodically counted and discarded. The percentages of decayed fruits were calculated in relation to total number of fruits [1].

$$\text{Decay \%} = \frac{\text{Total number of decayed fruits}}{\text{Total Number of fruits}} \times 100$$

2- Percentage of Weight Loss: The loss in mass fruit weight was recorded, calculated and expressed as percentage loss of the initial weight as the equation of [3].

$$\text{Weight Loss \%} = \frac{A-B}{A} \times 100$$

Where: A = the initial weight at the beginning of storage and B = weight at examine date,

3- Firmness (Ib/inch^2): It was determined using Ametek pressure tester, fitted with an 8 mm hemispherical probe (probe penetration 2 mm). Firmness of mango fruits from each replicate was measured at two opposite points on the equator of each fruit after removing a thin slice of skin from each site (the results were calculated as described by [17].

4- Respiration rate (ml CO_2/ kg1/hr^{-1}): Fruits of each sampling date were weighed and placed in 2-liter jars at 8^{o}C and 20^{o}C, and the jars were sealed for 24 hr. with a cap and a rubber septum. CO_2 samples of the headspace were removed from a septum with a syringe and injected into Servomex Inst. (Model 1450 C-Gas Analyzer) to measure carbon dioxide production. Respiration rate was calculated as (ml CO_2/ kg^1/hr^{-1}) using [18] formula.

Chemical Fruit Quality Measurements:

1. ***The Total Soluble Solids Content (TSS)*** was measured using a T/C hand HANNNA refract meter, Brix-readings 0-85% ranges (Model HI 96801, Woonsocket -USA - made in Romania) and express in percentage. [2].
2. ***Total Acidity (TA):*** was expressed as malic acid and determined by titrating 5 ml juice with 0.1 N sodium hydroxide using phenolphthalein as an indicator [2].
3. ***Statistical analysis:*** The design for this experiment was a completely randomized design (CRD) with three replications. Data were analyzed with the analysis of variance (ANOVA) procedure of MSTATC program; Treatments means were compared by Duncan's multiple range tests at 5% level of probability in the average of two seasons of study [23].

Results and Discussion

A-Physical Fruit Quality Measurements:

1- Weight loss %

The effect of 1-methylcyclopropane on the percentage of weight loss during storage of Tommy Atkins mango fruits was directly proportional to the length of storage period; it gradually increased significantly ($P<0.05$) in the cumulative weight loss percentage.

Our results are further in line with [20], [9] .They found a significant accumulative loss in weight as an efficient of 1-MCP with delaying mango ripening process. Similarly, [4] on Kasar mongo found that 1-MCP treatment of 2000 ppb for 24 hr gave the best results. [7] on Alphanso mangoes and [14] on Tainong fruits at different concentrations, exposure time and storage temperatures, leading to 1-MCP significant influence. They concluded that the reduction in a weight loss of 1-MCP treated fruits may be attributed to slow respiration and transpiration rate of water through tissues and maintenance of tissue rigidity of the fruits.

2- Decay Percentage %:

Results in (Figure B) showed that there was no decay or any discarded fruits of Tommy Atkins mangoes during the first two weeks of storage at 8oC in all 1-MCP treatments other than control fruits. However, decay percentage showed significant and gradual increase with the progress of storage period at 8oC with 750ppb recorded higher percent (28.10 and 25%), followed by 2250 recorded the highest percent (37.50 and 37.50) of decay at the 45 days storage.

At 1500 ppb treatment pronounced significant effective in reducing decay percent reaching to the minimum (39.50 and 39.50 %) after 60 days of storage at both seasons of study. As for the control fruits, it was recorded a high percent (25 %) of decay at the first 2 weeks, then it reached the highest percent (50 %) at the end of storage period (60 days). Our results are further in line with [20] [9] .They found a significant accumulative loss in weight as an efficient of 1-MCP with delaying mango ripening process. Similarly [4] on Kasar Mango found that 1-MCP treatment of 2000 ppb for 24 h gave the best results. [7] on Alphanso mango and [14] on Tainong fruits at different concentrations, exposure time and storage temperatures, leading to 1-MCP significant influence. They concluded that the reduction in a weight loss of 1-MCP treated fruits may be attributed to slow respiration and transpiration rate of water through tissues and maintenance of tissue rigidity of the fruits.

