*Int.J.Curr.Microbiol.App.Sci* (2018) *7*(10): 2784-2790

International Journal of Current Microbiology and Applied Sciences
*ISSN: 2319-7706* **Volume 7 Number 10 (2018)**
Journal homepage: http://www.ijcmas.com

**Original Research Article** https://doi.org/10.20546/ijcmas.2018.710.323

# Ripening Behaviour of Chitosan Coated Sapota Fruits under Low Temperature Storage Condition

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**Keywords**

Sapota, Chitosan coating, Storage, Quality

**Article Info**

***Accepted:***
20 September 2018
***Available Online:***
10 October 2018

**A B S T R A C T**

Sapota (*Achras zapota* L.) is one of the tropical climacteric fruits preferred by the consumers due to its sweet taste and aroma. Fruits become ripe very quickly after harvesting due to sudden climacteric rise with high respiration rate and ethylene production. This quick ripening causes loosening the texture of fruit leads to softening of and spoilage. The short shelf life of the fruit is a marketing problem which is a major cause of huge postharvest loss of this fruit. Edible coating of fruits can reduce the ripening rate by making a thin layer above fruit surface to interfere gaseous exchange between air and fruit which ultimately reduce respiration rate and ripening. Chitosan is one such edible coating material frequently used in fruits to enhance storage life. In the present experiment solution of chitosan powder (0.5, 1.0, 1.5 and 2.0% w/v) has been prepared in 0.5% glacial acetic acid with surfactant and plasticizer. Freshly harvested and washed sapota fruits were then dipped in coating solution for 1 min followed by air drying. Fruits were then stored in controlled condition (12+1 $^{o}$C, 85-90% RH). 1.5% chitosan coating resulted best for keeping the maximum fruits (more than 75%) for 30 days under controlled condition. Chitosan coating also reduced the physiological losses in weight compared to the uncoated fruits. The same treatment has also resulted maximum retention of quality by maximum TSS, total sugar and reducing sugar.

## Introduction

Sapota (*Achras zapota* L.) is one of the tropical climacteric fruits preferred by the consumers due to its sweet taste and aroma. Fruits are mainly used as table purpose as fresh, fruit salad, milk shake or processed like squash, jam, candy etc. The fruit is very nutritious and rich in carbohydrate, calcium, phosphorus and antioxidants like beta carotene and ascorbic acid etc. In India major sapota growing states are Karnataka, Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh and West Bengal (Anon. 2017). Fruits become ripe very quickly after harvesting due to sudden climacteric rise with high respiration rate and ethylene production. The quick ripening of fruits cause loosening the texture of fruit leads to softening of and spoilage which is main cause of perishable nature of the fruit (Jagtap and Katrodia, 1998). Sapota is one of the climacteric fruit and thus the rise in respiration rate and ethylene production is very quick and high after harvest (Sankaranarayan *et al.*, 2007). High respiration results the loss of stored carbohydrate causing deterioration of fruit quality. Besides higher transpiration rate causes maximum physiological losses in weight and the fruits loss its turgidity. The short shelf life of the fruit is a marketing problem which is a major cause of huge postharvest loss of this fruit. Inspite of the considerable production of this fruit tremendous post-harvest loss (Gajanana *et al.*, 2006) is one bottleneck to the growers.

Chitosan is a linear polysacchiride of (1, 4) linked 2-amio-deoxy-β-D-glucan. It is a deacetylated derivative of chitin which is a naturally available polysaccharide (Youwei and Yinzhe, 2013). It has found to be non-toxic, biodegradable, biocompatible polysaccharide having antimicrobial and antifungal activity (Majeti and Ravi, 2000). This edible coating can form a semi permeable film above fruit surface and can reduce respiration rate by adjusting the permeability of oxygen and carbon di-oxide. It can also act as barrier to propagate harmful microbes above fruit surface thus coated fruits can be stored for longer period. Additionally chitosan coating can also reduce the transpiration loss. Considering these attributes chitosan is used as edible coating in many fruits (Mohammed, 2010). Thus the present experiment was undertaken to study the effect of chitosan coating on sapota fruits on its ripening behaviour under low temperature storage.

