Journal of Crop and Weed, 10(2):43-49(2014)

Physico-chemical properties of sapota (*Manilkara achras*(Mill) Fosb.) fruits coated with corn starch

K. DEY, A. GHOSH, N. BHOWMICK, [1]A. GHOSH

Dept. of Pomology and Post Harvest Technology, [1]Dept. of Agril. Statistics, Uttar Banga Krishi Viswavidyalaya, Pundibari-736165, Cooch Behar

Received: 08-08-2014, Revised: 15-09-2014, Accepted: 28-09-2014

ABSTRACT

To study the effect of corn starch on storage life and quality of sapota fruits, an experiment was conducted during 2014 at Department of Pomology and Post-Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Coochbehar, West Bengal. The fruits were dipped on different concentrations of corn starch solutions and stored at ambient storage for assessing the different physical and bio-chemical parameters. The effectiveness of the treatments in extending fruit shelf life was evaluated by recording physiological loss in weight and other horticultural traits like colour change, length, breadth, total soluble solids, titrable acidity, total sugar, reducing sugar, phenol content and ascorbic acid content. Fruits coated with 2.5% corn starch showed delay in disease occurrence and physiological loss compare to other treatments.

***Keywords*:** Corn starch, physico-chemical properties, sapota, storage life.

Sapota (*Manilkar aachras*(Mill) Fosb.) belongs to the family Sapotaceae, is one of the major fruit crops grown in India, Mexico, Guatemala and Venezuela (Kulkarni *et al*.,2007). It is a good source of sugar which ranges between 12 and 14 per cent (Bose and Mitra,1990) and used for making jams, jellies, osmodehydrated slices and squash (Reddy, 1959). Products like sweet chutney, dried sapota pieces, sapota milk shake, nectar, blended sapota drinks, pickle, preserve and candy and wine can also be prepared with good sensory quality (Sawant, 1989, Gautam and Chundawat, 1998). Fruits are produced throughout the year but production is not consistent. One of the major problem in sapota cultivation is the occurrence of certain physiological disorders, apart from the problems of pests and diseases, which reduce the quality of the fruit drastically (Ugalat *et al*., 2013). India is the leading producer of sapota in the world. It is highly perishable and is also sensitive to cold storage. Bulk of the produce is used for table purpose and is handled at ambient conditions causing considerable post-harvest losses. Sapota fruits are required to be managed appropriately in order to get a regulated market supply with the help of post-harvest treatments followed by storage at appropriate temperature and relative humidity. Controlled atmosphere and modified packaging can lengthen the storage life of fruits but these processes are capital intensive and costly to run. A cheaper alternative is required for both extending postharvest life and keeping production costs low, hence there lies a possibility of using edible coatings (Baldwin *et al*., 1995) as a cheaper alternative. Starch-based edible coatings can be the perfect alternative to post-harvest packing and preservation of different fruits such as sapota due to their low cost, biodegradability and superb mechanical properties. Environmentally-friendly aspects of the coatings make them good alternatives in packaging technology, without ecological costs of alleviating environmental damage caused by synthetic non-biodegradable materials (Janna, 2012). The main objective of this work was to study the ability of corn starch based coatings to extend the shelf life of sapota fruits and on physiological and bio-chemical changes associated with storage.

Email: koyeldey02@gmail.com

MATERIALS AND METHODS

Fully matured, uniform size sapota fruits were collected from the University farm, Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar and immediately brought to the laboratory of the Department of Pomology and Post-harvest Technology for storage after necessary treatments. The fruits after washing in running tap water were dried in the shade for few minutes. The fruits were subjected to coating of following treatments T_1- Corn starch 0.5%, T_2- Corn starch 1%, T_3- Corn starch 1.5%, T_4- Corn starch 2%, T_5- Corn starch 2.5%, T_6- Corn starch 3% and T_7- Control. Corn starch (Himedia, Mumbai, India) coating solution was prepared by dissolving 0.5%, 1%,1.5%,2%,2.5% and 3% (w v^{-1}) starch in distilled water with agitation for 10 min at 90ºC. The pH value was adjusted to 5.6 with 50% (w v^{-1}) citric acid (Merck) solution and the solutions were equilibrated for 10 min. Glycerol (Merck) 87% was added as a plasticizer at a concentration of 2ml/l solution. The coating of fruits was done following the methodology of Janna(2012). Fruit samples were

