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PROLONGING THE SHELF LIFE AND MAINTAINING FRUIT QUALITY OF NAOMI MANGO CULTIVAR

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ABSTRACT

Mango fruits being climacteric have a short shelf life; and post-harvest dipping is considered as one of the most popular techniques to prolong its shelf life dipping based on starch, olive oil, beeswax and sodium benzoate have been evaluated with reference to the shelf life and quality of mango Naomi cultivar fruit harvested at full stage of maturity. The dipped and undipped (control) fruits were stored on the lab's tables in the room conditions (25±5 <C and 65-70% R.H.), samples of each treatment were randomly taken every 4 days to evaluate after harvest dipping treatments effect during shelf life of fruits. Results indicated that every dipping treatment has a significant impact on the quality and shelf life of the fruit. The beeswax and olive oil treated mango fruits had the longest shelf life with good quality, while the shelf life of untreated (control) fruit was the shortest. The total soluble solids and sugar contents were also high in starch-treated fruit. The overall data conclude that beeswax was the best post-harvest dipping material, which might be due to the fact that beeswax is an antioxidant and antimicrobial as well as hydrophobic in nature.

Keywords: Mango, post-harvest treatments, Starch, Olive oil, Beeswax, Sodium Benzoate, fruit quality, shelf life, Naomi

INTRODUCTION

Mango (*Mangifera indica* L., Family Anacardiaceae) is well known as the queen of fruit that has an excellent exotic flavor. Mango is a tropical and seasonal fruit which is generally available during summer season in Egypt and main harvesting period is in the month of May to September. In relation to fruits, Egypt has two major problems including fruit post-harvest losses due to over production in growing season and deficit in off season due to lack of appropriate processing and preservation techniques. In addition, mango is also a perishable fruit and cannot be preserved naturally for long time after harvesting. 'Naomi' ripens in midseason. Trees are harvested in September, 3 or 4 weeks after 'Haden' and 'Tommy Atkins'. Fruit are oblong, usually with a small, but sometimes absent, sinus. The ventral shoulder is higher than the dorsal one, and the apex is obtuse or rounded. Fruit size is uniform; average fruit weight is 450 g. The skin of mature fruit is smooth and thin, with an attractive red pigmentation. The yellow flesh is tender, juicy, and nearly fibreless. The flavor is mild and moderately sweet, with a weak pleasant aroma. Harvested fruit were sensitive to rough handling (Degani, *et al*., 1990).

There are various methods to extend shelf life of mangoes or reduce post-harvest losses like wax coating, washing with water, heat treatment, freezing and refrigeration, immersion into sugar or brine solution, and so on. Several researchers reported that heat treatment improved the firmness and avoided the browning of fresh-cut mangoes and reduced the respiration rate. Edible coatings are also promising to improve the quality and extend the shelf-life of fresh-cut products. They act as barriers to water loss and gas exchange by creating a micro-modified atmosphere around the product (Ben-Yehoshua, 2005). According to Kader (2002) many chemical treatments have been banned or restricted as postharvest fungicide treatments of fruits in some countries, and the demand of pesticide free produces are increasing day by day. After harvest dipping treatment is one of the important and popular techniques used to prolong the shelf life and reduce their wastage. Therefore, a number of scholars are working on the identification of such coating materials, which have the potential to reduce the wastage, prolong the shelf life, keep the good shape and color while retaining the real taste, and ensure that it is less toxic for human beings (Hagenmaier and Baker 1993; Baldwin *et al.,* 1999; Hoa *et al.,* 2002; Hoa and Ducamp 2008; Malik and Singh 2005; Anjum *et al.,* 2006; Martinez-Romero *et al.,* 2006; Zeng *et al.,* 2006; Bakkali *et al.,* 2008; Regnier *et al.,* 2008; Abbasi *et al.,* 2009; Abd-AllA and Haggag 2010).

On the other hand, finding a coating material with such types of chemical and physical properties is a real challenge for scientists. Therefore, in practice, an accommodative attitude is adopted and a material that can meet the maximum required characteristics is selected. As a consequence, a number of coatings have been used and discussed by the scientists and efforts are still going on to find the best one. Initially, the coating materials were selected, irrespective of the taste and bioactivity; however, later on, emphasis was given on toxicity, taste and appearance.

