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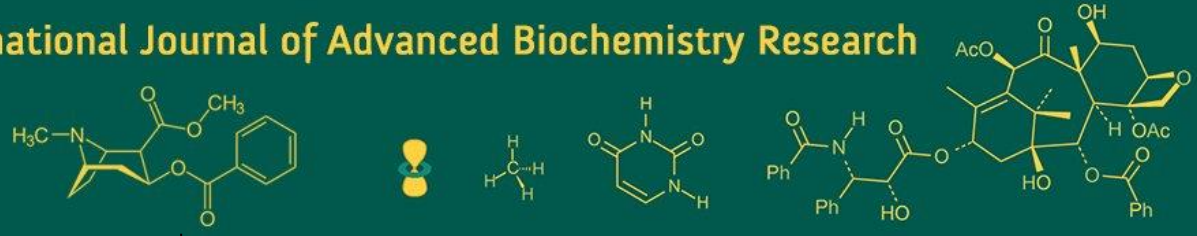

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Shelf-life enhancement of guava by using ethylene inhibitor and different coating material

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Abstract
Guava (*Psidium guajava* L.) is considered one of the most vital fruits, and is also known as the apple of tropical and subtropical regions of the world. The objective of this work was the Shelf-life enhancement of guava by using ethylene inhibitor and different coating materials. The effect of edible coatings based on 1-MCP (1-Methylcyclopropene), mineral oil, chitosan, and bee wax (BW) applied to guavas harvested green and stored for 15 days at 35°C was evaluated. Guavas were coated with cards of ethylene inhibitor (1-Methylcyclopropene), mineral oil (0.4, 0.8, 1.2 ml), chitosan (1, 2, 3%), and beeswax (2%), and control (uncoated). The coatings reduced the respiration rate, inhibited ethylene synthesis and slowed the ripening process. The effect on fruit ripening was indicated by peel colour, TSS, change in titratable acidity, decreased fruit softening and weight loss, retained ascorbic acid content and maintained the overall quality of the fruits. The shelf life of guava having edible coatings such as 1-MCP, mineral oil, chitosan and beeswax as compared to control sample days (2 days) were found to be 8,6,4,4 days, respectively. The fruits treated with 1-MCP showed the best results in maintaining the quality of the fruits, reducing weight loss, delaying the ripening and maximum shelf life of about 8 days.

Keywords: 1-MCP, bee wax, chitosan, guava, mineral oil, shelf life

Introduction
Guava (*Psidium guajava* L.) is considered one of the most vital fruits, is also known as the apple of tropical and subtropical regions of the world (Singh, 2011; Mitra *et al*, 2012) [15, 9]. In India, the major guava growing states are Maharashtra, Chattisgarh, Karnataka, Andhra Pradesh, Bihar, Uttar Pradesh, Gujarat, Haryana and Madhya Pradesh. Guava fruit is a rich in terms of nutrients and minerals. A 100 g serving of guava serves nutrients around of carbohydrates (14 g), proteins (2.6 g), fat (1 g), calories (68 kcal), sugar (9 g), fibre (5 g) and minerals like potassium (417 mg), sodium (2 mg) etc. The pulp presents a high content of vitamins C (228.3 mg), B6 (0.11 mg), and B9 (49 mg) and its vitamin C content (228.3 mg) is two to five-fold higher than that of citric fruit **(**Gill 2015) [4].

The guava is a climacteric fruit that continues to mature or ripen even after harvest, showing an increase in the rate of respiration and metabolic activities within a short period of time, leading to rapid senescence or spoilage of fruit. In countries such as India, among fruits, the maximum post-harvest losses occur in guava fruit (nearly 18.1%), including 4.1% storage losses and 3.7% packaging and transportation losses. Due to lack of packaging facilities and the improper storage of guava, there is a huge losses in physiological weight, changes in total soluble solid (TSS) and reducing vitamin C and browning of guava has been widely documented in the literature. Many researchers have concluded that the rate of oxygen consumption and the evolution of CO2 and ethylene production during the packaging and storage of fruit play a major role in extending shelf life (Bron, 2005; Porat, 2009; Singh, 2011; Hong, 2012; Liu, 2012; Mangaraj, 2014; Murmu, 2018) [2, 11, 15, 6, 7, 8, 10].