## Materials and Methods

Present research work has been carried out at the laboratory of Department of Horticulture & Postharvest Technology, Institute of Agriculture, Visva-Bharati University, Sriniketan, West Bengal during the year 2015-16. Following are the steps followed for the present experiment.

### Preparation of chitosan solution and treatment of fruits

Chitosan powder of different concentrations i.e. 0.5, 1.0, 1.5 and 2.0% w/v were dissolved in 100 ml of 0.5% glacial acetic acid solution. 0.1ml each of tween-80 (as surfactant) and glycerol (as plasticizer) were added to the solution. The freshly harvested fruits were washed in water dried and dipped in coating solution for 1 min followed by air drying. Fruits were then stored in controlled condition (12+1 $^{o}$C, 85-90% RH).

### Observations recorded

Different observations have been taken on each fifth day upto 35$^{th}$ day. The following are the observations have considered in the present experiment in the present study:

### Physiological losses in weight (PLW)

The physiological losses in weight of fruit mainly occur due to transpiration and respiration. It was calculated with the following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight of fruits} - \text{Final weight of fruits}}{\text{Initial weight of fruits}} \times 100$$

### Fruit pressure

Fruit pressure actually denotes the turgidity of the fruits and measured by fruit pressure tester, expressed in Kg.

### Shelf life

Number of healthy fruits out of 100 fruits was considered as the indicator shelf life for particular day. Maximum number in latest day of storage was considered maximum in storage life.

### Total Soluble Solid (TSS)

Total soluble solid of *ber* were estimated with the help of a hand refractometer. A drop of fruit juice was squeezed out and strained clear juice was instilled on the plate to record the refractometer reading, calibrated in $^{o}$ Brix at room temperature.

### Total sugar

Total sugar content of the fruit was determined by titrimetic procedures. Firstly non reducing sugar contain of pulp sample was converted into reducing sugar by acid hydrolysis. After conversion, the sugar of the aqueous solution was determined by titrating against the freshly made mixture containing equal volume of Fehling's solution.

### Reducing sugar

The reducing sugar content of the aqueous extract was determined by titrating against the Fehling's solutions as stated above.

Statistical analysis was done as per Gomez and Gomez (1984) following the standard procedure in Completely Randomized Design with seven treatments and three replication.

## Results and Discussion

Observations on physiological losses in weight, fruit pressure, total soluble solids, total sugar and reducing sugar have been taken five days interval upto 35$^{th}$ day of storage and the significant findings are as follows:

### Physiological losses in weight (PLW)

In the present experiment chitosan coating significantly reduced the physiological losses in weight (Table 1). Maximum PLW was recorded in control or non-coated fruits and it was 17.23% on 35$^{th}$ day. Minimum PLW was observed under chitosan @ 2.0% measured as 8.93% and 11.25% on 30$^{th}$ day and 35$^{th}$ day respectively. Chitosan @ 1.5% resulted 10.34% of PLW on 30$^{th}$ days of storage and 13.07% on 35$^{th}$ day. This may be due to the formation of a thin layer above the fruit surface which prevented transpiration loss to a certain limit (Macwan *et al.,* 2018). This may also be due to the formation of modified atmosphere above the fruit surface which inhibited the moisture loss and thereby physiological losses in weight (Park, 1999).

### Fruit pressure

In the present experiment chitosan coating of fruits also resulted better fruit pressure retention significantly (Table 2). Fruit pressure retention was maximum upto 30$^{th}$ day (1.98 kg) in the fruits treated with chitosan @ 1.5%. Fruit pressure has been then reduced to 1.46 kg on 35$^{th}$ day under chitosan @ 1.5%. 2.0% chitosan coating of fruits also resulted higher fruit pressure retention (1.72 kg) on 30$^{th}$ days of storage. Textural loss of fruits were observed in the fruits under no coating of chitosan and it was observed significantly minimum (1.50 kg on 30$^{th}$ day and 0.91 kg on 35$^{th}$ days of storage). The retention of fruit pressure in the coated fruits is due to slower ripening rate facilitated by the formation of modified atmosphere by chitosan coating (Vishwasrao and Ananthanarayan, 2016).