In the recent years, the prime interest of the scientists to explore the natural coatings that can solve the problem remained. Therefore, the chitosan, carnauba wax, aloe vera gel, semper fresh, shellac, zein and polysaccharide-based coating materials have been used by the scientists, and their efficiency and the problems associated with them have been highlighted (Ketsa and Prabhasa- vat 1992; Sumnu and Bayindirli 1995; Diaz-Sobac *et al.,* 1996; Baldwin 1998; Carrillo-Lopez *et al.,* 2000; Kittur *et al.,* 2001; Hoa *et al.,* 2002; Srinivasa *et al.,* 2004; Feygenberg *et al.,* 2005; Dang *et al.,* 2008; Zhu *et al.,* 2008; Abbasi *et al.,* 2011). On the other hand, beeswax contains triacontanol as the main constituent, which is antioxidant, anti peroxidative, anti-inflammatory, antiulcerogenic, gastroprotective and anticolitis; hence, it can be considered as a good potential for coating. Olive oil is commonly used in Mediterranean and other diets. It has several phenolic compounds that are known as antioxidant, which is effective against oxidative stress and other related diseases (Covas 2008). Starch-based coatings retard the metabolic reactions by reducing respiration rate and thus delay the senescence of the coated fruit (Baldwin 1994; Garcia *et al.,* 1998a, b). Similarly, sodium benzoate is commonly used as food preservative, which has been used since 1909. It is not only harmless for human beings, but also bacteriostatic and fungistatic (Comes and Beelman 2002; Stanojevic *et al.,* 2009). Therefore, in this study, we have investigated the impact of starch, olive oil and bees wax natural coating materials on the quality, shelf life and waste percent, and compared these coating materials with sodium benzoate, a chemical coating.

MATERIALS AND METHODS

This study was carried out during the 2017 and 2018 seasons on mango fruits (*Mangifera Indica L.*) Naomi cultivar. The study was conducted in a private orchard located in Cairo Alexandria desert road. The trees were received the standard horticultural care adapted in the area. The full matured fruits were picked manually by hand, packed in carton boxes and taken directly to the Post-Harvest Laboratory in Horticulture Department, Faculty of Agriculture, Cairo University. The sound fruits were selected. All fruits were washed with regular tap water and soap and then rinsed with water. Fruit uniform in size and good in quality were selected. 150 fruits were chosen, fruits were treated by five treatments of coatings, and each treatment consisted of 30 fruits, and then was divided into three replicates, ten fruits for each replicate. This was done for the first and the second season of study.

The treatments were as follow

1. Starch. (2% homogeneous solution of starch was made in warm water and allowed to cool down to 30^o C).

2. Olive oil. (was obtained from a local market).

3. Beeswax. (dissolved in ethanol to obtain 2% solution).

4. Sodium Benzoate. (Five percent homogenous solution of sodium benzoate in water was prepared by stirring the mixture vigorously).

5. Fruit without coating (control).

For dipping purposes, the fruits were dipped once in the dipping material and retained in it for less than 1 min to have a uniform thin layer of the material over the surface of the fruit. The dipped and undipped (control) fruits were stored on the lab's tables in the room conditions (25±5 <C and 65-70% R.H.), samples of each treatment were randomly taken every 4 days to evaluate coating treatments effect during shelf life of fruits. Evaluation of treatments effects was carried out through the following parameters:

Fruit firmness

Measurements of firmness were taken with a Bosch penetrometer (model FT 327, Bosch, Osaka, Japan). The firmness was determined by the force (g/mm) necessary for a 2-mm probe to puncture the fruit peel at four different points and taking the average of the values (external firmness). The values obtained were rescaled according to the hedonic scale for comparison purposes (Larmond 1987): 10–8 means firm; 8–6 slightly soft; 6–4 soft; 4–2 was over soft.

Moisture and Fruit dry matter contents

The flesh of fruit samples was cut into small pieces and dried at (60 – 65^0C) for 48 h. the moisture and dry matter percentage were calculated using the following equations:

Moisture (%)

$$\frac{\text{Weight before drying} - \text{Weight after drying}}{\text{Weight before drying}} \times 100$$

Fruit dry matter content (%)

$$\frac{\text{Average dry weight (g.)}}{\text{Average fresh weight (g.)}} \times 100$$

Fruit total soluble solids

Total soluble solids were measured from 10 g of the mixed pulp using a digital refractometer (Atago Palette PR 101, Atago Co. Ltd., Itabashi-Ku, Tokyo, Japan).