Coating material like edible wax i.e. bees wax used for waxing which retards the rate of moisture loss, maintains turgidity and plumpness and covers injuries on the surface of the commodity (Wills and Golding, 2016) [17]. Edible waxing was also reported to delay fruit ripening, reduce water loss, maintain quality and extend shelf-life (Mohamed and Abu-Goukh, 2003) [1].

Mineral oil used as coating material which leads to enhance shelf life of fruits, reduced the spoilage and improved the fruit quality by delaying the senescence during storage. Also chitosan coatings materials independently or in combinations of other coating have been used to increase shelf life of guava (Xin *et al*., 2017) [18]. Cassava starch associated to chitosan delayed ripening of 'Tommy Atkins' mangoes followed refrigeration at 12 °C, in addition to providing better fruit appearance (Azeredo *et al*., 2016) [13]. Recently, 1-methylcyclopropene (1-MCP) has been employed as ethylene inhibitor to increase the shelf-life of some horticultural commodities (Sisler *et al*., 2003) [16], therefore it can be slow down the ripening process as well as senescence of fruit. 1- methylcyclopropene delayed fruit ripening, maintained quality and extended shelf-life of mango (Hofman *et al*., 2001) [5] and tomato.

2. Materials and Method

2.1 Selection of material

2.1.1 Selection of Raw Materials

Unripe guavas (cv. Lucknow 49) were procured from the orchard of the farmer from Rahata, Dist. Ahmednagar (M.S), for the present investigation. Graded guava was washed under the tap of water to remove the impurities and insecticides available on its surface then it was stored at 2.5 °C until its use for further experiments. The different edible coating materials like bees wax, mineral oil, chitosan.

2.2 Experimental Methodology

2.2.1 Sample preparation

Unripe guava was removed from the refrigerator so it can be achieved the ambient condition and remove the condensed atmospheric moisture from guava surfaces by using dry cloths before the coating.

2.3 Preparation of coating solutions

2.3.1 Chitosan

The desired concentration of coating material i.e. chitosan 1, 2, and 3% by weight was prepared by dissolving required amount of chitosan materials into pre-determined amount of distilled water and acetic acid (glacial).

2.3.2 Bees wax

Bees wax (2%) prepared by dissolving 4.0 g of wax 200 ml of water and ethyl alcohol mixture (3:1 L) at 70 °C and stirred for 10 min by using mechanical stirrer.

2.3.3 Mineral oil

Mineral oil of volume 0.4, 0.8 & 1.2 ml were used to apply as a coating material directly on the surface of guavas having nearly same shape and size independently. Mineral oil was used to apply on fruits surface is shown in Plate 1.

2.3.4 Treatment of 1-Methylcyclopropene (1-MCP)

Cards of ethylene inhibitor (1-Methylcyclopropene) were used for to control the action of ethylene on matured guava. Cards of 1-Methylcyclopropene were placed separately in air tight closed chamber in which fruits are already placed.

2.4 Variables under study

Variables selected for this study were classified in three major categories as fixed parameters, independent variables and dependent variables.

2.4.1 Fixed parameters

1. Type of fruit and its variety – Guava (cv. Lucknow 49)
2. Storage condition – Ambient condition
3. Type of ethylene inhibitor – 1-MCP

2.4.2 Independent variables

1. Coating material concentration

a) Bees wax – 2% for each single fruit
b) Mineral oil – 0.4, 0.8 & 1.2 ml for each single fruit
c) Chitosan - 1, 2, & 3% for each single fruit

2.4.3 Dependent variables

1. Physical properties - PWL, firmness
2. Chemical properties - TSS, titratable acidity, pH, reducing sugar, non-reducing sugar, total sugar, ascorbic acid (Vit. C), pectin
3. Microbial analysis - TPC (Total Plate Count)
4. Sensory Evaluation – Colour, taste, flavour, texture, overall acceptability

