



## RESEARCH ARTICLE

## EFFECTS OF DIFFERENT CONCENTRATIONS OF CHITOSAN ON SHELF LIFE AND QUALITY OF MANGO

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## ABSTRACT

An experiment was carried out at the Laboratory of the Department of Horticulture, BAU, Mymensingh during the period from March to October, 2017 to find out suitable concentration of chitosan on shelf life and quality of mango. The experiment was consisted of six concentrations of chitosan (control; and chitosan coating at the rates of 0.5, 0.75, 1.0, 1.5 and 2%) and the experiment was laid out in a completely randomized design with three replications. Results revealed that weight loss was minimum (11.23%) in fruits treated with 1.5% chitosan, while it was the maximum (12.76%) in fruits coated with 0.75% chitosan. The changes in colour were faster with 1% chitosan coated mango, whereas the changes were slower with 0.5% chitosan. Firmness were faster in mangoes coated with 1% chitosan whereas were slower which coated with 1.5% and 2.0%. There were no visible diseases until day 4 of storage and Shelf life of mango was significantly extended by chitosan, and the 2% concentration outperformed rest of the treatments.

## KEYWORDS

Mango, Shelf life, Chitosan, Disease severity.

## 1. INTRODUCTION

Mango (*Mangifera indica* L.) is the most important tropical fruit crop after banana and plantains and commonly cultivated in many tropical and subtropical regions (FAO, 2012). About 250 varieties of mangoes are grown in Bangladesh and in terms of total production, Bangladesh ranks eight (10,47,850 tones) among the worldwide production (Shafique, 2006; FAOSTAT, 2013). The mango is indigenous to the Indian Subcontinent for 4000 years. Asia is the main producer with 76.9% of the total world production, followed by USA with 13.38%, Africa with 9% and less than 1% each for Europe and Oceania (Sauco, 2002). In terms of total production of mango, Bangladesh ranks eight among the worldwide production. The world top ten mango growing countries are India (1,63,37,400 tones), China (43,51,593 tones), Thailand (25,50,600 tones), Pakistan (17,84,300 tones), Mexico (16,32,650 tones), Indonesia (1,313,540 tones), Brazil (1,188,910 tones) Bangladesh (10,47,850 tones), Philippines (8,23,576 tones) and Nigeria (7, 90, 200 tones) (FAOSTAT, 2013). In Bangladesh, mango ranks first in terms of area and third in terms of production. In 2015-16, it occupied 132,590.39 hectares of land and total production is 1161.68 thousand metric tons whereas, in 2010 the area and production of mango were 132,000 ha and 1047 thousand metric tons, respectively (BBS, 2017; BBS, 2011).

In Bangladesh at present, mango occupied 25.22% garden area under fruits. In 2017-18, it occupied 109584 acres of land and total production is 1165804 metric tons whereas, in 2015 the area and production of mango were 93480 acres and 1161685 metric tons, respectively (BBS, 2019). In spite of adequate flowering, low fruit yield in mango orchards have been experienced because of low initial fruit set and subsequently higher fruit let abscission (Singh and Singh, 1995). Fruit let abscission is a very complex physiological process, occurs in many cultivars of mango and at all stages of development, but it is particularly high during the first 3-4 weeks after pollination and accounts for over 90 % loss of fruit lets (Bains et al., 1997; Wahdan et al., 2011). The use of growth substances and some chemical compounds may regulate fruit set in mango.

Mango is a climacteric fruits, so it is necessary to study and understand the shelf life of mango under different treatments to mitigate the postharvest losses. Shelf life of mango indicates the period between the time of harvest and time of start of rotting of fruits. It is a determining factor for marketing and industrial processing. Due to mishandling, inadequate storage or lack of postharvest technical knowledge, producers and traders have to face about 27% losses (Hassan et al., 2010). A worldwide increase in the demand of fresh mango fruit is being observed, increasing the prospect for the producing countries (Amin et al., 2007). The mango is very popular fruit with the masses due to its wide range of adaptability, high nutritive

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value and richness in variety, delicious taste and excellent flavour. Mango helps to prevent many deficiency diseases because it is a rich source of vitamins, minerals and total soluble solids.

