EFFECT OF CHITOSAN ON STORAGE BEHAVIOUR OF SAPOTA *Manilkaraachras*(Mill) fosbergcv. 'Kalipatti'

ABSTRACT:

The present study was undertaken to study the effect of chitosan treatments on the storage behaviour of sapota*Manilkaraachras* (Mill) fosberg cv. Kalipattiis stored at ambient temperature. The climacteric rise in sapota fruits shortens the postharvest life and degrades the quality of the fruits. A polysaccharide like a chitosan has been used as an edible coating to extend the storage life of sapota fruits, which is an innovative approach for fruit preservation and sustainable development. Chitosan-based coatings have tremendous potential in several fruits to extend the shelf-life. An investigation was carried out to know the effectiveness of post-harvest treatments with edible coatings (0.5%, 1%, 1.5%, and 2% chitosan) compared with the control. 1% chitosan coating resulted in maximum fruits (more than 75%) having a shelf life of 7 days under ambient condition which was at par with 1.5% chitosan coating. Chitosan coating reduced the physiological losses in weight as compared to the uncoated fruits. The maximum retention of physical parameters such as fruit firmness, specific gravity, colour L*, a* and b* values as well as slow ripening and less spoilage behaviourwas observed in chitosan-coated sapota fruits.

Key words: Sapota, Chitosan, Physical parameters, Shelf life.

Introduction

Sapota (*Manilkaraachras)* is a tropical fruit native to Mexico and Central America and belongs to the family Sapotaceae. It is a climacteric fruit which requires ethylene to ripen due to which it gets ripens within 3-5 days after harvest (Lakshminarayana and Subramanyam, 1966)[13].Sapota is referred to by many names, including chico, sapodilla, lamut, and chicle, among others. Fruits from it are almost availablearound the year. It is robust, extremely productive, and typically free of harmful pests, illnesses, and physiological issues. As a result, it has become a significant fruit crop that is widely grown in India.

InIndia,sapotaranksfifth bothinproductionandconsumptionnext tomango,banana,citrusandgrapes (Shrivastava*et al*., 2017) [18]. Sapota is grown mainly in coastal areas such as Maharashtra, Gujarat, Karnataka and Tamil Nadu. It is consumed mostly indigenously. Sapota contains various important nutrients which have certain health benefits (Anand*et al*., 2007) [3].The fruits have an appreciable amount of protein, fat, fibre, calcium, phosphorus, iron, carotene and vitamin C. It is also rich in bio-iron required for the formation of haemoglobin (JaishankarAndKukanoor, 2016) [8].

Fruits like sapota have a very short shelf life when stored in ambient conditions because they are highly perishable. Furthermore, it is delicate to cold storage (Sudha*et al*., 2007)[19]. Fruit post-harvest losses are high in tropical countries like India, ranging between 25 and 30%. The respiration rate and ethylene production significantly increase during ripening, which happens quickly. All of these which classify it as a fruit with a very short shelf life and high perishability, making its commercialization more challenging (Jaishankar And Kukanoor, 2016)[8].

With their strong climacteric ripening behaviour and high perishability, sapota fruit must be handled carefully after harvest to transport to distant markets in the best possible condition. The postharvest quality and shelf life of sapota fruits are affected by pre-harvest factors like plant nutrition and post-harvest factors like storage conditions, and packaging (Madani*et al*., 2018)[14].

Chitosan plays a vital role in the post-harvest management of horticultural crops by minimizing post-harvest losses and enhancing the quality of produce. Chitosan is currently employed in post-harvest fruit preservation. The main advantages of edible active coatings are to preserve the quality, increase the shelf life, and guard against the microbiological decomposition of fresh fruits. The chemical compound chitosan has a wide range of possible uses in the chemical, biological, food, pharmaceutical, and medical industries. Because of its film-forming abilities, antibacterial effects, lack of toxicity, biodegradability, and biochemical features, chitosan one of the finest nutritionally and physiologically safe preservative coatings for various sorts of foods.Permeablefilms on fruit surface, modify the fruits internal atmosphere, regulate gas exchange, reduce transpiration losses, delay the ripening, and maintain the quality of harvested fruit (kaya *et al*., 2016)[9]

The chitosan-based edible coating with a known allergen on the food products should be clearly understood and labelled. This is because of chitosan coating with many kinds of antimicrobial agents is made from ingredients that might cause the allergic reaction on the surface of fruits and vegetables (Xing *etal*., 2016)[20].