Fruit total titratable acidity

The total titratable acidity was determined by titrating 100 mL of juice against sodium hydroxide having concentration of 0.1 N (AOAC 2000). Pulp from five mango fruits was obtained and mixed thoroughly and it was used later on for the measurement.

Total sugar

The total sugar was measured by determining the refractive index using a digital refractometer.

Ethylene

Ethylene produced was monitored by gas chromatograph, Clarus 500, supplied by Perkin Elmer (Waltham, MA), using flame ionization detector. The measurements were made in triplicate and the concentration of ethylene was calculated by comparing the peak areas with the known standards.

Fruit Respiration rate

Individual small clusters for each treatment were weighed and placed in 2-liter jars at 20°C. The jars were sealed for 3 h with a cap and a rubber septum. The resulting O_2 and CO_2 samples of the headspace were removed from the septum with a syringe and injected into Servomex Inst. Model 1450C (Food Pack Gas Analyzer) to measure oxygen and carbon dioxide production. Respiration rate was calculated as ml CO2/kg fruits/hr. (Lurie and Pesis, 1992). Initial reading at harvest day was scored under room temperature, and then every 4 days till the end of cold storage period. The ripened stage of the fruit was detected through the variation in firmness, sugar contents and the evolution rate of ethylene with the passage of time (Shorter and Joyce 1998). The fruit was considered as loss when it was infected by the disease and/or its firmness value was less than 4.

Statistical analysis

The current study followed a complete randomized block design, with three replicates for each treatment. Data obtained throughout the current study were tested for analysis of variance as indicated by Snedecor and Cochran (1972) and means were compared using LSD test at 5% (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Fruit firmness

Data in Table (1) clarifya significant decrement in mango fruit firmness with prolonging storage period at room temperature. All dipping treatments maintained significantly fruit firmness higher than the control. Dipping treatment with beeswax was supremacy in maintaining fruit firmness, followed by Sodium B treatment after seventeen storage days at room temperature in both studied seasons. Using olive oil as a dipping agent proved to be more effective in maintaining fruit firmness than starch treatment throughout storage period. Data in the table revealed a significant interaction between storage period and treatments in both seasons. So, at the end of storage, the least fruit firmness values were recorded with the control treatment (3.61 & 3.64 lb/inch²), contrarily were the values of the beeswax treatment as it recorded the highest (4.25 and 4.29 lb/inch²) in both seasons, respectively. The fruit firmness was decreased for all treatments. The value of firmness was the highest in beeswax treatment as compared with others.

It was attributed to the fact that the beeswax reduced the evaporation, improved the texture of fruit and hence delayed its wrinkling and softening during the storage period (McWilliam 1989; Ladaniya and Sonkar 1997; Shahid 2007). As the ripening of mango fruits is characterized by loss of firmness due to cell wall digestion by pectinesterase, poly galacturonase and other enzymes.

Moisture and Fruit dry matter contents

The moisture loss percent calculated for each dipping treatment is displayed in Table 2. The Starch dipping treatment was the most effective for reducing the moisture loss as compared with others. The reason for the reduction in moisture loss may be the blockage of lenticels and/or stomates (Dhalla and Hanson 1988). This idea was also supported by the reduction in respiration. This consistency of moisture content might be occurring due to lower rate of transpiration from mango tissues during the storage period (Mahomud *et al*., 2010).

Fruit total soluble solids

Data in Table (3) showed a significant increase in mango fruit TSS with prolonging storage period at room temperature. All dipping treatments compared with control treatment maintained significantly fruit TSS higher than the olive oil. Dipping treatment with starch was supremacy in maintaining fruit TSS, followed by Sodium B treatment after seventeen storage days at room temperature in both studied seasons. Using starch as a dipping agent proved to be more effective in maintaining fruit TSS than beeswax treatment throughout storage period. Data in the table revealed a significant interaction between storage period and treatments in both seasons. So, at the end of storage, the least fruit TSS values were recorded with the olive oil treatment (78.34 & 79.05%), contrarily were the values of the starch treatment as it recorded the highest (86.91and 87.69%) in both seasons, respectively.