Now-a-days, very few fruitful techniques are available in Bangladesh to prolong shelf life of mango. Hence, it is necessary to understand the postharvest quality attributes of mango in order to develop and apply adequate postharvest technologies. Use of coating materials may play an important role in extending shelf life of mango by reducing physiological processes and microbial decay. There might be reports that chitosan may be useful to extend shelf life. Concentration of chitosan concerning mango on postharvest quality are very scanty in the scientific literature in Bangladesh. At the same time, very little systematic study has so far been conducted in Bangladesh to reduce the postharvest losses and extension of shelf life of mango. Therefore, this present study was aimed to find out suitable concentration of chitosan to prolong shelf life to reducing postharvest loss and confirming the standard quality of mango for its high marketing value.

## 2. MATERIALS AND METHODS

The experiments were conducted to achieve the objective of the study. The materials and methods are separately presented in the following.

### 2.1 Experimental Location

The experiments were carried out at the laboratories of the Department of Horticulture and the Department of Biochemistry and Molecular Biology, Bangladesh Agricultural University, Mymensingh during the period of month July, 2017. The temperature and relative humidity of the storage room were recorded during this period.

### 2.2 Experimental materials

The experimental materials were mature hard fruits of mango variety named Harivanga. Mango used in the experiment was collected from the orchard of mango grower, Bodorgong on 6 July 2017. Maturity of mangoes was indicated when the shoulders were in line with the stem end and the color was olive green. Maturity was also judged by the grower's recommendation.

### 2.3 Experimental treatments

This experiment was aimed at finding out suitable concentration of chitosan to extend shelf life and maintain quality of mango. The experimental treatments comprised:

T<sub>0</sub>: Control,

T<sub>1</sub>: Mangoes coated with 0.5% chitosan,

T<sub>2</sub>: Mangoes coated with 0.75% chitosan,

T<sub>3</sub>: Mangoes coated with 1.0% chitosan

T<sub>4</sub>: Mangoes coated with 1.5% chitosan,

T<sub>5</sub>: Mangoes coated with 2.0% chitosan.

### 2.4 Experimental design

The single-factor experiment was laid out in the completely randomized design with three replications of 3 fruits. A total of 54 fruits of more or less similar shape and size and free of visible disease symptoms were harvested. The skin adherences, dots and latex were cleaned by gently wiping the fruits with moist and clean towel. There were 6 treatment combinations. Each treatment combination comprised 9 fruits.

### 2.5 Methods of application of postharvest treatments

The postharvest treatments were randomly assigned to the experimental fruits. The treated fruits were kept on brown papers that were previously placed on laboratory table at ambient condition. 54 fruits were randomly divided to place 9 fruits in each treatment for this experiment. Then the fruits were subjected to the following Modified Atmosphere treatments as

per the experimental design.

#### 2.5.1 Control

Fruits were randomly selected from the lot and the fruits were kept on brown paper placed on the laboratory table at ambient conditions.

#### 2.5.2 Chitosan treatment

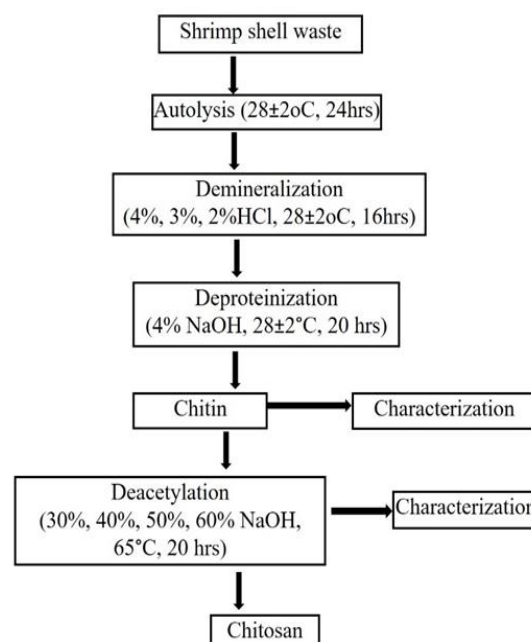
Five concentrations of chitosan (0.50, 0.75, 1.0, 1.5 and 2.0% solution) were prepared.