MATERIALS AND METHODS

The present investigation entitled Study on the effect of chitosan on storage behaviour of sapota [*Manilkaraachras* (Mill) Forsberg] cv. 'Kalipatti' was undertaken at the Laboratory of the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Technology and Management (PGI-PHTM), Killa-Roha, Dist- Raigad (Maharashtra State) during the year 2021-22. The experiment was laid out in a Completely Randomized Design (CRD) with four replications (25 fruits / replication). There were five treatments viz., T_1: Control, T_2: 0.5% Chitosan, T_3: 1% Chitosan, T_4: 1.5% Chitosan and T_5: 2% Chitosan under ambient conditions.

Edible coating preparation and fruit treatment

The chitosan solution having a concentration of 7% was purchased from the market. Chitosan solution of different concentrations i.e., 0.5, 1.0, 1.5, and 2.0 per cent w/v was made. Solutions were homogenously mixed with the use of a hot magnetic stirrer 1200rpm for 5 minutes each. The freshly harvested fruits were washed in water, dried, and dipped in a coating solution for five min followed by air drying. After surface drying, the fruits of each treatment were kept in cardboard boxes of previously placed in the laboratory of PGI-PHTM of the FVF Department at ambient storage conditions. During storage, the fruits were observed daily (after 24 hrs) for changes in physical and chemical parameters.

Physical parameters

Colour

The colour reader (make Konica Minolta, Japan CR-10) was used to determine the skin colour of sapota fruits and expressed as L*, a* and b* values.

Physiological Weight in Loss (%)

The sapota fruits were weighed initially as well as at each storage interval. The difference between the initial and final weights of fruit was regarded as a complete loss of weight. Results were presented using the standard method of and expressed as a percentage loss of the starting weight (AOAC 1994)[4].

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

The specific gravity of fruits

Individual fruit was weighed on monoplane sensitive electronic balance. The volume of fruit was determined by the water displacement method using a measuring cylinder and the average volume of 10 fruits was recorded in millilitres (ml). The specific gravity of the fruit was computed by dividing the values of fresh weight of the fruit by that of volume and the average of 10 fruits was calculated by formula.

The specific gravity of fruit = Weight of fruit (g)/ Volume of fruit (ml)

Fruit firmness (kg/cm^2)

A total of ten fruits per treatment were observed for fruit firmness and determined by using a fruit pressure tester and recorded at kg/cm^2

Ripening and spoilage pattern

For studying the ripening and spoilage pattern fifty fruits per treatments were observed for stages like unripe, half-ripe, ripe, shrivelled and diseased every alternate day.

Sensory evaluation

The fruits treated with various concentrations of chitosan were evaluated for their organoleptic qualities like colour, flavour, texture and overall acceptability on a hedonic scale (Amerine*et al*. 1965)[2] as given below.

A panel of six judges was selected based on their consistency and reliability of judgment. The panellists were asked to score the differences between the samples by allotting the numbers from 1 to 9, where 1 represented Dislike extremely, 2, Dislike very much, 3, Dislike moderately, 4, Dislike slightly, 5,Neither like nor dislike, 6, Like slightly, 7, Like moderately, 8, Like very much and 9, Like extremely.

Result and Discussion

Colour

L* value for the colour

The in-control decreased from 62.03 to 25.37 while it was better maintained in chitosan-coated fruits with less amount of decrease. The mean of the treatments shows that the L* value for colour was maintained better inT_3 and T_4 treatments.

The maximum L* value for colour was found in T_3 (35.58) which was at par with T_4 (34.33) followed by T_2 (33.43) and T_5 (31.55) while the minimum colour L* value was found in T_1 (25.37) on 7th day of storage.

Colour is one of the major visual attributes of fruits. The change in colour of sapota fruits from light brown to dark brown continued over the storage period due to which there is a decrease in colour values. Control fruits showed faster colour change than coated ones. A lower rate of decrease in colour values found in coated fruits indicated that edible coating has relatively delayed the browning and colour development of the peel which leads to slower changes in colour development. The slow colour development can be attributed to the modified internal atmosphere created within the fruit (Saha*et al*., 2015)[17].

a* value for the colour

During the initial days of storage i.e., 0 to 2nd day, the a* value for colour was found to be non-significant, while the-a* value for colour was increased from 3rd day to 7th day of storage the minimum a* value for colour was observed in T_3 (11.32) which was at par with T_4 (11.40) while, maximum a* values for colour was recorded in T_1 (11.58).