analysed for physico-chemical properties at an interval of 3 days after treatments. The percentage of weight loss was calculated based on initial weight and weight at subsequent intervals. The decay percentage of fruits were calculated as the number of decayed fruit divided by initial number of all fruit multiplied by hundred (El-Anany *et al*., 2009). The length and breadth (centimetre scale) of sapota fruits were measured as an index for shrinkage and it was measured by digital vernier callipers at zero time of storage (beginning) and 3 days interval during the storage period. The fruit colour was recorded with the help of Royal Horticulture Society mini colour chart (5^{th} edition, 2007). Total soluble solids (TSS), total sugar and reducing sugar were estimated by the method described by Mazumdar and Majumder (2003). The acidity and ascorbic acid were estimated by the method described by Rangana (1977). Phenol content of fruits was estimated by the method described by Thimmaiah (2004). Analysis of variance (one way classified data) for each parameter was performed using ProcGlm of Statistical Analysis System (SAS) software (version 9.3). Mean separation for different treatment under different parameter were performed using Least Significant Different (LSD) method (Pd" 0.05). Normality of residuals under the assumption of ANOVA was tested using Shapiro-Wilkprocedure using Proc-Univariate procedure of SAS (version 9.3). Angular transformation was done for percentage data (Gomez and Gomez, 1983).

RESULTS AND DISCUSSION

Observation during storage of sapota fruits revealed that the physiological loss in weight (Table 1) was increased in all the treatments as the storage period progressed. On 3^{rd} day after treatment the physiological loss in weight was statistically at par for all the treatments. On 6^{th} and 9^{th} days the corn starch treatments had significant effect over control fruits for physiological loss in weight; however all the corn starch treatments were statistically *at par.* The physiological loss in weight was found minimum (3.82%) in T_5 followed by T_6 (10.54%) where as it was

Table 1: Effect of corn starch coatings on physiological loss in weight and decay

Treatments	Physiological loss in weight (5)			
	3 DAT	6 DAT	9 DAT	Cumulative
T_1	11.15a	14.1b	24.86b	16.62b
T_2	11.09a	15.11b	22.48b	16.89b
T_3	14.57a	21.46ab	33.24b	20.53b
T_4	14.63a	20.92ab	31.28b	20.47b
T_5	3.82a	11.25b	17.56b	15.1b
T_6	10.54a	14.38b	21.06b	15.88b
T_7(Control)	14.57a	32.52a	54.38a	31.03a
SEm (±)	**3.86**	**4.45**	**6.52**	**3.26**
LSD(0.05)	**NS**	**13.51**	**19.77**	**9.90**

Treatments	Decay (%)		
	3 DAT	6 DAT	9 DAT
T_1	23.32(28.84)b	42.96(40.98)d	66.41(54.60)b
T_2	26.98(31.28)ab	44.53(41.9)d	67.67(55.35)b
T_3	29.19(32.65)a	44.8(42.01)cd	67.58(55.33)b
T_4	27.01(31.33)ab	47.28(43.45)bc	68.62(55.93)b
T_5	15.14(22.79)c	27.26(31.47)e	38.71(38.95)c
T_6	27.53(31.63)ab	48.38(44.07)b	69.57(56.52)ab
T_7(Control)	32.75(34.91)a	52.51(46.41)a	72.91(58.65)a
SEm (±)	**1.20**	**0.49**	**0.80**
LSD(0.05)	**3.63**	**1.47**	**2.43**

Means with the same letter are not significantly different.Values in parenthesis are angular transformed value.