3- Respiration rate (ml CO_2/kg^{-1}/hr^{-1}):

Results in (Table 1) showed that there was no decay or any discarded fruits of Tommy Atkins mangoes during the first two weeks of storage at 8^{o}C in all 1-MCP treatments other than control fruits. However, decay percentage showed significant and gradual increase with the progress of storage period

at 8°C with 750ppb recorded higher percent (28.10 and 25.00 %), followed by 2250 recorded the highest percent (37.50 and 37.50) of decay at the 45 days storage. On the other hand, fruits treated with 1-MCP at 750 ppb they was more in between in all stage at 8° C (9.54 and 10.25).The results showed the same trend after ripening at 20°C and had the maximum respiration rate (52.23 and 53.03) in the control fruits after 60 days of storage at 8°C. This increase was paralleled with expanding cold storage period, but it was greatly more than that occurred in treated fruits. The respiration rate is an indicator of metabolic activity and gives an indication of the potential shelf life of the fruits (Table 1)

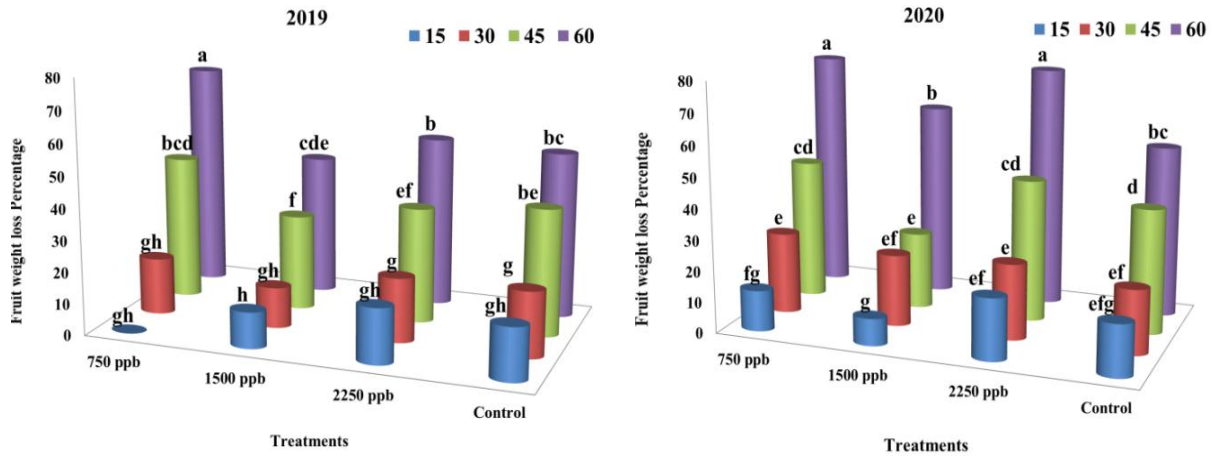

Figure. A: Weight loss percentage of Tommy Atkins mango fruit affected by different 1-MCP concentrations and storage for 60 days at the seasons of 2019 and 2020. The vertical bars represent a mean of ±S.E.

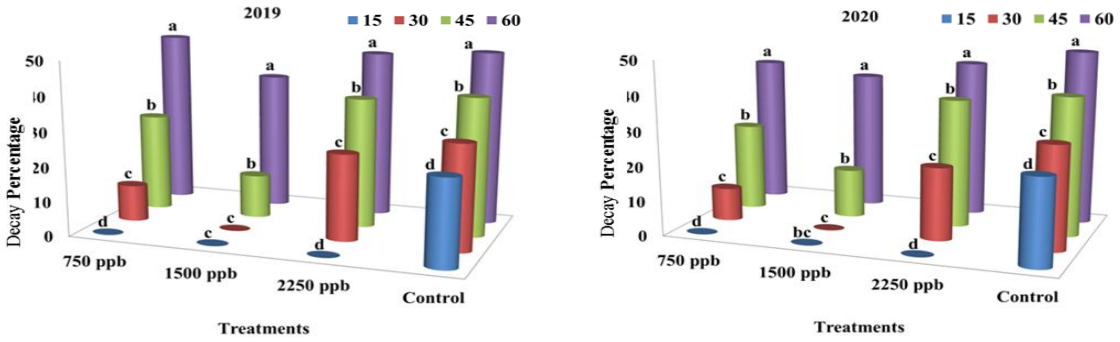

Figure B: Decay percentage percentage of Tommy Atkins mango fruit affected by different 1-MCP concentrations and storage for 60 days at the seasons of 2019 and 2020. The vertical bars represent a mean of ±S.E.