2.5 Experimental Work Plan

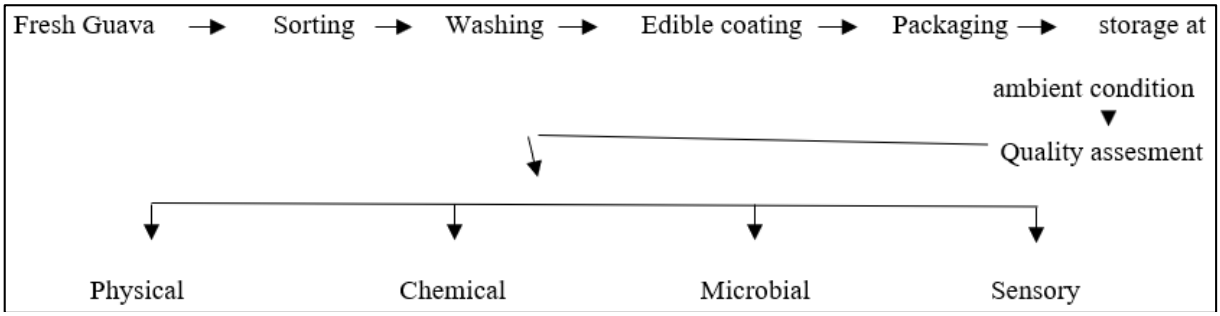

Fig 1: Flow chart of experimental work plan

2.6 Packaging of Control and Coated Guavas

Control and coated guavas were packed in export quality corrugated fiberboard (CFB) packaging boxes as per the treatments.

2.7 Procedure for Storage Study of Guava at Ambient Conditions

Control and coated guavas which were packed in export quality corrugated fiberboard (CFB) packaging boxes were stored at ambient conditions. For storage study, total 16 guava fruits of each treatment i.e. control and coated with edible coating materials i.e. chitosan, beeswax, mineral oil and 1-MCP treated were packed in CFB boxes before conducting its storage study at room temperature for 14 days. Fruits of each treatment which were kept for storage study, they were divided into two sets one for observations on physiological loss in weight and the other for physico-chemical analysis during storage. Average temperature (ºC)

and relative humidity (%) conditions in the storage in environment of guavas in the month of March, 2023. After every two days intervals, two fruits of each treatment were taken out from CFB boxes and used to evaluate its different quality *viz*., physical properties i.e. PLW, firmness; chemical properties i.e. TSS, titratable acidity, pH, reducing sugar, non-reducing sugar, total sugar, ascorbic acid (Vit. C), pectin; microbial analysis i.e. TPC (Total Plate Count) and sensory characteristic evaluation i.e. Colour, taste, flavour, texture, overall acceptability was determined after 2 days of intervals of storage period. The different qualities of each treatment were evaluated by standard procedures and NIR spectrometer.

3. Results and Discussion

3.1 Effect of different coating materials on physiological weight loss of guava during storage

Physiological weight loss per cent for all treatments i.e control, coated and 1-MCP treated guava during the storage period was determined by using standard procedure. From Table 1, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the per cent physiological weight loss of guava was increased from 0 to 5.36, 12.84, 18.69, 25.56, 31.02, 36.78 & 39.40 for control guavas, 0 to 1.02, 6.64, 11.97, 16.74, 21.75, 25.18, & 27.37 1-MCP treated guavas, and 0 to 0.25, 1.27, 5.12, 7.20, 10.72, 13.64 & 16.03 for bees wax coated guava due to loss of weight in fresh fruit is mainly due to the loss of water caused by transpiration and respiration processes. physiological weight loss of guava was increased from 0 to 4.36, 11.34, 17.65, 23.56, 30.02, 35.78, 38.00 for 1% chitosan coated guavas., 0 to 2.82, 7.22, 12.96, 19.03, 25.31, 29.74, 34.37 for 2% chitosan coated guavas and 0 to 2.19, 6.72, 10.99, 15.31, 20.09, 22.93, 26.19 for 3% chitosan coated guavas fruits.

Also from Table 1, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the per cent physiological weight loss of guava was increased from 0 to 2.98, 7.88, 11.93, 15.82, 20.31, 22.94, 26.27 for 0.4 ml mineral oil coated guavas., 0 to 0.93, 5.28, 9.72, 13.83, 18.58, 20.78, 24.38 for 0.8 ml mineral oil coated guavas and 0 to 1.94, 7.72, 12.22, 16.37, 20.94, 24.52, 26.54 for 1.2 ml mineral oil coated guavas fruits.