DAT : Days after treatment

T_1- Corn starch 0.5%, T_2- Corn starch 1%, T_3- Corn starch 1.5%, T_4- Corn starch 2%, T_5- Corn starch 2.5%, T_6- Corn starch 3% and T_7- Control.

maximum (14.57%) in the fruits under control (T_7). However, on 9th days after treatment, the physiological loss in weight was found minimum (17.56%) in T_5 and statistically at par with corn starch 3% (21.06%), whereas, it was maximum (54.38%) in control. Oluwaseun*et al.* (2013) observed that corn starch coated cucumber showed a significant delay in weight loss compared to uncoated ones. Physiological loss in weight for all the coated fruits was statistically at par at 9th days after storage. The reduction in weight loss was probably due to the effects of these coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates (Baldwin *et al.*, 1999). The basic mechanism of weight loss from fresh fruit and vegetables is by vapour pressure at different locations (Yaman and Bayoindirli, 2002), although respiration also causes a weight reduction (Pan and Bhowmick, 1992).

The coatings reduced decay compared to control fruit for all the treatments and fruits treated with corn starch-2.5% (T_5) showed minimum decay (38.71%) after 9th days of storage than uncoated fruits (T_7) which showed maximum decay (72.91%). Lower decay percentage was probably due to the effect of the coating on delaying senescence (Tanada-Palmu and Grosso, 2005).

Lower percentage of shrinkage of fruits was observed in T_5(9.14 %) i.e. from 5.47 cm to 4.97 cm compared to fruits of control (Table 2) on 9th day of storage. The shrinkage percentage of 2.5% starch was 5.44% (from 5.70 cm to 5.39 cm) for fruit breadth. However, the length and breadth of all the treated fruits were statistically at par at 3rd, 6th and 9th days after storage. The lesser shrinkage might be due to the anti-senescent action of coatings which had an inhibitory effect on ethylene biosynthesis and retard the activity of enzymes responsible for ripening. Cell degradation was prevented which in turn facilitated reduced moisture loss and lesser respiratory gas exchange, hence delay in senescence and lower the shrinkage percentage (Sudha *et al.*,2007).

Observation during storage of sapota fruits revealed that the fruit colour of sapota fruits harvested was changed from light grey (G-B-G-N 199-C) to brown (B-G 200-D) or greyish orange (G-O-G 177-A)

Table 2: Effect of corn starch coatings on length and breadth (cm.)

Treatments	Days after treatments							
	3		6		9		Shrinkage (%)	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
T_1	5.61a	5.94a	5.06a	5.47a	5.03a	5.30a	10.34	10.77
T_2	5.51a	5.93a	5.19a	5.75a	4.95a	5.56a	10.16	6.24
T_3	5.40a	5.69a	5.28a	5.49a	4.87a	5.26a	9.81	7.56
T_4	5.72a	5.55a	5.43a	5.36a	5.10a	5.09a	10.84	8.29
T_5	5.47a	5.70a	5.20a	5.53a	4.97a	5.39a	9.14	5.44
T_6	5.32a	5.88a	5.05a	5.54a	4.76a	5.38a	10.53	8.50
T_7(Control)	5.68a	5.92a	5.42a	5.34a	4.90a	4.79a	13.73	19.09
SEm (±)	**1.31**	**1.69**	**1.55**	**2.11**	**2.21**	**2.55**		
LSD(0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**		

Means with the same letter are not significantly different.

T_1- Corn starch 0.5%, T_2- Corn starch 1%, T_3- Corn starch 1.5%, T_4- Corn starch 2%, T_5- Corn starch 2.5%, T_6- Corn starch 3% and T_7- Control.

during storage (Table 3). At the time of the harvesting,sapota fruits were light grey in colour. On 9th days after treatment of fruits, the fruits were greyish orange coloured in all treated fruits except T_6 and uncoated sample where the colour was greyish brown. Castricini*et al*. (2012) observed that papaya coated with cassava starch and carboxy methyl starch helped to maintain the colour during storage.