The result of similar findings was observed in an experiment on Study of physico-chemical properties of sapota (AchrasSapota L.)Sapota a* values of sapota fruits was found between was 7.10 to 10.42 and average a* value of sapota were 7.14±0.02 (Jadhav*et al*., 2018). The colour of the outer peel of sapota was turning reddish brown. However, this colour change towards red was more in control than that of treated ones and this edible coating could delay the ripening process of Sapota fruit there-by becoming more reddish brown (Padmaja*et al*., 2015)[15].

Table No.1 Effect of chitosan-based edible coating on L* value and a* value for thecolourof sapota fruits cv. Kallipatti during storage.

Treatments	L* value for the colour								a* value for the colour							
	Days of Storage								Days of Storage							
	0	1	2	3	4	5	6	7	0	1	2	3	4	5	6	7
T_1	62	58.4	56.2	50.2	43.6	37.3	32.7	25.4	5.82	6.27	7.63	8.74	9.31	10.5	11.2	11.6
T_2	63.1	60.5	59	54.7	46	39.9	35.3	33.4	5.51	6.18	7.1	7.79	9.08	10.4	10.9	11.5
T_3	63.9	60.6	58.1	52.1	46.3	42.4	38.4	35.6	5.34	5.75	6.46	7.52	8.63	9.85	10.6	11.3
T_4	64.3	63.1	59.9	53.1	48.5	44.2	38.9	34.3	5.50	5.9	6.88	7.86	8.71	9.65	10.7	11.4
T_5	63.3	60.6	57.7	50.9	46.1	39.9	34.5	31.6	5.13	6.04	7.23	8.08	9.23	10.2	10.9	11.4
Mean	**63.3**	**60.6**	**58.2**	**52.2**	**40.7**	**36**	**36**	**32.1**	**5.46**	**6.03**	**7.06**	**8**	**10.1**	**10.9**	**10.9**	**11.4**
S.E ±	2.41	3.02	2.39	2.94	2.91	1.12	0.91	0.43	0.25	0.3	0.26	0.14	0.13	0.09	0.07	0.03
CD @ 5%	NS	NS	NS	NS	NS	3.66	2.96	1.41	NS	NS	NS	0.47	0.41	0.3	0.24	0.1

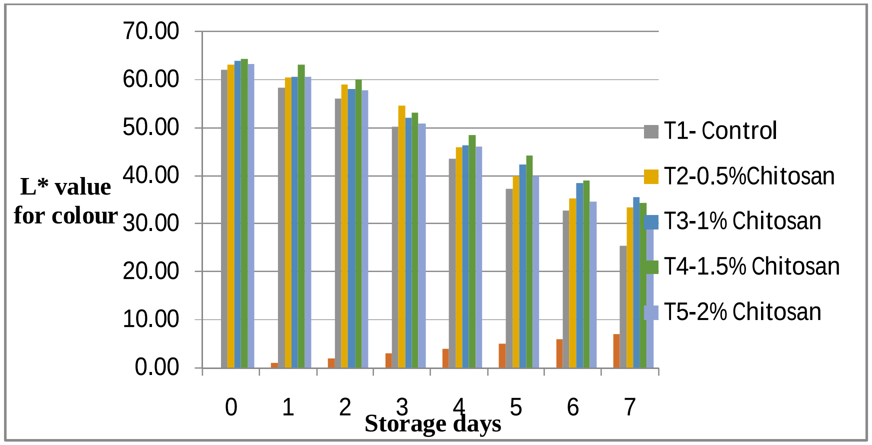

Fig 1: Effect of chitosan-based edible coating on L* value forthe colourof sapota fruits cv. Kallipattiduring storage