### 2.6 Preparation of chitosan

Fresh shrimps are collected at first. Shrimp head and skin are separated from shrimp using sharp knife. The collected shrimp shell wastes are then washed with tap water and crushed with mortar pestle. Crushed shrimp shell wastes are kept in a polyethylene bags at ambient temperature ( $28\pm 2^{\circ}\text{C}$ ) for 24 hours for partial autolysis to facilitate chemical extraction of chitosan and to improve the quality of chitosan (Taon, 2009). There are mainly 3 (three) steps, namely Demineralization, Deproteinization and Deacetylation are followed for the isolation of chitosan. The procedure of isolating chitosan from fresh shrimp shell is given below.

### 2.7 Preparation and application of chitosan solution

Using shrimp shell Chitosan 0.50%, 0.75%, 1.0%, 1.5% and 2.0% solutions were prepared using 0.6% acetic acid, adding 25% glycerol (w/w chitosan) as plasticizer. Each of the solutions was thoroughly mixed, filtered and the pH was adjusted to 5.6 using 1M sodium hydroxide.



**Figure 1:** Flow chart showing traditional method of production of chitin and chitosan from shrimp (Toan, 2009).

Washed and air-dried mango fingers were dipped into the solution for five minutes ensuring that enough quantity the solution was being absorbed. Uncoated mangoes (control samples) were immersed in a 0.6% glacial acetic acid solution at pH 5.6 for the same duration of time. The treated and control samples were dried in ambient conditions ( $26\pm 2^{\circ}\text{C}$  and 40-50% relative humidity). Then, the treated samples control and coated mangoes were kept at ambient conditions in the laboratory.

### 2.8 Parameters studied

In this experiment the following parameters were studied i.e. colour, firmness, weight loss, disease severity and shelf life.

### 2.9 Observation

During the entire period of storage, the fruits used in the experiment were

observed every day. Data were recorded during storage is influenced by different postharvest treatments and varieties.

## 2.10 Methods of studying parameters listed earlier

### 2.10.1 Colour

Days required to reach different stages of colour during storage and ripening were determined objectively using numerical rating scale of 1-6, where 0 = <10% yellow; 1 = 10-30% yellow; 2 = 30-50% yellow; 3 = 50-75% yellow; 4 = 75-100% yellow; 5 = Blackened/ rotten.

### 2.10.2 Firmness

Days required to reach different stages of firmness during storage and ripening were determined using numerical rating scale of 1-6, where 1 = Hard green, 2 = Sprung, 3 = Between sprung and eating ripe, 4 = Eating ripe, 5 = Over ripe, 6 = rotten. Similar rating scale was used (Hassan, 2006).

### 2.10.3 Estimation of total weight loss

The fruits of each treatment were individually weight by using electric balance and kept for storage. Percent total weight loss was calculated at an interval of 3 days during storage by using the following formula (Thenkabail and Lyon, 2016):

$$\text{Weight loss (\%)} = \frac{IW-FW}{IW} \times 100$$

Where,

IW= Initial fruit weights (g) and

FW= Final fruit weight (g).

### 2.10.4 Disease severity

Disease severity represents the percent diseased portion of the infested mango fruit. The percentage of fruit skin diseased was recorded five times starting at the 3 days after storage. All the infected fruits were selected to determine percent fruit area infected. The percentage of fruit area diseased was measured based on eye estimation. The mean values regarding infected fruit area were calculated.