Observation during storage of sapota fruits revealed that the TSS content of sapota fruits was increased up to a certain period and thereafter that it was decreased in all the treatments as the storage period progressed (Table 4). On 3rd days after treatment, the TSS content was found highest (29.23º brix) in T_5 followed by (28.8º brix) T_6, whereas, it was lowest (27.59º brix) in T_7. However, on 9th days after treatment, TSS content was found maximum (28.19º brix) in T_5 followed by (27.84º brix) T_2 and it was

Table 3: Effect of corn starch coatings on colour and TSS

Treat-ments	Colour		
	3 DAT	**6 DAT**	**9 DAT**
T_1	G-B-G-N199-C	G-O-G177-A	G-O-G177-A
T_2	B-G 200-D	G-O-G117-A	G-O-G117-A
T_3	G-B-G-N199-C	G-O-G177-A	G-O-G177-A
T_4	B-G 200-D	G-O-G177-A	G-O-G177-A
T_5	B-G 200-D	G-O-G177-B	G-O-G177-B
T_6	B-G 200-D	GBGN 199-C	GBGN199C
T_7	B-G 200-D	G-B-G-N- 199-C	GBGN199C
Treatments	**TSS (º Brix)**		
	3 DAT	**6 DAT**	**9 DAT**
T_1	27.9a	28.89a	26.47ab
T_2	27.79a	29.52a	27.84ab
T_3	27.79a	29.01a	26.46ab
T_4	27.78a	29.4a	27.51ab
T_5	29.23a	30.01a	28.19a
T_6	28.8a	29.65a	27.7ab
T_7(Control)	27.59a	28.83a	23.42b
SEm (±)	**1.18**	**0.90**	**1.48**
LSD(0.05)	**NS**	**NS**	**4.48**

Means with the same letter are not significantly different.

DAT- Days after reattretment

T_1- Corn starch 0.5%, T_2- Corn starch 1%, T_3- Corn starch 1.5%, T_4- Corn starch 2%, T_5- Corn starch 2.5%, T_6- Corn starch 3% and T_7- Control.

minimum (23.42º brix) in T_7. The data of all the treated fruits were statistically at par at 3rd and 6th days after storage, i.e., coating has no effect on TSS and all the corn starch coated fruits were statistically at par at 9th days of storage. The increase in TSS content during storage may possibly due to hydrolysis of starch into sugars as on complete hydrolysis of starch. No further increase occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration (Wills *et al.*, 1980).

Total sugar percentage is an important factor for determining the quality of sapota fruits. The flavour depends on total sugar percentage (Nandaneand Jain, 2011). It was increased for a certain period and after that it was decreased in all the treatments as the storage period advanced (Table 6). On 3rd days after treatment of sample, the total sugar content was found highest (19.05%) in T_5, where as it was lowest (18.97%) in the uncoated fruit, however all the treatments were statistically at par. Up to 6th days after treatment, total sugar content was increased and after that total sugar content was decreased. On 9th day after treatment, total sugar content was found maximum (18.92%) in T_5 where as it was minimum (18.22%) in T_7, but all the corn starch treated fruits were statistically at par. The change in sugar content was occurred due to utilization of sugar as a respiratory substrate (Nandane and Jain, 2011).

It can be observed from table-5, that in general reducing sugar content showed an increasing trend upto 6th day of storage and then decreased on 9th day of storage. On 9th day of storage, T_5 showed highest (10.32%) result and the lowest (10.11%) result was observed in control. However, the data of all the treated fruits were statistically at par throughout the storage period. The change of reducing sugar content is occurred due to utilization of sugar as a respiratory substrate (Nandane and Jain,2011).