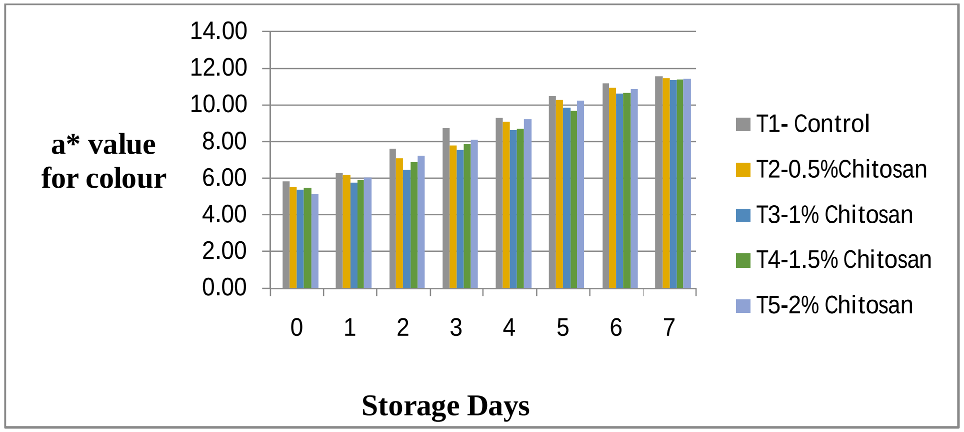

Fig 2: Effect of chitosan-based edible coating on a* values for the colourof sapota fruits cv. Kallipatti during storage

b* value for the colour

The b* values for colour showed a decreasing trend of values for both the control and treated sapota. The b* value for colour was found to be non-significant at the initial days of storage. On the 7th day of storage, significantmaximum b* values for colour were found in T_3 (17.35), while the minimum b* value for colour were found in T_1 (14.39). The result of similar findings was observed that the b* value of colourin sapota fruits ranges between 37.26 to 41.91 and the average value of b* is 40.50±0.03 (Jadhav *et al*., 2018). b* value shows a decreasing trend of values for both control and treated sapota. The degree of decrease was more in control fruits (Padmaja*et al*., 2015)[15].

Specific gravity

The specific gravity was found to be non-significant during the initial days of storage. Maximum specific gravity was found in T_3 (1.09), (1.110), (1.088) and T_4 (1.100), (1.090) respectively, while minimum specific gravity was observed in T_1 (1.066) and T_5 (1.061).

The findings of Khanvilkar*et al*. (2018) in sapota cv. 'Kalipatti' support the current studies. Jain *et al*. (2019) and Baidya*et al*. (2019) observed significant variation in fruit weight and volume, which resulted in variation in the specific gravity of sapota fruits (2020).The specific gravity of mature sapota fruit has been indicated between 1.025 and 1.10 depending on the cultivar, for 'Kalipatti' it has been reported as being 1.10 Awasarmal*et al*. (2011)[5].

Table No. 2 Effect of chitosan-based edible coating on b* values and Specific gravityfor the colourof sapota fruits cv. Kallipatti during storage.

Treatments	b* value for thecolour								Specific gravity							
	Days of storage								Days of storage							
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
T_1	29.6	28.4	26.1	23.8	20.2	18.6	16.1	14.4	1.02	1.02	1.03	1.06	1.07	1.07	1.05	1.03
T_2	29.7	27.6	24.7	23.3	20.5	19.3	17.3	15.3	1.02	1.02	1.04	1.08	1.08	1.08	1.06	1.07
T_3	31.8	30	28.6	26.9	24.5	22	19.4	17.4	1.02	1.03	1.05	1.07	1.09	1.11	1.09	1.09
T_4	30.8	28.2	28.1	25.3	24	22.2	18.5	16.2	1.02	1.02	1.05	1.07	1.08	1.1	1.11	1.09
T_5	30.3	28.8	27.4	25.2	23.4	21.4	18.4	16.4	1.02	1.03	1.04	1.06	1.07	1.06	1.06	1.05
Mean	**30.43**	**28.57**	**26.97**	**24.9**	**20.72**	**17.94**	**17.94**	**15.92**	**1.016**	**1.024**	**1.039**	**1.067**	**1.077**	**1.084**	**1.075**	**1.065**
S.E ±	0.55	0.5	0.97	0.81	0.46	0.38	0.25	0.24	0	0	0	0.01	0.01	0.01	0.01	0
CD @ 5%	NS	NS	NS	NS	1.49	1.23	0.82	0.78	NS	NS	NS	NS	0.01	0.02	0.03	0.01