### Shelf life

Chitosan coating enhanced the shelf life of sapota fruits significantly in the present experiment (Table 3). All the treated and non-treated fruits exhibited a good shelf life (more than 80 percent fresh fruits) upto 30$^{th}$ days of storage under controlled condition. However, the fruits coated with chitosan @ 1.5%

exhibited significantly maximum shelf life (86 fresh fruits) on 30th days of storage. A sudden decrease in shelf life from 81 to 68 percent of fresh fruits from 30th day to 35th day under non-treated fruits was also noticed in the present experiment. Dey *et al.*, (2014) reported better shelf life of fruits when edible coating is applied. Menezes and Athmaselvi (2016) also reported that the edible coating can increase the shelf life of fruits. Thus the findings of the present experiment is scientifically justified by the findings of Dey *et al.*, (2014) and Menezes and Athmaselvi (2016).

## Total Soluble Solid (TSS)

In every treatment a rise in the content of total soluble solids was observed in the present experiment (Table 4). The maximum rise of TSS (23.1 $^{o}$Brix) was observed in the fruits treated with chitosan @ 1.5% on 30th days of storage.

On contrary non-coated and other chitosan coated fruits @ 0.5, 1.0 and 2.0% showed maximum rise of TSS on 25th days of storage measuring 21.9, 22.5, 21.8 and 21.3 $^{o}$Brix respectively. It indicates the slow ripening in case of chitosan coating @ 1.5% and faster ripening in other cases. Similar finding was observed by Tharanathan (2003), Dey *et al.*, (2014) and Menezes and Athmaselvi (2016).

Perhaps higher TSS in chitosan coated fruits was due to the slower respiration rate enhanced by modified atmosphere formed with chitosan layer (Park, 1999).

**Table.1** Changes in Physiological losses in weight (PLW %)

| Treatments | 1st day | 5th day | 10th day | 15th day | 20th day | 25th day | 30th day | 35th day |
|---|---|---|---|---|---|---|---|---|
| T1 (Chitosan @ 0.0%) | 0.0 | 1.25 | 3.93 | 6.55 | 8.17 | 10.42 | 14.78 | 17.23 |
| T2 (Chitosan @ 0.5%) | 0.0 | 1.20 | 2.08 | 4.26 | 6.46 | 9.55 | 12.31 | 15.94 |
| T3 (Chitosan @ 1.0%) | 0.0 | 1.01 | 1.97 | 4.67 | 5.93 | 8.80 | 11.15 | 13.53 |
| T4 (Chitosan @ 1.5%) | 0.0 | 0.95 | 1.53 | 3.96 | 5.64 | 8.88 | 10.34 | 13.07 |
| T5 (Chitosan @ 2.0%) | 0.0 | 0.78 | 1.15 | 3.48 | 5.31 | 6.88 | 8.93 | 11.25 |
| SE$\pm$M | -- | NS | 0.12 | 0.10 | 0.13 | 0.17 | 0.19 | 0.28 |
| CD (0.05) | -- | NS | 0.36 | 0.31 | 0.40 | 0.52 | 0.57 | 0.84 |

**Table.2** Changes in fruit pressure (Kg)

| Treatments | 1st day | 5th day | 10th day | 15th day | 20th day | 25th day | 30th day | 35th day |
|---|---|---|---|---|---|---|---|---|
| T1 (Chitosan @ 0.0%) | 3.56 | 3.24 | 3.03 | 2.86 | 2.51 | 2.20 | 1.50 | 0.91 |
| T2 (Chitosan @ 0.5%) | 3.49 | 3.11 | 2.95 | 2.72 | 2.45 | 2.08 | 1.57 | 0.99 |
| T3 (Chitosan @ 1.0%) | 3.50 | 3.20 | 3.05 | 2.79 | 2.46 | 2.10 | 1.63 | 0.93 |
| T4 (Chitosan @ 1.5%) | 3.51 | 3.36 | 3.11 | 2.93 | 2.67 | 2.36 | 1.98 | 1.46 |
| T5 (Chitosan @ 2.0%) | 3.46 | 3.07 | 2.97 | 2.69 | 2.32 | 2.05 | 1.72 | 1.10 |
| SE$\pm$M | NS | NS | NS | NS | NS | NS | 0.07 | 0.06 |
| CD (0.05) | NS | NS | NS | NS | NS | NS | 0.23 | 0.20 |