The titrable acidity values of coated and uncoated fruit during storage decreased with storage time (Table-5). The value was highest (0.45%) in T_5 on 3rd days after treatment and the lowest (0.4%) in T_7. However, the data of all the treated fruits were statistically at par. The coating has no effect on titrable

Table 4: Effect of corn starch coatings on sugar content

Treatments	Total Sugar (%)		
	3 DAT	6 DAT	9 DAT
T_1	19.02a	19.29ab	18.65ab
T_2	18.99a	19.14ab	18.64ab
T_3	19.03a	19.12ab	18.67ab
T_4	19a	19.13ab	18.46ab
T_5	19.05a	19.45a	18.92a
T_6	18.99a	19.16ab	18.64ab
T_7	18.97a	19.07b	18.22b
SEm (±)	**0.03**	**0.12**	**0.19**
LSD(0.05)	**NS**	**0.37**	**0.57**

Means with the same letter are not significantly different.

Treatments	**Reducing suger (%)**		
	3 DAT	**6 DAT**	**9 DAT**
T_1	10.84a	11.11ab	10.15ab
T_2	10.84a	11.15ab	10.21ab
T_3	10.79a	11.12ab	10.18ab
T_4	10.86a	11.17ab	10.17ab
T_5	10.92a	11.21a	10.32a
T_6	10.91a	11.13ab	10.16ab
T_7	10.77a	11.06b	10.11b
SEm (±)	**0.06**	**0.04**	**0.06**
LSD(0.05)	**NS**	**0.12**	**0.18**

Means with the same letter are not significantly different.

DAT-Days after treatment

T_1- Corn starch 0.5%, T_2- Corn starch 1%, T_3- Corn starch 1.5%, T_4- Corn starch 2%, T_5- Corn starch 2.5%, T_6- Corn starch 3% and T_7- Control.

acidity during storage of sapota fruits. The low level of titrable acidity in control fruit compared to coated fruit suggests that the corn starch coating delayed ripening by providing a transparent coating around the fruit. Since organic acids, such as malic or citric acid, are primary substrates for respiration, a reduction in acidity is expected in highly respiring fruit (El-Anany*et al*., 2009). It is also considered that coatings reduce the rate of respiration and may therefore delay the utilization of organic acids (Yaman and Bayoindirli, 2002).

The ascorbic acid content of coated and uncoated sapota fruits increased to a maximum upto 6th days of storage and subsequently declined at 9th days (Table-10). On 9th days after storage, it was observed maximum (9.51 mg 100^{-1}g pulp) and minimum (8.09 mg 100^{-1}g pulp)in T_5 and untreated fruits, respectively. From the experimental result it is clear that coated fruits retained more amount of ascorbic acid, which is similar with the result of Oluwaseun *et al.,* (2013). This was probably because corn starch coating acted as a gas barrier, inhibiting oxygen from entering the fruit, thus reducing the oxidation of ascorbic acid. Ascorbic acid is lost at later stage due to the activities of phenol oxidase and ascorbic acid oxidase enzymes during storage (Salunkhe *et al*., 1991).

The maximum amount of phenol content was observed in T_5 and reached to a peak (138.11 mg 100^{-1}g pulp) after 6 days then decreased during the end of storage period (Table-11). The increase in total phenol content is related with the enhancement of antioxidant capacity (Reyes and Cisneros-Zevallos, 2003). A low amount of total phenol content or a sharp decline after 6 days of storage in fruit might be due to the higher rate of respiration which resulted in the loss of total phenol content due to the degradation of certain phenol compounds (Day, 2001).