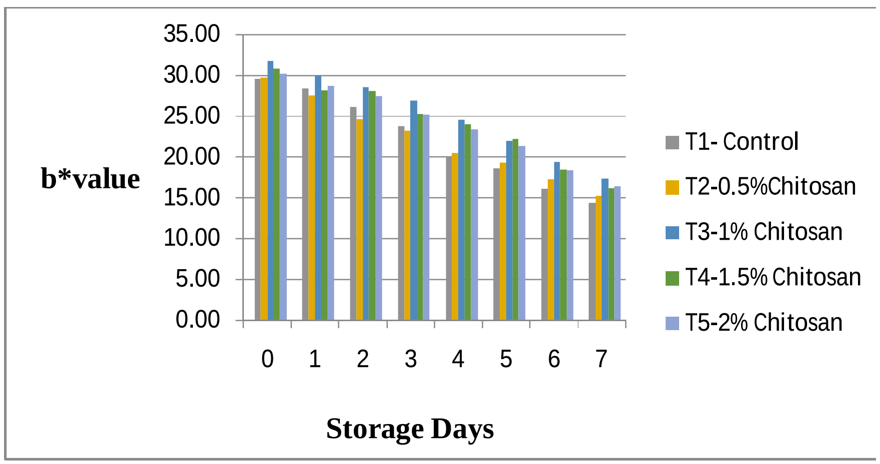

Fig 3: Effect of chitosan-based edible coating on b* values for the colourof sapota fruits cv. Kallipatti during storage.

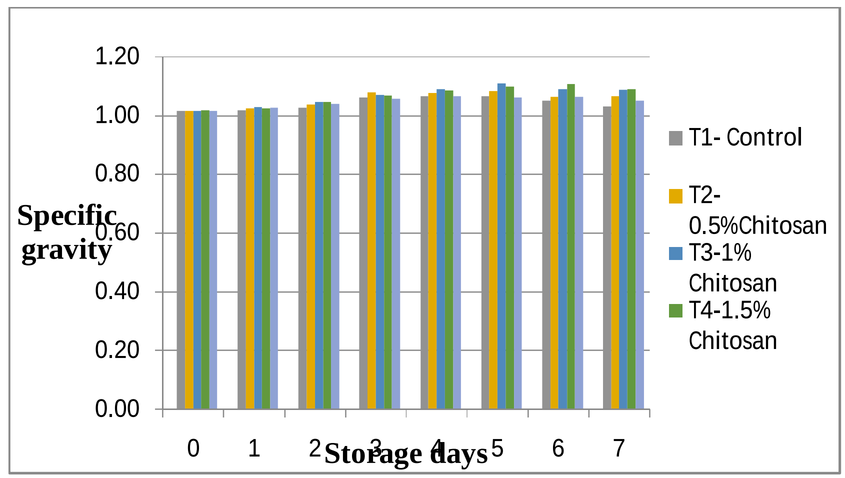

Fig 4: Effect of chitosan-based edible coating on specific gravity (kg m^{-3}) of sapota fruits cv. Kalipatti during storage.

Physiological loss in weight (%)

The data revealed that the different concentrations of chitosan treatments exerted significant effects on PLW from 4th day of storage. Fruits under control not survived on day 5, whereas fruits in T_3 and T_4 treatments not survived on day 7. On 5th day maximum PLW was recorded in T_1 (18.28%) while the minimum was recorded in T_3 and T_4 treatments (10.33%) and (11.77%) respectively, while on the 7th day maximum PLW was recorded in T_1 (28.64%) while the minimum was recorded in T_3 (15.67).

Chitosan coating forms a thin and transparent layer on the sapota skin surface that contributes to slowing down the dehydration process, responsible for fruit weight loss. Our results are in agreement with previous studies that demonstrated that chitosan coating retarded fruit weight loss in different fruit crops, such as strawberry, sweet cherry, loquat, and plum (Petriccione*et al.*, 2019)[16].

Fruit firmness (kg/cm^2)

Chitosan exerted an effect on fruit firmness during the initial storage period and was found to be non-significant. The fruit firmness was found to be non-significant during the initial days of storage to 2nd day, while the fruit firmness was continuously decreased from 3rd day to 7th day of storage.