Table 1: The physiological weight loss (%) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**
T_1: Control	0	5.36	12.84	18.69	25.56	31.02	36.78	39.40
T_2: 1-MCP	0	1.02	6.64	11.97	16.74	21.75	25.18	27.37
T_3: Bees wax (2%)	0	0.25	1.27	5.12	7.20	10.72	13.64	16.03
T_4: Chitosan (1%)	0	4.36	11.34	17.65	23.56	30.02	35.78	38.00
T_5: Chitosan (2%)	0	2.82	7.22	12.96	19.03	25.31	29.74	34.37
T_6: Chitosan (3%)	0	2.19	6.72	10.99	15.31	20.09	22.93	26.19
T_7: Min. oil (0.4 ml)	0	2.98	7.88	11.93	15.82	20.31	22.94	26.27
T_8: Min. oil (0.8 ml)	0	0.93	5.28	9.72	13.83	18.58	20.78	24.38
T_9: Min. oil (1.2 ml)	0	1.94	7.72	12.22	16.37	20.94	24.52	26.54
S.D. %	0	1.66	3.33	4.03	5.38	6.16	7.31	7.34
C.V. %	0	5.13	4.43	7.69	9.11	9.35	10.38	10.41

3.2 Effect of different coating materials on firmness of guava during storage

Firmness for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an Instron Universal Testing Instrument. From Table 2, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the firmness of guava was decreased from 35.90, 31.40, 22.25, 18.14, 15.47, 8.57, 6.12, 5.80 for control guavas, 35.90, 34.60, 30.54, 25.59, 20.63, 14.12, 9.27, 7.98 for 1-MCP treated guavas, and 35.90, 34.90, 31.52, 27.19, 23.25, 17.26, 11.13, 9.98 for bees wax coated guava due to firmness of fresh fruit is mainly due to the loss of water caused by transpiration and respiration processes. Storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the firmness of guava was decreased from 35.90, 32.43, 27.25, 23.29, 17.47, 13.17, 9.42, 7.12 for 1% chitosan coated guavas, 35.90, 32.61, 28.28, 24.50, 18.43, 12.78, 8.29, 7.37 for 2% chitosan coated guavas and 35.90, 32.89, 29.47, 22.11, 18.35, 12.46, 9.41, 7.45 for 3% chitosan coated guavas fruits. As the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the firmness of guava was decreased from 35.90, 32.24, 28.25, 23.45, 17.48, 12.20, 9.01, 8.36 for 0.4 ml mineral oil coated guavas, 35.90, 32.17, 28.54, 22.59, 16.60, 13.92, 8.15, 8.08 for 0.8 ml mineral oil coated guavas and 35.90, 32.46, 29.24, 22.39, 16.15, 13.26, 8.23, 8.10 for 1.2 ml mineral oil coated guavas fruits.

Table 2: Firmness (N) of control and coated fresh guava fruit during storage period:

Treatments	Storage period (days)							
	0	**2**	**4**	**6**	**8**	**10**	**12**	**14**
T_1: Control	35.90	31.40	22.25	18.14	15.47	8.57	6.12	5.80
T_2: 1-MCP	35.90	34.60	30.54	25.59	20.63	14.12	9.27	7.98
T_3: Bees wax (2%)	35.90	34.90	31.52	27.19	23.25	17.26	11.13	9.98
T_4: Chitosan (1%)	35.90	32.43	27.25	23.29	17.47	13.17	9.42	7.12
T_5: Chitosan (2%)	35.90	32.61	28.28	24.50	18.43	12.78	8.29	7.37
T_6: Chitosan (3%)	35.90	32.89	29.47	22.11	18.35	12.46	9.41	7.45
T_7: Min. oil (0.4 ml)	35.90	32.24	28.25	23.45	17.48	12.20	9.01	8.36
T_8: Min. oil (0.8 ml)	35.90	32.17	28.54	22.59	16.60	13.92	8.15	8.08
T_9: Min. oil (1.2 ml)	35.90	32.46	29.24	22.39	16.15	13.26	8.23	8.10
S.D. %	0	1.15	2.63	2.53	2.42	2.26	1.35	1.14
C.V. %	0	3.50	9.27	10.88	13.28	17.28	15.40	14.50