The results of this study indicate that sapota fruit coated with 2.5% corn starch showed a significant delay in change of weight, length and breadth, total soluble solids, titrable acidity, total and reducing

Table 5: Effect of corn starch coatings on titrable acidity, ascorbic acid and phenol content

Treatments	Tritrable acidity (%)		
	3	**6**	**9**
T_1	0.44a	0.37a	0.21a
T_2	0.44a	0.36a	0.22a
T_3	0.44a	0.38a	0.2a
T_4	0.43a	0.37a	0.21a
T_5	0.45a	0.39a	0.24a
T_6	0.42a	0.39a	0.21a
T_7	0.4a	0.35a	0.2a
SEm (±)	**0.05**	**0.05**	**0.05**
LSD(0.05)	**NS**	**NS**	**NS**
Treatments	**Scorbic acid (mg 100g^{-1} pulp)**		
	3 DAT	**6 DAT**	**9 DAT**
T_1	11.74abc	11.95ab	9ab
T_2	11.67bc	11.88b	8.74ab
T_3	11.74abc	11.92ab	8.38b
T_4	11.72abc	11.86b	8.68ab
T_5	11.9a	12.03a	9.51a
T_6	11.87ab	11.93ab	9.1ab
T_7	11.65c	11.84b	8.09b
SEm (±)	**0.06**	**0.05**	**0.04**
LSD(0.05)	**0.20**	**0.15**	**0.11**
Treatments	**Phenol (mg/100g pulp)**		
	3 DAT	**6 DAT**	**9 DAT**
T_1	127.98a	137.22a	106.75a
T_2	124.4a	137.44a	107.1a
T_3	131.34a	137.38a	107.17a
T_4	124.71a	134.09a	107.64a
T_5	134.74a	138.11a	107.91a
T_6	129.2a	134.56a	106.51a
T_7	123.25a	133.27a	105.95a
SEm (±)	**3.90**	**2.32**	**1.06**
LSD(0.05)	**NS**	**NS**	**NS**

Means with the same letter are not significantly different.

T_1- Corn starch 0.5%, T_2- Corn starch 1%, T_3- Corn starch 1.5%, T_4- Corn starch 2%, T_5- Corn starch 2.5%, T_6- Corn starch 3% and T_7- Control.

sugar, ascorbic acid content, phenol content and colour during storage as compared to uncoated control fruit. This suggests that corn starch not only extends the shelf life but also preserves the ascorbic acid and phenol content during storage which is associated with antioxidant capacity and also suggests that corn starch is promising as an edible coating to be used in commercial postharvest applications for prolonging the storage life.

REFERENCES

Baldwin, E.A., Nisperos C, M., Shaw, P.E. and Burns, J.K. 1995. Effect of coatings and prolonged storage conditions on fresh orange flavour volatiles, degrees brix and ascorbic acid levels. *J.Agric. Food Chem.*,**43**:1321-31.

Baldwin, E.A., Burns, J.K., Kazokas W., Brecht, J.K., Hagenmaier, R.D., Bender, R.J. and Peris, E. 1999.

Effect of two edible coatings with different permeability characteristics on mango (*Mangifera indica* L.) ripening during storage. *Postharvest Biol. Technol.*,**17**:215-26.

Bose, T. K. and Mitra S. K. 1990.In: *Fruits: Tropical and subtropical*, Naya Prakash, Calcutta.pp.565-91.

Castricini A., Coneglian, R.C.C. and Deliza, R. 2012. Starch edible coating of papaya: effect on sensory characteristics. *Ciênc. Tecnol. Aliment. Campinas*, **32**:84-92.

Day, B. 2001.Modified atmosphere packaging of fresh fruits and vegetables-an overview. *Acta Hort.*, **553**:585-90.

El-Anany, A.M., Hassan, G.F.A. and Rahab A.F.M. 2009. Effects of edible coatings on the shelf-life and quality of Anna apple (*Malus domestica* Borkh) during cold storage. *J.Food Technol.,* **7**:5-11.

Gautam, S.K. and Chundawat, B.S. 1998. Standardization of technology of sapota wine making. *Indian Food Pac.*, **52**:17-21.

Gomez, K. A., and Gomez, A. A. 1983.Problem data.In: *Statistical Procedures for Agricultural Research.* 2nd ed., John Wiley and Sons; New York, USA. pp. 275-315.