**Table.3** Shelf life of fruits (no. of healthy fruits)

| Treatments | 1st day | 5th day | 10th day | 15th day | 20th day | 25th day | 30th day | 35th day |
|---|---|---|---|---|---|---|---|---|
| T1 (Chitosan @ 0.0%) | 100 | 100 | 100 | 100 | 94 | 87 | 81 | 68 |
| T2 (Chitosan @ 0.5%) | 100 | 100 | 100 | 100 | 96 | 91 | 80 | 72 |
| T3 (Chitosan @ 1.0%) | 100 | 100 | 100 | 100 | 95 | 89 | 80 | 74 |
| T4 (Chitosan @ 1.5%) | 100 | 100 | 100 | 100 | 99 | 93 | 86 | 78 |
| T5 (Chitosan @ 2.0%) | 100 | 100 | 100 | 95 | 91 | 84 | 79 | 70 |
| SE+M | NS | NS | NS | NS | 0.68 | 1.24 | 1.37 | 1.26 |
| CD (0.05) | NS | NS | NS | NS | 2.05 | 3.72 | 4.11 | 3.78 |

**Table.4** Changes in total soluble solids (TSS $^{o}$Brix)

| Treatments | 1st day | 5th day | 10th day | 15th day | 20th day | 25th day | 30th day | 35th day |
|---|---|---|---|---|---|---|---|---|
| T1 (Chitosan @ 0.0%) | 7.2 | 11.8 | 15.7 | 17.5 | 19.4 | 21.9 | 20.3 | 18.6 |
| T2 (Chitosan @ 0.5%) | 7.5 | 11.0 | 14.5 | 18.1 | 20.7 | 22.5 | 21.1 | 19.3 |
| T3 (Chitosan @ 1.0%) | 7.6 | 11.4 | 14.2 | 17.2 | 18.9 | 21.8 | 20.4 | 18.7 |
| T4 (Chitosan @ 1.5%) | 7.1 | 10.5 | 13.7 | 16.5 | 19.2 | 22.7 | 23.1 | 21.6 |
| T5 (Chitosan @ 2.0%) | 7.4 | 10.8 | 13.6 | 16.9 | 19.7 | 21.3 | 19.5 | 18.0 |
| SE+M | NS | NS | 0.40 | 0.42 | 0.35 | 0.35 | 0.48 | 0.44 |
| CD (0.05) | NS | NS | 1.11 | 1.20 | 1.02 | 1.06 | 1.41 | 1.32 |

**Table.5** Changes in total sugar (%)

| Treatments | 1st day | 5th day | 10th day | 15th day | 20th day | 25th day | 30th day | 35th day |
|---|---|---|---|---|---|---|---|---|
| T1 (Chitosan @ 0.0%) | 8.3 | 9.3 | 11.8 | 13.9 | 16.8 | 15.6 | 15.2 | 13.5 |
| T2 (Chitosan @ 0.5%) | 8.0 | 8.7 | 10.1 | 10.9 | 12.3 | 14.8 | 16.0 | 15.1 |
| T3 (Chitosan @ 1.0%) | 8.1 | 9.5 | 10.4 | 11.7 | 15.5 | 16.1 | 15.7 | 15.2 |
| T4 (Chitosan @ 1.5%) | 8.2 | 8.9 | 9.7 | 10.6 | 11.9 | 14.5 | 18.2 | 17.4 |
| T5 (Chitosan @ 2.0%) | 8.3 | 10.5 | 12.7 | 16.9 | 16.1 | 15.2 | 14.3 | 13.0 |
| SE+M | NS | NS | 0.36 | 0.42 | 0.44 | 0.40 | 0.46 | 0.39 |
| CD (0.05) | NS | NS | 1.12 | 1.25 | 1.31 | 1.22 | 1.05 | 1.16 |