3.3 Effect of different coating materials on TSS of guava during storage

TSS for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an NIR spectrometer. From Table 3, it is observed that the TSS of guava was increased and declined from 9.10, 10.60, 11.50, 11.88 at 0 to 2, 4, 6 days and 11.28, 11.11, 10.50, 10.17 at 8 to 10, 12, 14 days for control guavas, 9.10, 10.49, 11.06, 11.17 at 0 to 2, 4, 6, 8 days and 11.00, 10.27, 10.14, 9.98 at 8 to 10, 12, 14 days for 1-MCP treated guavas, and 9.10, 10.39, 11.18, 11.53 at 0 to 2, 4, 6 days and 11.36, 11.14, 10.89, 10.24 at 8 to 12, 14 days for bees wax coated guava fruit. TSS of guava was increased and declined from 9.10, 10.55, 11.07, 11.60 at 0 to 2, 4, 6 days and 11.03, 10.73, 10.50, 9.78 at 8 to 10, 12, 14 days for 1% chitosan coated guavas, 9.10, 10.53, 11.29, 11.78 at 0 to 2, 4, 6 days and 11.18, 10.88, 10.25, 9.54 at 8 to 10, 12, 14 days for 2% chitosan coated guavas, and 9.10, 10.66, 11.28, 11.61 at 0 to 2, 4, 6 days and 11.42, 10.52, 10.23, 9.25 at 8 to 10, 12, 14 days for 3% chitosan coated guavas fruits.

From Table 3, it is observed that the TSS of guava was increased and declined from 9.10, 10.50, 11.13, 11.73, 11.93 at 0 to 2, 4, 6, 8 days and 11.10, 10.88, 10.54 at 10 to 12, 14 days for 0.4 ml mineral oil coated guavas, 9.10, 10.64, 11.23, 11.59, 11.68 at 0 to 2, 4, 6, 8 days and 11.35, 10.20, 9.98 at 10 to 12, 14 days for 0.8 ml mineral oil coated guavas and 9.10, 10.73, 11.32, 11.66, 11.99 at 0 to 2, 4, 6, 8 days 11.46, 10.69, 10.10 and at 10 to 12, 14 days for 1.2 ml mineral oil coated guavas fruits.

The initial increase in TSS content during storage might be due to hydrolysis of starch into sugars and subsequent declined due to the metabolism of sugars into organic acids during respiration. The delay in the rise of TSS content could be due to the slowing down of respiration and metabolic activity (Hong *et al*. 2012) [6].

Table 3: The TSS (^{0}Brix) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	9.10	10.60	11.50	11.88	11.28	11.11	10.50	10.17
T_2: 1-MCP	9.10	10.49	11.06	11.17	11.00	10.27	10.14	9.98
T_3: Bees wax (2%)	9.10	10.39	11.18	11.53	11.36	11.14	10.89	10.24
T_4: Chitosan (1%)	9.10	10.55	11.07	11.60	11.03	10.73	10.50	9.78
T_5: Chitosan (2%)	9.10	10.53	11.29	11.78	11.18	10.88	10.25	9.54
T_6: Chitosan (3%)	9.10	10.66	11.28	11.61	11.42	10.52	10.23	9.25
T_7: Min. oil (0.4 ml)	9.10	10.50	11.13	11.73	11.93	11.10	10.88	10.54
T_8: Min. oil (0.8 ml)	9.10	10.64	11.23	11.59	11.68	11.35	10.20	9.98
T_9: Min. oil (1.2 ml)	9.10	10.73	11.32	11.66	11.99	11.46	10.69	10.10
S.D. %	0	0.10	0.14	0.20	0.36	0.39	0.29	0.39
C.V. %	0	0.98	1.24	1.72	3.19	3.54	2.79	3.88