An increase in TSS is considered to be due to the hydrolytic conversion of polysaccharides into soluble sugar for climacteric fruits during the ripening process. During the ripening process, the transition of chlorophyll into carotenoids, the biochemical conversions of starch into sugar, insoluble proto pectin into pectin and the loss of organic acid through oxidation are responsible for the increase in these parameters (Kays 1991; Martinez *et al.,*

Table (1): Effect of coating treatments on fruit firmness (lb/inch²) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	8.26	7.42	6.55	5.57	3.61	6.28
Starch	8.40	7.62	6.69	5.69	3.70	6.42
Olive oil	8.97	8.08	7.13	6.09	3.94	6.84
Sodium B.	9.13	8.22	7.28	6.14	3.97	6.95
Beeswax	9.76	8.80	7.76	6.59	4.25	7.43
Mean	8.90	8.03	7.08	6.02	3.90	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	5	9	13	17	
Control	8.34	7.49	6.61	5.62	3.64	6.34
Starch	8.48	7.68	6.75	5.74	3.73	6.48
Olive oil	9.05	8.15	7.20	6.14	3.98	6.90
Sodium B.	9.21	8.29	7.34	6.20	4.01	7.01
Beeswax	9.85	8.88	7.83	6.65	4.29	7.50
Mean	8.99	8.10	7.14	6.07	3.93	

LSD value at 0.05:
Dates: 0.052 Treatments: 0.052 Interaction: 0.116
Dates: 0.053 Treatments: 0.053 Interaction: 0.118

Table (2): Effect of coating treatments on fruit moisture content (%) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	51.21	56.66	69.93	76.27	86.25	68.06
Starch	55.74	61.79	76.15	82.97	93.73	74.08
Olive oil	50.31	55.85	68.68	74.85	84.61	66.86
Sodium B.	53.00	58.84	72.38	78.87	89.16	70.45
Beeswax	52.03	57.71	71.07	77.48	87.50	69.16
Mean	52.46	58.17	71.64	78.09	88.25	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	5	9	13	17	
Control	51.67	57.17	70.56	76.96	87.03	68.68
Starch	56.24	62.35	76.84	83.71	94.57	74.74
Olive oil	50.76	56.35	69.30	75.52	85.37	67.46
Sodium B.	53.48	59.37	73.04	79.58	89.97	71.09
Beeswax	52.50	58.23	71.71	78.18	88.29	69.78
Mean	52.93	58.70	72.29	78.79	89.04	

LSD value at 0.05:
Dates: 0.08 Treatments: 0.08 Interaction: 0.17
Dates: 0.08 Treatments: 0.08 Interaction: 0.17

Table (3): Effect of coating treatments on fruit total soluble solids content (%) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	15.07	17.10	21.52	78.31	79.90	42.38
Starch	16.58	18.89	22.05	85.26	86.91	45.94
Olive oil	14.30	16.20	21.29	76.94	78.34	41.42
Sodium B.	15.97	17.86	21.83	81.07	82.68	43.88
Beeswax	15.53	17.62	21.59	79.56	81.16	43.09
Mean	15.49	17.53	21.65	80.23	81.80	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	5	9	13	17	
Control	15.21	17.25	21.71	79.02	80.62	42.76
Starch	16.73	19.06	22.25	86.03	87.69	46.35
Olive oil	14.43	16.35	21.49	77.63	79.05	41.79
Sodium B.	16.11	18.02	22.03	81.80	83.42	44.28
Beeswax	15.67	17.78	21.78	80.27	81.89	43.48
Mean	15.63	17.69	21.85	80.95	82.54	

LSD value at 0.05:
Dates: 0.11 Treatments: 0.11 Interaction: 0.24
Dates: 0.11 Treatments: 0.11 Interaction: 0.25

Table (4): Effect of coating treatments on fruit acidity (%) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	2.06	1.77	1.34	69.28	54.24	25.74
Starch	1.10	0.95	0.74	68.82	77.08	29.74
Olive oil	2.24	1.91	1.51	70.76	79.26	31.14
Sodium B.	1.96	1.75	1.34	67.37	75.47	29.58
Beeswax	1.99	1.75	1.34	65.77	73.64	28.90
Mean	1.87	1.63	1.25	68.40	71.94	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	5	9	13	17	
Control	2.06	1.77	1.34	69.28	54.24	25.74
Starch	1.10	0.95	0.74	68.82	77.08	29.74
Olive oil	2.24	1.91	1.51	70.76	79.26	31.14
Sodium B.	1.96	1.75	1.34	67.37	75.47	29.58
Beeswax	1.99	1.75	1.34	65.77	73.64	28.90
Mean	1.87	1.63	1.25	68.40	71.94	

LSD value at 0.05:
Dates: 5.94 Treatments: 5.94 Interaction: 13.28
Dates: 5.99 Treatments: 5.99 Interaction: 13.40