Table 1: Effect of 1-methylcyclopropane (1-MCP) treatments at different concentrations on physical characteristics of Tommy Atkins mango fruits during storage period for 60 days at the seasons of 2019 and 2020

		Respiration rat (ml $CO_2/kg^{-1}/hr^{-1}$)		Firmness ($lb/inch^2$)	
1-MCP	Storage	2019	2020	2019	2020

Concentration	in days	At removal, 8ºC	After holding, 20ºC	At removal, 8ºC	After holding, 20ºC	At removal, 8ºC	After holding, 20ºC	At removal, 8ºC	After holding, 20ºC
750 ppb	15	2.96i	14.58fg	3.39j	15.06 k	17.08bc	11.25bc	16.93a	11.50a
	30	6.25g	28.45de	7.70gh	30.32 h	17.00ab	13.50a	14.38b	4.50bc
	45	7.27f	37.48bc	8.36fg	37.88e	16.10a	5.00f	12.25de	3.50bc
	60	9.54c	48.04a	10.25d	48.59b	11.50e	2.70gh	11.05dc	3.23cde
1500 ppb	15	2.51j	11.67g	2.92j	11.71l	17.70bc	12.28ab	17.18a	11.75a
	30	5.46h	26.08e	6.37i	26.23i	17.00a	9.50cde	14.80bc	4.75b
	45	6.09g	33.28cd	7.19h	33.66f	16.65ab	6.67f	14.00bc	4.45bcd
	60	8.48d	41.84b	9.21e	43.11c	13.25d	3.48g	13.75bcd	2.75gh
2250 ppb	15	3.01i	19.46f	3.39j	19.73j	17.60ab	9.08de	17.28a	12.00a
	30	8.31d	33.51cd	9.44e	33.14fg	17.65ab	8.30ef	13.95bc	4.00bcd
	45	9.54c	38.68bc	11.20c	40.21df	16.10a	5.75f	13.00bc	3.98bcd
	60	11.97a	49.85a	13.77a	55.28a	13.50d	4.00g	12.75bcd	2.00efg
Control	15	3.07i	25.71e	2.92j	25.11i	16.80c	11.25bc	17.58a	11.75a
	30	7.82e	29.59de	8.99ef	30.99gh	13.68a	9.75bcd	13.30bcd	8.75def
	45	10.16b	42.24b	11.22c	41.88cd	12.05a	5.38ef	12.50b	4.75fg
	60	11.64a	52.23a	12.90b	53.03a	11.50e	1.08h	10.75e	0.00h

Values followed by the same letter (S) within each column are not significantly different at 5%.

4- Firmness (Ib/inch²)

Firmness of Tommy Atkins mango fruits had significant and continuous decrease throughout the progress of cold storage periods at 8°C as well as after holding at 20°C all treatments in both seasons of investigation. At the cold storage at 8ºC, all treated and untreated mango fruits had less firmness values than control fruits especially fruits treated with 1-MCP at 1500 ppb which showed a clear highest firm values (16.65 and 15.00Ib/inch²) stored for 45 days. Moreover, the same high firm fruits at 1500 ppb (1-MCP) concentration throughout storage periods for 45 days at 8°C and the ripened 20°Crecorded the highest firmness (6.67 and 4.45) in the two seasons respectively (Table 1).

As reported by, the differences in firmness of the mango fruits could be as a result of respiration which enhances ripening, similar results were obtained by [16],[5],[25] in maintaining firmness of mango fruit cultivars examined with 1-MCP application. They reported that 1-MCP remove the activities of the enzymes and delays the onset of softening in both climacteric and non-climacteric fruit. The softening of mangoes can be prevented or delayed by 1-MCP, but the effects of treatment have been closely associated with ethylene production. Meanwhile, [7] exposed Alphanso mango fruits with 1-MCP at 2.0 µL/L for 24 h. and stored at 20°C, exhibited gradual decrease in texture in terms of firmness during 33 days of storage period as compared to control during 12 days of storage. This reduction in firmness may be due to the hydrolase enzyme (PG, PME β-galactosidase and pectate layase (PL) degrade the polymeric carbon hydrates, which is induced by ethylene during ripening [7].