The firmness increased irrespective of treatments in the storage duration. Fruits under control were not survived on day 5 whereas fruits in T2 and T3 treatment survived on day 7. On the 5th day of storage minimum firmness was recorded in T_3 (10.33 kg/cm^2), whereas the maximum fruit firmness was recorded in T_1 (18.28 kg/cm^2). At the end of storage lowest firmness (15.67 kg/cm^2) observed in T_3 treatment. 1% chitosan coating showed a highest firmness at 7th day of storage.

The retention of firmness with chitosan coating is in agreement with the results of Ali. al. (2011) that the higher firmness of the coated fruits may be because as the respiration rate is reduced also reduced the degradation of water-insoluble calcium pectate (Ca-pectate) or calcium bridge that renders strength to the fruit skin according to the (Keneko*et al.*, 2002)[10].

Table No.3 Effect of chitosan based edible coating on physiological loss in weight (%) and Fruit firmness (kg/cm^2) of sapota fruits cv. Kalipatti during storage.

Treatments	Physiological loss in weight (%)									Fruit firmness (kg/cm^2)							
		Days of storage								Days of storage							
	0	1	2	3	4	5	6	7	8	0	1	2	3	4	5	6	7
T_1	0	2.78	4.89	7.96	12.8	18.3	22.9	24.4	28.6	65.9	57	48.9	39.8	31.9	19.9	17.9	11
T_2	0	2.61	4.86	6.98	11.9	13.3	17.5	21	22.9	68.4	56.4	48.2	39.8	33.6	24.5	19.5	12.6
T_3	0	3.13	4.7	6.31	8.69	10.3	11.4	14.1	15.7	67.3	61.5	53.1	45.8	38.4	30.2	23.7	15.2
T_4	0	2.75	4.73	6.91	9.45	11.8	12	16.1	19.1	66	59.4	50.8	44.9	39.3	30.9	24	15.1

T_5	0	3.01	4.99	7.34	10	12	15.6	17.7	18.6	69.7	57.2	49.2	40.3	34.3	24.3	20.8	12.9
Mean	**0**	**2.86**	**4.83**	**7.1**	**10.56**	**13.12**	**15.88**	**18.64**	**20.98**	**67.45**	**58.29**	**50.04**	**42.12**	**35.48**	**25.93**	**21.19**	**13.34**
S.E ±	0	0.29	0.31	0.39	0.36	0.25	0.25	0.22	0.21	1.8	1.38	1.24	0.69	0.61	0.52	0.5	0.33
CD @ 5%	0	NS	NS	NS	1.17	0.81	0.8	0.71	0.67	NS	NS	NS	2.25	1.98	1.68	1.64	1.06

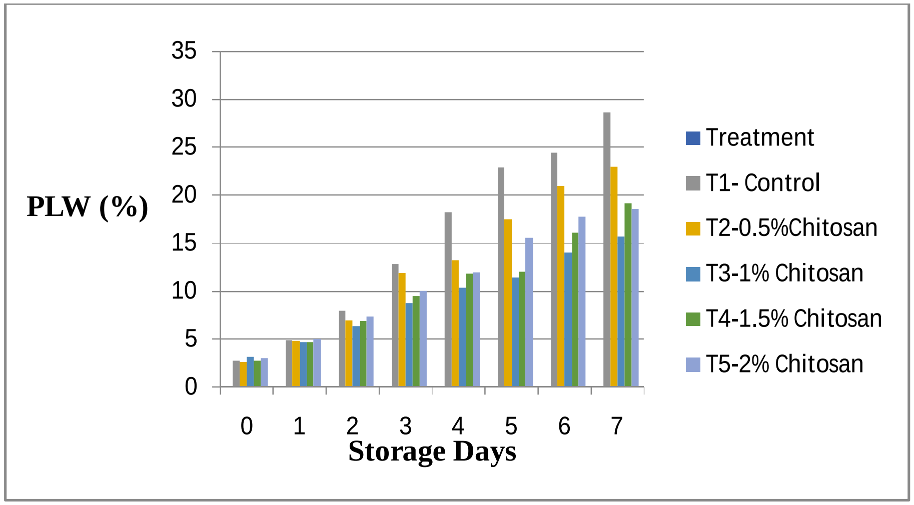

Fig 5: Effect of chitosan-based edible coating on Physiological loss in weight (%) of sapota fruits cv. Kalipatti during storage.