### 2.10.5 Estimation of shelf life

Shelf life of mango fruits as influenced by variety & different postharvest storage treatments was calculated by counting the days required to ripe fully as to retaining, optimum marketing and eating qualities.

## 2.11 Statistical analysis

The collected data were statistically analyzed by Analysis of Variance (ANOVA) tests. The mean of different parameters was compared by DMRT (Duncans' Multiple Range Test) as described (Gomez and Gomez, 1984). The collected data on various parameters were statistically analyzed using MSTAT statistical package. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was performed by F-test. The significance of difference between the pairs of means was compared by least significant difference (LSD) test at the 1% and 5% levels of probability (Gomez and Gomez, 1984).

## 3. RESULTS

This chapter comprises the presentation of the results obtained from the present investigation. The data were recorded every day on shelf life and quality of mango. Results are presented as follows.

### 3.1 Colour

Significant variation was observed in respect of colour changes of mango during storage and ripening. The changes in colour were faster (scores 1.0, 1.0, 1.33, 4.33, 6.00, 6.00, 6.00, and 6.00) in mangoes coated with 1% chitosan, whereas the changes were slower (scores 1.00, 1.00, 1.00, 1.00, 3.00, 4.33, 4.33, 4.67) in those mangoes coated with 0.5% chitosan (Table 1).

Concentration of chitosan (%)	Colour scores <sup>A</sup> of mango at different days after storage							
	1	2	3	4	5	6	7	8
T <sub>0</sub> (Control)	1.00	1.00	1.33	3.00	4.33	4.33	6.00	6.00
T <sub>1</sub> (0.5% chitosan)	1.00	1.00	1.00	1.00	3.00	4.33	4.33	4.67
T <sub>2</sub> (0.75% chitosan)	1.00	1.00	1.33	1.33	3.00	4.33	6.00	6.00
T <sub>3</sub> (1% chitosan)	1.00	1.00	1.33	4.33	6.00	6.00	6.00	6.00
T <sub>4</sub> (1.5% chitosan)	1.00	1.00	1.33	1.33	3.00	3.00	4.67	6.00
T <sub>5</sub> (2% chitosan)	1.00	1.00	1.00	1.00	1.00	2.67	6.00	6.00
LSD <sub>0.05</sub>			0.06	0.19	0.42	0.42	0.22	0.11
LSD <sub>0.01</sub>			0.09	0.27	0.59	0.59	0.31	0.15
Level of significance			**	**	**	**	**	**

<sup>A</sup>Colour Scores: 1 = 0- <10% yellow; 2 = 10- <30% yellow; 3 = 30- <50% yellow; 4 = 50- <75% yellow; 5 = 75-100% yellow; 6 = Blackened/ rotten.

\* Significant at 5% level of probability; \*\* Significant at 1% level of probability.

### 3.2 Firmness

Statistically highly significant variation was observed in respect of firmness of mango during storage. Faster rates of firmness (Scores 1.00, 1.00, 2.00, 4.33, 6.00, 6.00, 6.00, 6.00 and 6.00) were found in mangoes coated with 1% chitosan. On the contrary, the rates of firmness changes were slower in mango fruits coated with 1.5% (1.00, 1.00, 1.33, 3.33, 4.67, 4.67, 5.67, 6.00, and 6.00) and 2.0% (1.00, 1.00, 2.00, 3.00, 4.00, 4.67, 6.00, 6.00, and 6.00) chitosan (Table 2).

### 3.3 Weight loss of mango

Postharvest coating of mango fruits with chitosan caused significant variation in respect of total weight loss increase with the advancement of storage period. Weight losses were found to be higher in mangoes treated with higher concentrations of chitosan as compared to those coated with lower concentrations of chitosan as well as the untreated control. The highest weight loss (12.76%) was observed in mangoes coated with 0.75% chitosan at the 8<sup>th</sup> day of storage, whereas the lowest weight loss (11.23%) was observed in fruits coated with 1.5% chitosan at the same day of storage (Table 3). Among the chitosan concentrations, 1.50% resulted in the best in terms of controlling weight loss of mango during storage.