B- Chemical Fruit Quality Measurements:

1- Total Soluble Solids (TSS) %:

Results showed gradual and significant increase throughout storage period, recording approximately the same and significantly equal TSS values of 750 ppb, 1500 ppb, 2250 ppb and control) fruits after 60 days of storage. As for 1-MCP concentrations, and fruits storage at 8oC for 60 days and ripened at 20°C,

than the least TSS values at the both seasons of study (15.03 and 15.4) (Table 2)

Our results are in accordance with that examines different concentrations of 1-MCP on different cultivars of mangoes. However [8] reported a significant lowest response of 1-MCP (2ppm) on TSS content than control fruits as the storage period increase on Khirshapat mango Furthermore [4] examined 1-MCP on Kesar mango fruits at 4 concentrations and Found that the best result was exhibited at 2000 ppb for 24 h. Moreover, 1-MCP at 1 µL/L for 24 h on Tainong mango fruit revealed the soluble solids content increase as the storage duration extended [14].In addition [7] showed that Alphanso mango fruits exposed to 1-MCP at 2.0 µL/L and stored at 20oC had gradual increase in TSS values. This increase in soluble solids content during storage may be probably due to the conversion of starch into soluble sugars, and the breakdown of complex organic metabolites into simple molecules.

2- Total acidity (TA %):

Results showed a progressive significant decrease in titratable acidity (TA) either in all 1-MCP tested concentrations or control through storage and ripening periods. With a significant equal and lowest TA % in fruits stored to 4.5 and 60 days at all experiment concentrations of 1-MCP as well as control treatment. In addition, the minimum value was recorded with 750 ppb of 1-MCP, reached to the least level of TA decline (0.14 and 0.24 %) after removal from 20^{o}C. Meanwhile the corresponding values of control fruits exhibited the least TA % (0.21 and 0.23) after ripping at 20°C in 2019 and 2020 of study (Table 2)

These results coincided with those [8] who reported that Khirshap mangoes exposed to 1-MCP at 2 ppm showed the better result in case of control with slightly significant decrease of total acidity from 2.58 to 1.76 (%) at 12-13oC on day 24 under storage period. They observed mild changing trend of pH production compared with untreated fruit (control) which gave a significant lower TA value which is very remarkable. At the same concern, a noticeable TA decrease was reported by [14] which examined1-MCP at 1 µL/L for 24 h on Tainong mango cultivar and [7] tested 1-MCP at 2.0µL/L on Alphonso mango fruit. Meanwhile, they concluded that low storage temperatures (12^{o}C to 13^{o}C) and 1-MCP treatment probably inhibited the activities of the enzymes to change the (TA) contents. The decrease in titratable acids during storage may be accredited to a marked increase in malic acid utilization during ripening [7].

Conclusions

The results show that (1-MCP) at 1500 ppb and storage at 8°C for 45 days was the best treatment for maintaining Tommy Atkins Mango fruit quality after cold storage and the following ripening period at 20°C.

Table 2

Effect of postharvest treatments of 1-methylcyclopropane (1-MCP) at different concentrations on Chemical Fruit Quality of Tommy Atkins mangoes at the two seasons

1-MCP Concentration	Storage in days	TSS %				Total acidity %			
		2019		2020		2019		2020	
		At removal, 8^{o}C	After holding, 20^{o}C	At removal, 8^{o}C	After holding, 20^{o}C	At removal, 8^{o}C	After holding, 20^{o}C	At removal, 8^{o}C	After holding, 20^{o}C
750 ppb	15	7.03 i	8.68 i	7.10 ij	8.10 k	2.15a	0.45a	1.92 def	0.38 ah
	30	10.43 f	11.88 ef	10.83 g	11.75 hi	1.95b	0.35ab	1.88 eg	0.31 bcd
	45	11.88 cd	12.78 d	11.75 f	12.65 ef	1.27 b	0.24 cde	1.18 f	0.30 bcd
	60	12.78 b	15.03b	12.65 cd	15.40 b	1.02 b	0.14 cde	1.00 cd	0.24 bcd
1500 ppb	15	6.84 i	10.43h	6.60 k	10.83 j	2.15 a	0.36abc	2.12 def	0.48 a
	30	8.68 g	11.53 fg	8.10 h	11.43 i	1.85 b	0.30 ab	1.85 de	0.34bcd