Janna, C. 2012. An experimentaldesign approach for edible starch-based coatings development.Paper Presented in *5th Int. Symp. on Food Packaging*, Berlin, Germany, 14-16th November, 2012.

Kulkarni, P. A., Policegoudra, R.S. and Aradhya, S.M. 2007. Chemical composition and antioxidant activity of sapota (*Achras sapota* Linn.) fruit. *J. Food Biochem.*, **31:** 399-414.

Mazumdar, B.C. and Majumder, K. 2003. Determination of chemical constituents. In. *Methods on Physico-Chemical Analysis of Fruits*, Daya Publishing House, Delhi.pp. 93-139.

Nandane, A.S. and Jain, R.K.2011. Effect of composite edible coating on physicochemical properties of tomatoes stored at ambient conditions. *Indian J. Adv. Engg. Technol.,* **2**:211-17.

Oluwaseun, A.C., Arowora, K. A., Bolajoko F.O., Bunmi, A.J. and Olagbaju, A.R., 2013. Effect of edible coating of carboxy methyl cellulose and corn starch on cucumber stored at ambient temperature. *Asian J. Agric. Biol.*,**1**:133-40.

Pan, J.C. and Bhowmick, S.R.1992. Shelf life of mature green tomatoes stored in controlled atmosphere and high humidity. *J. Food Sci.*, **57**:948-53.

Rangana, S. 1977. Ascorbic acid. In: *Manual Analysis of Fruit and Vegetable Products.* Tata McGraw-Hill Publish. Comp. Ltd., New Delhi, pp. 94-101.

Reddy, M. G. 1959, Physico- chemical investigations on sapota and its products. *M.Sc. Thesis CFTRI Research Institute, Mysore.*

Reyes, L.F. and Cisneros-Zevallos, L. 2003. Wounding stress increases the phenolic content and antioxidant capacity of purple-flesh potatoes. *J. Agric. Food Chem.*, **51**:5296-5300.

Salunkhe, D.K., Boun, H.R., and Reddy, N.R. 1991. *Storage Processing and Nutritional Quality of Fruits and. Vegetables, vol. 1.*Boston: CRC Press Inc.

Sawant, V. S. 1989. Studies on post-harvest handling and preservation of sapota (*Manilkaraachras* (Mill) Forsberg) fruit Cv. Kalipatti.*M.Sc. (Agri.) Thesis* Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Ratnagiri MH, India.

Sudha, R., Amutha, R., Muthulaksmi, S., Baby Rani, W., Indira, K. and Mareeswari, P. 2007. Influence of pre and post-harvest chemical treatments on physical characteristics of sapota (*Achrassapota* L.) Var. PKM-1.*Res. J. Agric.Biol. Sci.*, **3**:450-52.

Tanada P.S. andGrosso, C.R.F. 2005.Effect of edible wheat gluten-based films and coatings on refrigerated strawberry (*Fragaria ananassa)* quality. *Postharvest Biol. Technol.*, **36**:199-208.

Thimmaiah, S.R. 2004.*In. Standard Methods of Biochemical Analysis.*Kalyani Publishers, Noida, U.P. pp. 287-88.

Ugalat, J., Haradari, C. and Singh, H. 2013. Biochemical and physiological characterization of corky tissue affected fruit of sapota (*Manilkaraachras* (Mill) Fosberg) cv. Cricket Ball. *J. Crop Weed*.**9:**193-97.

Wills, R. B. H., Bembridge, P. A. and Scott, K. J. 1980.Use of flesh firmness and other objective tests to determine consumer acceptability of Delicious apples. *Aust. J. Exp. Agri. Ainm.*, **20**:252-56.

Yaman, O. and Bayoindirli, L. 2002. Effects of an edible coating and cold storage on shelf-life and quality of cherries. *Lebnsm. Wiss. Und. Technol.*, **35**: 46-150.