Concentration of chitosan (%)	Firmness scores <sup>A</sup> of mango at different days after storage								
	1	2	3	4	5	6	7	8	9
T <sub>0</sub> (Control)	1.00	1.00	1.67	4.00	5.00	5.33	5.67	6.00	6.00
T <sub>1</sub> (0.5% chitosan)	1.00	1.00	2.00	3.00	4.67	5.67	5.67	5.67	6.00
T <sub>2</sub> (0.75% chitosan)	1.00	1.00	2.00	3.00	5.33	5.67	5.67	6.00	6.00
T <sub>3</sub> (1% chitosan)	1.00	1.00	2.00	4.33	6.00	6.00	6.00	6.00	6.00
T <sub>4</sub> (1.5% chitosan)	1.00	1.00	1.33	3.33	4.67	4.67	5.67	6.00	6.00
T <sub>5</sub> (2% chitosan)	1.00	1.00	2.00	3.00	4.00	4.67	6.00	6.00	6.00
LSD <sub>0.05</sub>			0.06	0.22	0.31	0.30	0.08	0.08	0.06
LSD <sub>0.01</sub>			0.08	0.31	0.43	0.42	0.11	0.11	0.08
Level of significance			**	**	**	**	**	*	

<sup>A</sup> Firmness scores: 1 = Hard green, 2 = Sprung, 3 = Between sprung and eating ripe, 4 = Eating ripe, 5 = Over ripe, 6 = rotten.

\* Significant at 5% level of probability; \*\* Significant at 1% level of probability.

### 3.4 Disease Severity

There were no visible diseases until day 4 of storage. After that, disease started to become visible, and there were significant variation among the treatments. At the 10<sup>th</sup> day of storage, the lowest disease severity (45%) was observed in fruits coated with 2% chitosan, whereas the level was the highest in the case of 1% chitosan (Table 4) and 2% chitosan performed the best in keeping the disease level down throughout the storage period followed by 1.5% (Table 4).

**Table 3:** Effect of chitosan treatments on percent weight loss of mango (cv. Harivanga) at different days after storage

Concentration of chitosan (%)	Weight loss (%) at different days after storage							
	0	2	3	4	5	6	7	8
T <sub>0</sub> (Control)	285.67	2.10	3.42	5.52	6.87	9.07	10.64	12.75
T <sub>1</sub> (0.5% chitosan)	264.00	1.90	3.79	6.19	7.46	9.36	10.12	12.39
T <sub>2</sub> (0.75% chitosan)	256.33	1.97	3.79	5.49	7.05	9.14	10.43	12.76
T <sub>3</sub> (1% chitosan)	277.33	1.44	3.01	4.91	6.37	8.96	10.58	12.44
T <sub>4</sub> (1.5% chitosan)	258.33	1.91	3.46	5.27	6.96	8.61	9.66	11.23
T <sub>5</sub> (2% chitosan)	292.33	1.81	3.64	5.36	6.51	8.34	9.49	11.55
LSD <sub>0.05</sub>		0.15	0.20	0.27	0.25	0.12	0.19	0.32
LSD <sub>0.01</sub>		0.21	0.28	0.38	0.34	0.17	0.26	0.45
Level of significance		**	**	*	*	**	**	**

\*\* = Significant at 1% level of probability, \* = Significant at 5% level of probability

**Table 4:** Effect of chitosan treatments on percent disease severity of mango (cv. Harivanga) at different days after storage