	45	11.53 df	12.10 e	11.43 f	12.23 fg	1.55 c	0.26 ab	1.43 def	0.30bcd
	60	12.10 c	16.00a	12.23 e	15.60ab	1.02 d	0.18 e	1.13 a	0.28cd
2250 ppb	15	7.15 hi	11.18g	7.05 j	11.45 i	2.37 a	0.35 abc	1.42 ef	0.26cd
	30	11.18 e	12.28e	11.45 f	12.33fg	1.55 b	0.34 abc	1.35 hi	0.34bc
	45	12.28 c	13.00 d	12.33 df	13.18 gh	1.23 b	0.27 ab	1.23 i	0.31bcd
	60	13.00 b	15.70a	13.18 b	15.88a	1.00 c	0.25 ab	1.08 ab	0.29bcd
Control	15	7.50 h	12.20e	7.50 i	12.18gh	1.55 a	0.34abc	1.50 g	0.34bc
	30	12.20 c	12.80d	12.18 e	12.85df	1.31 b	0.32abc	1.28 1h	0.28bcd
	45	12.80 b	14.15c	12.85 bc	13.98c	1.00 c	0.26bcde	1.10 bc	0.22d
	60	14.15 a	15.85a	13.98 a	15.88a	0.75 d	0.21de	0.80 ab	0.23cd

Values followed by the same letter (S) within each column are not significantly different at 5%.

References

[1] A.O.A.C,(1990). Association Of Official Analytical Chemists.,1111 North19th Street, Suite 20, 16th Edi. Arlington, Virginia, USA. 22209.

[2] A.O.A.C (1994). Association of Official Agriculture Chemist.1111 North19th Street, Suite 20, 16th Edi. Arlington, Virginia, USA. 22209.

[3] A.O.A.C (2000). Association of Official Agriculture Chemist. 17th Ed., Washington, D.C. U.S.A. Pp. 490-520.

[4] Sakhale. B.K ,Gaikwad. S. S, Chavan. R. F (2018) Application of 1-Methylcyclopropene on Mango Fruit (Cv. Kesar): Potential For Shelf Life Enhancement And Retention of Quality J Food SciTechnol 55(2):776–781

[5] Cai, C., Chen, K., Xu,W., Zhang,W., Li, X. and Ferguson, I. (2006). Effect of 1-MCP on Postharvest Quality Of Loquat Fruit. Postharvest Biol. Technol. 40, 155–162.

[6] W. Campbell. (1993) Commercial Florida mango Cultivars, University of Florida Tropical Research and Education Center,18905S.W .280 St. Homestead FI.33031.

[7] FAO STAT, (2019). Food and Agriculture Organization FAOSTAT database collections, agricultural data, food and agriculture organization of the United Nations. http://www.faostat.fao.org.

[8] Gaikwad, S.S., Sakhale, B.K. and Chavan, R.F. (2020) Effect of 1– MCP concentration, exposure time and storage temperature on post-harvest quality of mango fruit cv. Alphanso,Food Research 4 (3) : 746 - 752

[9] Zakir . H. M. Fardush. S. Hossain, Z. Islam, S. Shariar , K. Rokshana, M. Hossian (2018) Effects Of Storage Temperatures On Different Biochemical Characteristics Of 1-Methylcyclopropene Treated Mango (Mangifera Indica L.) Variety Khirshapat, American Journal Of Food Science And Technology, Vol. 6, No. 2, 76-82

[10] J. Faasema, J.S. Alakali1 And J.O. Abu (2012) Effects Of Storage Temperature On1-Methylcyclopropene-Treated Mango (MangniferaIndica) Fruit Varieties Journal Of Food Processing And Preservation ISSN 1745-4549

[11] J.Muiruri (2013) "Evaluation Of Maturity Indices Of Selected Mango Varieties And Effect On Quality Attributes" Masters Of Science In Horticulture Of The University Of Nairobi A56/67250/2013

[12] Jorge A; Osuna-Garcia1; Jeffrey K. Brecht; Donald J. Huber and Yolanda Nolasco-Gonzalez (2015). Aqueous 1-Methylcyclopropene to Delay Ripening of 'Kent' Mango With or Without Quarantine Hot Water Treatment, 25 (3)349-357.