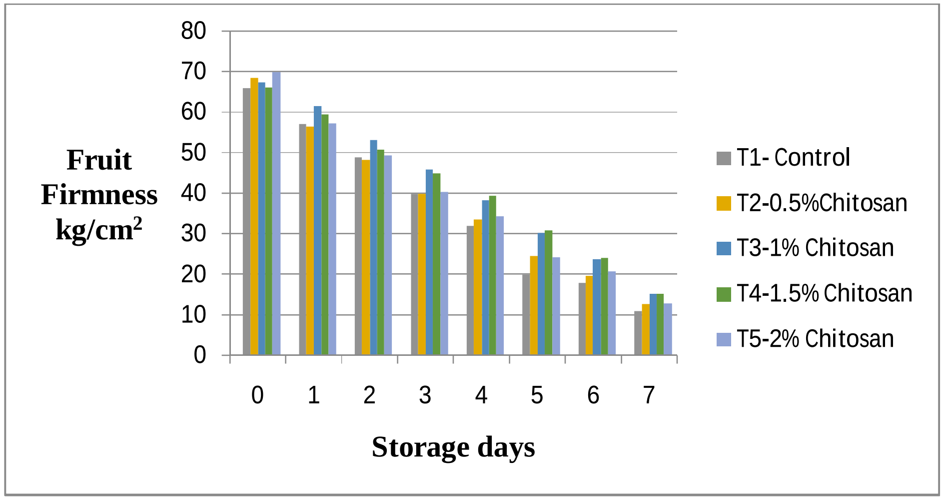

Fig 6: Effect of chitosan-based edible coating on Fruit firmness(kg/cm^2) of sapota fruits cv. Kallipatti during storage.

Ripening and spoilage pattern

Maximum unripe fruits were observed in T_3 (15.38%) and T_4 (12.31%) on the 5th day, while maximum half-ripe fruits were observed in T_4 (33.85%), whereas minimum half-ripe fruits were noted in T_2 (12.15%) and half ripe fruits were not observed in T_1 at the same day.

On 7th day of storage, maximum ripe fruits were noted in T_3 (76.92%) and T_4 (73.85%), while the minimum was noted in T_1 (44.15%). Maximum shrivelling and spoilage were observed in T_1 (28.8 %), followed by T_5 (23.08%). Maximum diseased fruits are observed in T_2 (30.77%) and T_1 (27.05 %) respectively, while minimum noted in T_3 (12.31%) and T_4 (15.38%) respectively.

Shriveling of sapota decreased with increase in the level of chitosan concentration for post-harvest coating of sapota. As the chitosan coating acts as a gas barrier, it slows down the loss of the respiration processes and moisture loss and allows retention of the firmness of fruits during storage. The results are confirmed as also reported (Yaman and Bayoundurh, 2002)[22] in grape. It might be due to the loss of moisture affecting the firmness of the berries during storage demonstrated by (Yadav*et al.*, 2022)[21].

Table No.4 Effect of chitosan-based edible coating on ripening and spoilage pattern (%) of sapota fruits cv. Kallipatti during storage.

Treatments	**Days of Storages**								
	Stages	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
T_1	**UR**	100	93.85	60.15	41.25	10.86			
	HR		6.15	30.14	42.5	22.56			
	R			9.71	16.25	46.36	70.55	46.15	44.15
	S					10.52	15.34	27.7	28.8
	D					9.7	14.11	26.15	27.05
T_2	**UR**	100	92.31	85.31	56.55	31			
	HR		7.69	14.69	33.33	35.31	12.15		
	R				10.12	30.61	65.41	61.54	49.23
	S					3.08	15.14	15.38	20
	D						7.3	23.08	30.77
T_3	**UR**	100	100	80	68.46	38.46	15.38		
	HR			20	31.54	33.85	30.77	18.46	
	R					27.69	53.85	63.08	76.92
	S							9.23	10.77
	D							9.23	12.31
T_4	**UR**	100	95.38	73.85	52.31	27.69	12.31		
	HR		4.62	26.15	43.08	53.85	33.85	7.69	

	R				4.61	18.46	49.23	69.23	73.85
	S						4.61	10.77	10.77
	D							12.31	15.38
	UR	100	92.31	86.15	66.1	18.46			
	HR		7.69	13.85	33.9	46.15	30.77	6.15	
T_5	**R**					35.39	46.15	61.54	53.85
	S						9.23	15.38	23.08
	D						13.85	16.93	23.07
	Total	**100**	**100**	**100**	**100**	**100**	**100**	**100**	**100**

Sensory evaluation

There were significant differences in all parameters of colour, flavour, texture, and overall acceptability. The flavour of the fruits with 1% and 1.5% coating was rated excellent (7.7 and 7.4), while minimum scoring was rated in control fruits (6.6).