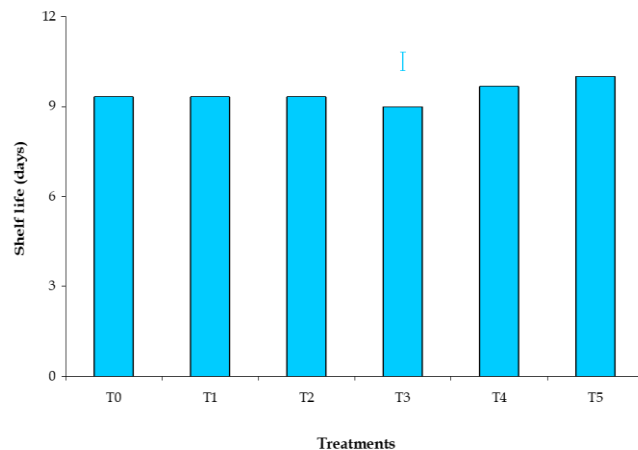
Concentration of chitosan (%)	Disease severity (%) at different days after storage									
	1	2	3	4	5	6	7	8	9	10
T <sub>0</sub> (Control)	0.00	0.00	0.00	0.00	8.33	9.67	18.33	32.67	56.67	65.00
T <sub>1</sub> (0.5% chitosan)	0.00	0.00	0.00	0.00	5.00	8.00	15.00	23.33	43.33	51.67
T <sub>2</sub> (0.75% chitosan)	0.00	0.00	0.00	0.00	3.33	5.33	16.67	22.67	48.33	58.33
T <sub>3</sub> (1% chitosan)	0.00	0.00	0.00	0.00	18.33	25.00	46.67	66.67	85.00	91.67
T <sub>4</sub> (1.5% chitosan)	0.00	0.00	0.00	0.00	6.67	10.00	23.33	33.33	41.67	48.33
T <sub>5</sub> (2% chitosan)	0.00	0.00	0.00	0.00	0.00	1.67	10.67	16.67	31.67	45.00
LSD <sub>0.05</sub>					1.27	2.07	2.87	3.79	6.24	5.01
LSD <sub>0.01</sub>					1.78	2.91	4.03	5.32	8.75	7.03
Level of significance	ND	ND	ND	ND	**	**	**	**	**	**

\* Significant at 5% level of probability; \*\* Significant at 1% level of probability.

ND Statistical analysis not done.

### 3.5 Shelf life

Shelf life was significantly influenced by chitosan treatments (Figure 2). The longest shelf life (10 days) was recorded in mangoes coated with the highest concentration of chitosan (2.0%) followed by 1.5% (9.67 days).



**Figure 2:** Effect of chitosan on shelf life of mango. The vertical bar represents LSD at 1% level of significance.

T<sub>0</sub> = Control, T<sub>1</sub> = 0.5% chitosan, T<sub>2</sub> = 0.75% chitosan, T<sub>3</sub> = 1% chitosan, T<sub>4</sub> = 1.5% chitosan, T<sub>5</sub> = 2% chitosan

\* Significant at 5% level of probability; \*\* Significant at 1% level of probability.

## 4. DISCUSSIONS

Colour is one of the most important criteria of quality of most fruits. The changes in colour of mango peel green to breaker are the most obvious changes which occur during storage of fruits. Change of peel colour during ripening and senescence of fruits involves chlorophyll degradation or qualitative and quantitative alternation of the green pigment into other pigments. During colour change the pulp becomes softer and sweeter as the ratio of the sugar to starch increased and the characteristic aroma is produced. Longer period was required for 0.5% chitosan treated fruits than others to reach different stages of ripening. These findings were observed who reported that the green peel colour of mature Alphonso and other varieties of mango turned from light green or green or dark green to light yellow or yellow or orange yellow due to the breakdown of chlorophyll due to a series of physico-chemical changes during ripening, leading to disappearance of green colour (Doreyappa and Huddar, 2001). The changes in colour were faster in mangoes coated with 1% chitosan, whereas the changes were slower in those mangoes coated with 0.5% chitosan. The result of the present study is also supported by the findings (Robinson, 1996). He stated that during colour changes, the pulp of the fruit became softer and sweeter as the ratio of sugars to starch increased and the characteristic aroma was produced.