Table (5): Effect of coating treatments on fruit total sugars content (%) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	19.31	21.04	23.12	24.18	26.31	22.79
Starch	20.94	22.17	24.55	25.52	27.17	24.07
Olive oil	19.13	20.15	23.17	23.93	25.95	22.46
Sodium B.	19.92	21.47	23.51	24.58	26.76	23.25
Beeswax	19.54	21.14	23.15	24.31	26.56	22.94
Mean	19.77	21.19	23.50	24.50	26.55	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	**5**	**9**	**13**	**17**	
Control	19.48	21.23	23.33	24.40	26.55	23.00
Starch	21.13	22.37	24.77	25.75	27.41	24.29
Olive oil	19.30	20.33	23.38	24.15	26.18	22.67
Sodium B.	20.10	21.66	23.72	24.80	27.00	23.46
Beeswax	19.71	21.33	23.36	24.53	26.80	23.15
Mean	19.95	21.38	23.71	24.73	26.79	

LSD value at 0.05:
Dates: 0.07 Treatments: 0.07 Interaction: 0.15
Dates: 0.07 Treatments: 0.07 Interaction: 0.15

Table (6): Effect of coating treatments on fruit Ethylene production (%) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	4.96	5.57	6.87	19.63	17.00	10.81
Starch	5.48	5.33	6.57	20.97	17.99	11.27
Olive oil	4.37	4.87	6.07	18.25	16.65	10.04
Sodium B.	4.11	4.61	5.65	20.19	17.60	10.43
Beeswax	3.98	4.49	5.43	20.01	17.45	10.27
Mean	4.58	4.98	6.12	19.81	17.34	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	**5**	**9**	**13**	**17**	
Control	5.01	5.62	6.93	19.81	17.15	10.90
Starch	4.82	5.38	6.63	21.16	18.15	11.23
Olive oil	4.41	4.92	6.28	18.41	16.80	10.16
Sodium B.	4.15	4.66	5.70	20.37	17.76	10.53
Beeswax	4.02	4.53	5.48	20.19	17.61	10.37
Mean	4.48	5.02	6.20	19.99	17.49	

LSD value at 0.05:
Dates: 0.09 Treatments: 0.09 Interaction: 0.20
Dates: 0.07 Treatments: 0.07 Interaction: 0.15

Table (7): Effect of coating treatments on fruit respiration rate (ml CO_2 /kg/h) of Naomi mango cv. Stored at room temperature (2017 & 2018 seasons)

Treatments	Season 2017 (Storage days)					Mean
	0	5	9	13	17	
Control	55.33	61.49	63.85	1.47	1.74	36.78
Starch	54.35	60.37	62.75	0.77	0.94	35.84
Olive oil	52.34	58.09	60.32	1.58	1.94	34.85
Sodium B.	50.37	55.86	58.15	1.38	1.71	33.50
Beeswax	48.38	53.67	55.83	1.40	1.73	32.20
Mean	52.16	57.90	60.18	1.32	1.61	
Treatments	**Season 2018 (Storage days)**					**Mean**
	0	**5**	**9**	**13**	**17**	
Control	55.83	62.04	64.42	1.48	1.76	37.11
Starch	54.84	60.91	63.32	0.78	0.95	36.16
Olive oil	52.81	58.61	60.86	1.60	1.96	35.17
Sodium B.	50.82	56.36	58.68	1.39	1.73	33.80
Beeswax	48.82	54.15	56.33	1.41	1.75	32.49
Mean	52.63	58.42	60.72	1.33	1.63	

LSD value at 0.05:
Dates: 0.78 Treatments: 0.78 Interaction: 0.18
Dates: 0.08 Treatments: 0.08 Interaction: 0.18

1997; Campestre *et al.,* 2002).

Fruit titratable acidity

Data in Table (4) show a significant increase in mango fruit acidity with prolonging storage period at room temperature. Dipping treatment with Olive oil was supremacy in maintaining fruit acidity after seventeen storage days at room temperature in both studied seasons. At the end of storage, the least fruit acidity values were recorded with the Control (25.74 and 25.74%), contrarily were the values of the Olive oil treatment as it recorded the highest (31.14and 31.14%) in both seasons, respectively. The slowing down of the ripening process by the olive oil dipping material kept the titratable acidity high for longer time (Wing *et al.,* 1988; Sumnu and Bayindirli 1995; Herianus *et al.,* 2003; Ribeiro *et al.,* 2007; Baloch *et al.,* 2011b). Waskar and Roy (1992) stated that the acid content in fruits during ripening depends upon the proton transfer process as the fruits ripen. Therefore, the lower acidity in untreated fruits might be resulting from an excess transfer of proton during ripening.