The texture of the fruits with 1% and 1.5% coating was rated excellent (8.1 and 8) respectively, while minimum scoring was rated in control fruits (6.8).

Overall acceptability of the fruits with 1% and 1.5% coating was rated excellent (8.4 and 8.1) respectively, while minimum scoring was rated in control fruits (7.4).

Sensory attributes of the papaya fruits treated with 1.5% chitosan concentration demonstrated the overall superiority, after 5 weeks of cold storage (Ali *et al*., 2011)[1]. (Kittur*et al*., 2001)[12]noticed that 1.0% chitosan coated mangoes had better sensory traits than the control and the waxol-treated mangoes, after 21 days of storage.

Table No.5 Effect of chitosan-based edible coating on sensory quality parameters of sapota fruits cv. Kallipatti during storage.

Sensory quality parameters				
Treatment	**Colour**	**Flavor**	**Texture**	**Overall acceptability**
T_1- Control	7.25	6.68	6.85	7.40
T_2-0.5%Chitosan	7.75	7.30	7.53	8.03

T_3-1% Chitosan	8.50	7.78	8.15	8.43
T_4-1.5% Chitosan	8.00	7.40	8.00	8.15
T_5-2% Chitosan	7.25	7.00	7.25	7.95
Mean	**7.75**	**7.23**	**7.56**	**7.99**
S.E ±	0.08	0.07	0.06	0.04
CD @ 5%	0.26	0.24	0.20	0.67

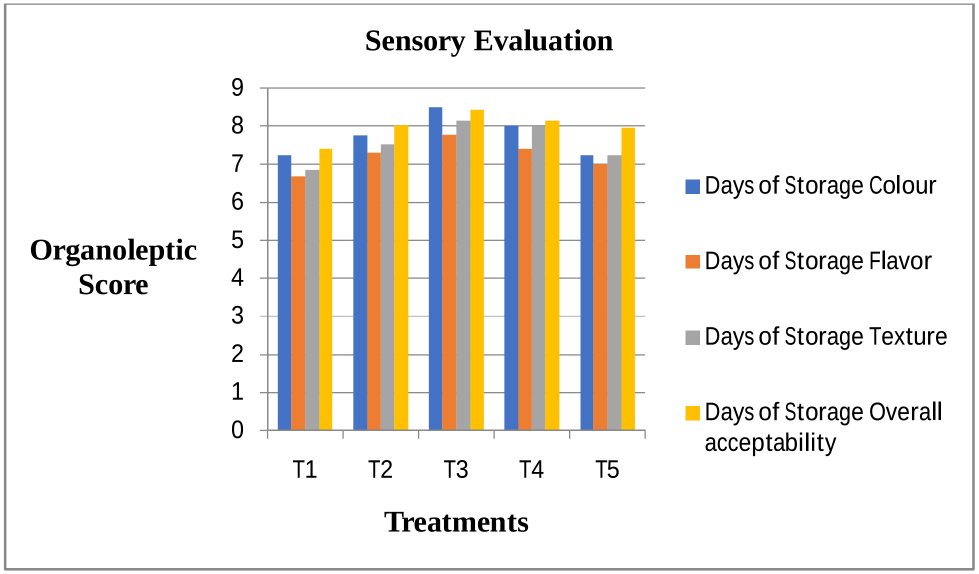

Fig 7: Effect of chitosan-based edible coating on sensory evaluation of sapota fruits cv. Kallipatti during storage.

Conclusion

It was determined that chitosan has the potential to be used as a coating technique for better sapota fruit storage.It can be concluded from the present investigation that the fruits treated with chitosan coating @ 1% followed by 1.5% helps in maintaining the quality and shelf life of sapota fruits up to the 7th day of storage. The fruits retained desirable colour, texture and postharvest quality till the end of their storage life.

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