Firmness is important criteria of fruits quality. The firmness of mango pulp from hard to eating ripe is obvious changes which occur during storage. With the change firmness the pulp become softer and sweeter as the ratio of the sugar to starch increases and characteristic aroma is produced. Faster rates of firmness were found in mangoes coated with 1% chitosan. On the contrary, the rates of firmness changes were slower in mango fruits coated with 1.5% and 2.0% chitosan. The firmness of mango changes due to conversion of starch into sugars.

The weight loss increased with the advancement of storage period. Weight losses were found to be higher in mangoes treated with higher concentrations of chitosan as compared to those coated with lower concentrations of chitosan as well as the untreated control. These results are in agreement with those of who observed that coated or uncoated Haden mango in Mexico had an increasing trend of weight loss with the passage of storage time (Carrillo et al., 2000). However, weight loss was lower in coated fruits (4.0 to 6.5%) as compared to control having higher percent weight loss (0.00 to 9.0%). These results are further in line with who observed that mature green Alphonso and other 7 varieties of mango fruits were influenced by size of fruit, storage temperature, variety and the reduction in length and thickness of fruits during ripening process were attributed to shrivelling of fruits due to higher percent loss of water

(12.8%) from fruits when stored at high temperature (18-34°C) (Doreyappy and Huddar, 2001). A group researcher also observed that weight loss in Avocado fruit was linear with the storage temperature (Perez et al., 2004).

Results disease severity revealed that 2% chitosan performed the best in keeping the disease level down throughout the storage period followed by 1.5% chitosan. At the 10<sup>th</sup> day of storage, the lowest disease severity (45%) was observed in fruits coated with 2% chitosan, whereas the level was the highest in the case of untreated control and 1% chitosan. The increase in percent disease severity observed in the present study is in support of the findings (Benitez et al., 2006; Nyanjage et al., 1998). They stated that treated fruits showed lower disease severity than untreated fruits.

Shelf life is the basic quality of fruits which helps long marketing time and it is the most important aspect in loss reduction of fruits. The extension of shelf life of fruit has been one of the prime concerns of marketing throughout the record of history. Similar results were found by Salunkhe and Desai (Salunkhe and Desai, 1984). The longest shelf life (10 days) was recorded in mangoes coated with the highest concentration of chitosan (2.0%) followed by 1.5% (9.67 days). The findings of the present study agree with the reports (Cheema et al., 1939). They tried that various wrappers such as polythene, cellophane, tissue paper and parafilm tried to prolong the storage life of mangoes.

## 5. SUMMARY

The experiments were carried to find out the suitable concentration of chitosan to increasing shelf life and quality of mango. Shelf life of mango was significantly extended by chitosan and the 2% concentration performed best rather than other treatments. Significant variation also observed in respect of colour changes of mango during storage and ripening. The changes in colour were faster in mangoes coated with 1% chitosan, whereas the changes were slower in those mangoes coated with 0.5% chitosan. Coated with 1% chitosan is very much responsible for faster rates of firmness. On the contrary, the rates of firmness changes were slower in mango fruits coated with 1.5% chitosan. Chitosan concentrations 1.50% resulted best in terms of controlling weight loss of mango during storage. On the other hand, highest weight loss was observed in mangoes coated with 0.75% chitosan. Lower disease severity was found in 2% chitosan throughout the storage period followed by 1.5% chitosan and higher disease severity was found in 1% chitosan throughout the storage period.

## 6. CONCLUSION

Mango is acknowledged as the king of fruit and one of the best fruits in the world market because of its great utility, excellent flavor, attractive fragrance and beautiful shades of colour, delicious taste and healthful value. Mango is highly perishable and postharvest loss is significant. An attempt was made to extend shelf life of mango using readily available coating materials. We suggest that the application of chitosan coating could be beneficial in extending postharvest life and maintaining quality and to some extent, controlling decay of mango fruit. The present study illustrated that, coating of 2% concentration chitosan are the promising strategy for the management postharvest fruit quality of mangoes .

However, further studies are suggested to examine the effects of other promising variety and wider range of coating materials on shelf life.

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