Total sugar

Data in Table (5) show a significant increase in mango fruit total sugars with prolonging storage period at room temperature. Dipping treatment with starch was supremacy in maintaining fruit total sugars, after seventeen storage days at room temperature in both studied seasons. Data in the table revealed a significant interaction between storage period and treatments in both seasons. So, at the end of storage, the least fruit total sugars values were recorded with the olive oil treatment (22.46 and 22.67%), contrarily were the values of the starch treatment as it recorded the highest (24.07 and 24.29%) in both seasons, respectively. This might be due to hydrolysis of starch and accumulation of sugars (Patil and Magar, 1976 and Ngalana *et al*., 1999) and conversion of starch through the process of glucogenesis (Islam, 2009). The reason for such was that starch, being hydrophilic and antimicrobial, can penetrate or diffuse into the fruit skin easily (Garcia *et al.,* 1998a, b; Ribeiro *et al.,* 2007; Oz and Ulukanli 2012).

Ethylene

Data in Table (6) reveal a significant interaction between storage period and treatments in both seasons. So, at the end of storage, the least fruit Ethylene production values were recorded with the olive oil treatment (10.04 & 10.16%), contrarily were the values of the starch treatment as it recorded the highest (11.27 and 11.23%) in both seasons, respectively.

These observations were also supported by the ethylene evolution during the storage period of the fruit. Due to the fact that these dipping materials were also antioxidant and antimicrobial, the ethylene production, decay process and attack of diseases were reduced, resulting in longer shelf life (Kittur *et al.,* 2001; Covas 2008). These dipping materials, being hydrophobic, reduces the water losses, alters internal CO_2, O_2 and ethylene level of the fruit, and hence delays ripening and keeps the fruits in good shape.

Fruit respiration rate

Data in Table (7) show a significant increase of mango fruit respiration rate with prolonging storage period at room temperature. Using Beeswax as a dipping agent decrease fruit respiration rate than all treatments throughout storage period. Data in the table revealed a significant interaction between storage period and treatments in both seasons. So, at the end of storage, the least fruit respiration rate values were recorded with the Beeswax treatment (32.20 & 32.49ml CO_2/kg/h), contrarily were the values of the starch treatment as it recorded the highest (36.78and 37.11 ml CO_2/kg/h) in both seasons, respectively.
This is attributed to the fact that beeswax reduces the ripening process and attack of microorganisms over the fruit and then reduces the respiration rate of fruits (Khan and Abourashed 2010). The fruit dipped in beeswax showed good quality, long shelf life, reduced weight loss and waste percent, and hence can be considered as the most beneficial among the coatings used.

CONCLUSION

The present study indicates that the beeswax and olive oil dipped mango fruits had the longest shelf life with good quality, while the shelf life of undipped (control) fruit was the shortest. The total soluble solids and sugar contents were also high in starch-dipped fruit. The obtained results indicate that every coating has its impact on the quality and shelf life of the fruit and is significantly different in most of the cases under the limit of $P < 0.05$. The overall data conclude that beeswax was the best dipping material, which might be due to the fact that beeswax is an antioxidant and antimicrobial as well as hydrophobic in nature.

REFERENCE

ABBASI, K.S., ANJUM, N., SAMMI, S., MASUD, T. and ALI, S. (2011). Effect of coatings and packaging material on the keeping quality of mangoes (*Mangifera indica* L.) stored at low temperature. *Pak. J. Nutr*. 10(2), 129–138.

ABBASI, N.A., IQBAL, Z., MQBOOL, M. and HAFIZ, A.I. (2009). Post-harvest quality of mango (*Mangifera indica* L.) fruit as affected by chitosan coating. *Pak. J. Bot*. 41, 343–357.

ABD-ALLA, M.A.I. and HAGGAG, W.M. (2010). New safe methods for controlling anthracnose disease of mango (*Mangifera indica* L.) fruits caused by Colletotrichum gloeosporioides (Penz.). *J. Am. Sci*. 8(8), 361–367.

ANJUM, N., TARIQ, M. and ASIA, L. (2006). Effect of various coating materials on keeping quality of mangoes (*Mangifera indica* L.) stored at low temperature. *Am. J. Food Technol.* 1(1), 52–58.