[13] Khaliq, G.; M. T. M. Mohamed; A. Ali; P. Ding And H. M. Ghazali (2015). Effect Of Gum Arabic Coating Combined With Calcium Chloride On Physico-Chemical And Qualitative Properties Of Mango (Mangiferaindica L.) Fruit during Low Temperature Storage, ScientiaHorticulturae 190 187–194.

[14] Kore, V.T.; Tawade, S. S. andKabir, J. (2017). Application of Edible Coatings on Fruits and Vegetables, Imperial Journal of Interdisciplinary Research (IJIR), l, 3, (1), 91-601.

[15] Li Li ,Changbao Li, Jian Sun , Jinfeng Sheng, Zhuguizhou, Mingxin, Pingyi, Xuemei He, FengjinZheng, Yayuan Tang, Jiemin Li, And Jie Tan (2020) The Effects Of 1-Methylcyclopropene In The Regulation Of Antioxidative System And Softening Ofmango Fruit During Storage. Journal Of Food Quality Volume 2020, Article ID 6090354, 11 Pages

[16] D .Maria. C. Antunes, Susana Dandlen, Ana M. Cavaco, And Grac-A Miguel (2010) Effects of Postharvest Application of 1-MCP and Post cutting Dip Treatment on the Quality and Nutritional Properties of Fresh-Cut Kiwifruit J. Agric. Food Chem. 2010, 58, 6173–6181 6173

[17] Mattheis, J.P., Fan, X.T. And Argenta, L.C. (2005). Interactive Responses Of Gala Apple Fruit Volatile Production To Controlled Atmosphere Storage And Chemical Inhibition Of Ethylene Action. J. Agric. Food Chem. 53, 4510–4516.

[18] Meir, S., M. Akerman, Y. Fuchs and G. Zauberman (1995). Further studies on the controlled atmospheres storage of avocados. Postharvest Biol. and Technol., 5(4), 323-330

[19] Pesis E. And R. Ben-Arie(1984) Involvement Of Acetaldehyde And Ethanol Accumulation During Induced Eastringency Of Persimmon Fruits. J. Food Sci., 49, 896-899.

[20] Arya.R and .Pruthi. N (2015) An Insight Into The Responses of 1-MCP (1-MethylCyclo Propene) on The Ripening Control And Shelf Life Extension of Mango J. Biol. Sci. Med. 1 (1): 36-42

[21] Rothore, H.A., Masud, T., Sammi, S., Soomro, A.H. (2007). Effect of Storage on Physio-Chemical Composition And Sensory Properties Of Mango Variety Dosehari. J. Nutr. 6, 143–148.

[22] Bally S. E, Aureliano .B, Alan H, Y Cohen, Natalie L , David J. Innes, María A. Islas-Osuna, David N. Kuhn, Lukas A. Mueller, Ron Ophir, Aditi Rambani, Amir Sherman and Haidong Yan The (2021).Tommy Atkins' mango genome reveals candidate genes for fruit quality, Bally et al. BMC Plant Biology 21:108

[23] Slaughter, D.C (2009). Nondestructive Maturity Assessment Methods For Mango: A Review Of Literature And Identification Of Future Research Needs. Biological And Agricultural Engineering, University Of California, Davis, USA.

[24] Steel, R.G. and J.H. Torrie. (1980). Principles and Procedures of Statistics: A Biometrical Approach. 2nd Ed.McGraw-Hill Book Co., New York, NY.

[25] Wang BG, Jiang WB, Liu HX, Lin L, Wang JH (2006) Enhancing The Postharvest Qualities Of Mango Fruit By Vacuum Infiltration Treatment With 1-Methylcyclopropene.J HorticSciBiotechnol 81:163–167.

[26] Xiangbin Xu , Huanhuan Lei , Xiuyan Ma , Tongfei Lai , Hongmiao Song , Xuequn Shi B, Jiangkuo Li.(2017) Antifungal Activity Of 1-Methylcyclopropene (1-MCP) Against Anthracnose (ColletotrichumGloeosporioides) In Postharvestmango Fruit And Its Possible Mechanisms Of ActionInternational Journal Of Food Microbiology 241 (2017) 1–6 International Journal Of Food Microbiology 241 (2017) 1–6

[27] Zheng, X., Ye, L., Jiang, T., Jing, G. and Li, J. (2012). Limiting the deterioration of mango fruit during storage at room temperature by oxalate treatment. Food Chemistry 130(2): 279–285.