**Table.6** Changes in reducing sugar (%)

| Treatments | 1st day | 5th day | 10th day | 15th day | 20th day | 25th day | 30th day | 35th day |
|---|---|---|---|---|---|---|---|---|
| T1 (Chitosan @ 0.0%) | 1.5 | 2.6 | 3.3 | 5.8 | 8.3 | 7.6 | 7.0 | 6.2 |
| T2 (Chitosan @ 0.5%) | 1.6 | 2.1 | 3.2 | 4.5 | 7.3 | 7.9 | 8.7 | 6.8 |
| T3 (Chitosan @ 1.0%) | 1.3 | 1.8 | 2.6 | 3.9 | 6.7 | 8.1 | 7.5 | 7.0 |
| T4 (Chitosan @ 1.5%) | 1.7 | 2.5 | 3.6 | 5.5 | 7.1 | 8.4 | 9.7 | 8.5 |
| T5 (Chitosan @ 2.0%) | 1.4 | 2.5 | 4.4 | 7.8 | 8.4 | 7.2 | 6.5 | 6.1 |
| SE+M | NS | NS | NS | 0.41 | 0.33 | 0.30 | 0.29 | 0.30 |
| CD (0.05) | NS | NS | NS | 1.27 | 1.01 | 0.90 | 0.85 | 0.88 |

## Total sugar

As the ripening progressed with the storage of fruits under controlled condition in the present experiment the content of total sugar also increased upto the peak of ripening of sapota fruits (Table 5). The changes of total sugar content of sapota fruits as effected by chitosan coating was more or less similar with the changes in TSS of the fruits. Maximum content of total sugar (18.3%) was recorded in the fruits coated with chitosan @ 1.5% on the $30^{th}$ days of storage. However in all other treatments the peak of total sugar content of fruits were fund on $25^{th}$ days of storage which denotes the slower ripening in chitosan coating @ 1.5% and faster ripening in others. The total sugar content of fruits coated with chitosan @ 1.5% on $35^{th}$ days of storage maintained a standard of 17.4%. The finding of the present experiment is supported by the findings of Tharanathan (2003) and those of Vishwasrao and Ananthanarayan (2016).

## Reducing sugar

The perusal of the data presented in the table number, it is clear that the chitosan coating enhanced the shelf life of fruits by slowering the ripening process which has been exhibited by slow rise in reducing sugar content of sapota fruits in the present experiment (Table 6). Chitosan coating of 1.5% has shown maximum rise of reducing sugar (9.7%) of fruits on $30^{th}$ days of storage after which it has been reduced to a standard of 8.5% on $35^{th}$ days of storage indicating the longer consumability of the fruits under same treatment. Non-coated fruits exhibited faster rise in peak of reducing sugar measuring 8.3% on $20^{th}$ day of storage which further reduced to 6.2% on $35^{th}$ days of storage of sapota fruits under controlled condition.

1.5% chitosan coating resulted best for keeping the maximum fruits (more than 75%) for 30 days under controlled condition. Minimum physiological losses in weight, maximum retention of quality with respect to highest TSS, total sugar and reducing sugar in the fruits coated with chitosan @ 1.5% indicated the best treatment in the present experiment.

## Acknowledgement

Authors are thankful to Board of Research in Nuclear Sciences, Department of Atomic Energy, Govt. of India for financial assistance through research project under which the present experiment has been conducted.

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**How to cite this article:**

Prahlad Deb and Gautam, S. 2018. Ripening Behaviour of Chitosan Coated Sapota Fruits under Low Temperature Storage Condition. *Int.J.Curr.Microbiol.App.Sci.* 7(10): 2784-2790.
doi: https://doi.org/10.20546/ijcmas.2018.710.323