Association of Official Agriculture Chemists (A.O.A.C),2000. *Official Methods of Analysis Chemists*. Washington, D.C., U.S.A.

BAKKALI, F., AVERBECK, S., AVERBECK, D. and IDAOMAR, M. (2008). Biological effects of essential oils – a review. *Food Chem. Toxicol*. 46, 446–475.

BALDWIN, E.A. (1994). Edible coatings for fresh fruits and vegetables: Past present, and future. In Edible Coatings and Films to Improve Food Quality (J.M. Krochta, E.A. Baldwin and M.O. Nisperos-Carriedo, eds.) pp. 25–64, *Technomic Publishing*, Lancaster, PA.

BALDWIN, E.A. (1998). Effect of coating on mango (*Mangifera indica* L.) flavor. *Proc. Fla. State Hort. Soc*. 111, 247–250.

BALDWIN, E.A., BURNS, J.K., KAZOKAS, W., BRECHT, J.K., HAGENMAIER, R.D., BENDER, R.J. and PESIS, E. (1999). Effect of two edible coatings with different permeability characteristics on mango (*Mangifera indica* L.) ripening during storage. *Postharvest Biol. Technol*. 17, 215–226.

Ben-Yehoshua S., Beaudry, R.M., fishman S., Jayanty S., Mir. (2005). Modified atmosphere packaging and controlled atmosphere storage, In, Environmentally friendly technology for agricultural produce quality. Ben Yehoshua, S. Ed. Taylor and Francis Group LLC. Boca Raton, FL, USA. 61-102.

CARRILLO-LOPEZ, A., RAMIREZ-BUSTAMANTE, F., VALDEZ-TORRES, J.B., ROJAS-VILLEGAS, R. and VAHIA, E.M. (2000). Ripening and quality changes in mango fruit as affected by coating with an edible film. *J. Food Qual.* 23(5),479–486.

COMES, J.E. and BEELMAN, R.B. (2002). Addition of fumaric acid and sodium benzoate as an alternative method to achieve a 5-log reduction of Escherichia coli O157:H7 populations in apple cider. *J. Food Prot.* 65(3), 476–483.

COVAS, M.I. (2008). Bioactive effects of olive oil phenolic compounds in humans: Reduction of heart disease factors and oxidative damage. *Inflammopharmacology* 16(5), 216–218.

DANG, K.T.H., SINGH, Z. and SWINNY, E.E. (2008). Edible coatings influence fruit ripening, quality and aroma biosynthesis in mango fruit. *J. Agric. Food Chem.* 56, 1361–1370.

Degani, C., R. E1-Batsri, and S. Gazit. (1990).

Enzymepolymorphism in mango. J. Amer. Soc.Hort. Sci. 115:844–847.

DIAZ-SOBAC, R., LUNA, A.V., BERISTAIN, C.I., DELACRUZ, J. and GARCIA, H.S. (1996). Emulsion coating to extend postharvest life of mango (*Mangifera indica* cv. Manila). *J. Food Process*. Preserv. 20(3), 191–202.

FEYGENBERG, O., HERSHKOVITZ, V., BEN-ARIE, R., JACOB, S., PESIS, E. and NIKITENKO, T. (2005). Postharvest use of organic coating for maintaining bio-organic avocado and mango. *Acta Hortic*. 682, 507–512.

GARCIA, M.A., MARTINO, M.N. and ZARITZKY, N.E. (1998a). Starch based coatings: Effect on refrigerated strawberries (Frageria x Ananassa). *J. Sci. Food Agric.* 76, 411–420.

GARCIA, M.A., MARTINO, M.N. and ZARITZKY, N.E. (1998b). Plasticizer effect on starch-based coatings: Applied on strawberry (Frageria x Ananassa) quality. *J. Sci. Food Agric.* 76, 411–420.

HAGENMAIER, R.D. and BAKER, R.A. (1993). Reduction in gas exchange of citrus fruit by wax coatings. *J. Agric. Food Chem*. 46, 3758–3767.

HOA, T.T. and DUCAMP, M.N. (2008). Effects of different coatings on biochemical changes of "cat Hoa loc" mangoes in storage. *Postharvest Biol. Technol*. 48, 150–152.

HOA, T.T., DUCAMP, M.N., LEBRUN, M. and BALDWIN, E.A. (2002). Effect of different coating treatments on the quality of mango fruit. J. Food Qual. 25, 471–486.

HOA, T.T., DUCAMP, M.N., LEBRUN, M. and BALDWIN, E.A. (2002). Effect of different coating treatments on the quality of mango fruit. *J. Food Qual.* 25, 471–486.

Islam M. N.,.Molla M. M, Nasrin T.A.A, Uddin A.F.M.M and Bhuyan M. A. J. (2009). Determination of maturity indices of ber (zizyphusmauritiana lam.) var. bari kul-2. Annual report, HRC, BARI, Gazipur.P.143

Kader A.A. (2002). Postharvest Technology Horticultural Crops. 3rd Edition. University of California. *Agriculture and Natural Resources.* 163–195.

KETSA, S. and PRABHASAVAT, T. (1992). Effect of skin coating on shelf life and quality of "Nang Klanwan" mangoes. *Acta Hortic*. 321, 764–770.

KITTUR, F.S., SAROJA, N., HABIBUNNIS, A. and THARANATHAN, R.N. (2001). Polysaccharide-based composite coating formulations for shelf-life extension of fresh banana and mango. *Eur. Food Res. Technol*. 213, 306–311.

Lurie, S. and E. Pesis, 1992. Effect of acetaldehyde and anaerobiosis as post-harvest treatment on the quality of peaches and nectarines. *Postharvest Biol. Technol.,* 1: 317-326.

Mahomud .M.S., Alam, M.R., Islam, M.A., Ali, M.A. and Amin, M.R. (2010). Effect of Temperature and Humidity on Shelf Life of Ripe Mangoes. *Bangladesh Research Publication Journal*, 3(4), 1193-1196.

MALIK, A.U. and SINGH, Z. (2005). Pre-storage application of polyamines improves shelf-life and fruit quality of mango. *J. Hortic. Sci. Biotechnol.* 80, 363–369.

MARTINEZ-ROMERO, D., ALBURQUERQUE, N., VALVERDE, J.M., GUILLEN, F., CASTILLO, S., VALERO, D. and SERRANO, M. (2006). Postharvest sweet cherry quality and safety maintenance by aloe vera treatment: A new edible coating. *Postharvest Biol. Technol*. 39(1), 93–100.

Ngalani, J.A; J.T. Tchango and M. Reynes. (1999). Starch and Sugar transformation during ripening of banana and plantain cultivars grown in cameroon. *Trop.Sci.* 39:115-119

Patil D.L. and Magar N.G. (1976). Physiochemical changes in banana fruit during ripening. *J. Maharastra Agric*. Univ.1:95-99.

REGNIER, T., DUPLOOY, G.W., COMBRINCK, S. and BOTHA, B.M. (2008). Fungitoxicity of Lippiascaberrima essential oil and selected terpenoid components on two mango postharvest spoilage pathogens. Postharvest *Biol. Technol.* 48, 254–258.

Snedecor, G.W. and W.G. Cochran, (1980). Statistical Methods. 7th Edn. Iowa State Univ. Press Ames. Low USA

SRINIVASA, P.C., SUSHEELAMMA, N.S., RAVI, R. and THARANATHAN, R.N. (2004). Quality of mango fruits during storage: Effect of synthetic and eco-friendly films. *J. Sci. Food Agric*. 84, 818–824.

STANOJEVIC, D., COMIC, L., STEFANOVIC, O. and SOLUJIC-SUKDOLAK, S. (2009). Antimicrobial effects of sodium benzoate, sodium nitrite and potassium sorbate and their synergistic action in vitro. Bulg.. 15(4), 307–311.

J. Agric. Sci SUMNU, G. and BAYINDIRLI, L. (1995). Effects of sucrose polyester coating on fruit quality of apricots. *J. Sci. Food Agric*. 67, 537–540.

Waskar, D.P. and Roy S.R. (1992). Post-harvest ripening changes in banana-a review. *Agric. Rev.* 13(1): 36-42.

ZENG, K.F., CAO, J.K. and JIANG, W.B. (2006). Enhancing disease resistance in harvested mango (*Mangifera indica* L. cv. "Matisu") fruit by salicylic acid. *J. Sci. Food Agric*. 86, 694–698.

ZHU, X., WANG, Q., CAO1, J. and JIANG, W. (2008). Effects of chitosan coating on postharvest quality of mango (*Mangifera indica* L. cv. Tainong) fruits. *J. Food Process. Preserv*. 32,770–784.