3.4 Effect of different coating materials on titratable acidity of guava during storage

Titratable acidity for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using NIR Spectrometer. From Table 4, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the titratable acidity of guava was decreased from 0.51, 0.41, 0.39, 0.35, 0.29, 0.26, 0.23, 0.20 for control guavas, 0.51, 0.44, 0.42, 0.39, 0.36, 0.32, 0.29, 0.26 for 1-MCP treated guavas, and 0.51, 0.44, 0.41, 0.37, 0.38, 0.31, 0.28, 0.25 for bees wax coated guava due to titratable acidity of fresh fruit is mainly due to the loss of water caused by transpiration and respiration processes. storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the titratable acidity of guava was decreased from 0.51, 0.42, 0.40, 0.39, 0.37, 0.34, 0.30, 0.24 for 1% chitosan coated guavas, 0.51, 0.45, 0.40, 0.37, 0.38, 0.31, 0.24, 0.21 for 2% chitosan coated guavas and 0.51, 0.43, 0.42, 0.41, 0.39, 0.34, 0.28, 0.22 for 3% chitosan coated guavas fruits. So it is it cleared that titratable acidity was decreased as the concentration of applied chitosan solution increased from 1% to 2% and 3% and storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days.

Also from Table 4, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the titratable acidity of guava was decreased from 0.51, 0.48, 0.42, 0.40, 0.38, 0.35, 0.29, 0.27 for 0.4 ml mineral oil coated guavas, 0.51, 0.44, 0.40, 0.36, 0.35, 0.31, 0.26, 0.23 for 0.8 ml mineral oil coated guavas and 0.51, 0.47, 0.43, 0.41, 0.43, 0.38, 0.32, 0.28 for 1.2 ml mineral oil coated guavas fruits. The decrease in acidity during storage may be due to the use of organic acid as respiratory substrates during storage and conversion of acid into sugars (Keditsu, *et al*., 2003) [21] and the acidity reduction appears to be a result of ripening process (Rodriguez and Mabery, 2018) [12].

Table 4: The titratable acidity (%) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	0.51	0.41	0.39	0.35	0.29	0.26	0.23	0.20
T_2: 1-MCP	0.51	0.44	0.42	0.39	0.36	0.32	0.29	0.26
T_3: Bees wax (2%)	0.51	0.44	0.41	0.37	0.38	0.31	0.28	0.25
T_4: Chitosan (1%)	0.51	0.42	0.40	0.39	0.37	0.34	0.30	0.24
T_5: Chitosan (2%)	0.51	0.45	0.40	0.37	0.38	0.31	0.24	0.21
T_6: Chitosan (3%)	0.51	0.43	0.42	0.41	0.39	0.34	0.28	0.22
T_7: Min. oil (0.4 ml)	0.51	0.48	0.42	0.40	0.38	0.35	0.29	0.27
T_8: Min. oil (0.8 ml)	0.51	0.44	0.40	0.36	0.35	0.31	0.26	0.23
T_9: Min. oil (1.2 ml)	0.51	0.47	0.43	0.41	0.43	0.38	0.32	0.28
S.D. %	0	0.02	0.01	0.02	0.04	0.03	0.03	0.03
C.V. %	0	5.03	3.23	5.69	10.11	10.35	10.38	11.41

3.5 Effect of different coating materials on pH of guava

From Table 5, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the pH of guava was decreased from 5.40, 5.34, 5.30, 5.24, 4.97, 4.70, 4.59, 3.58 for control guavas, 5.40, 5.24, 5.21, 5.16, 4.85, 4.77, 3.65, 3.20 for 1-MCP treated guavas, and 5.40, 5.10, 5.05, 4.94, 4.86, 4.78, 3.81, 3.15 for bees wax coated guava due to pH of fresh fruit is mainly due to the loss of water caused by transpiration and respiration processes. Storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the pH of guava was decreased from 5.40, 5.22, 5.16, 5.06, 4.91, 4.73, 3.82, 3.00 for 1% chitosan coated guavas, 5.40, 5.14, 5.11, 5.02, 4.78, 4.50, 4.39, 3.68 for 2% chitosan coated guavas and 5.40, 5.12, 5.08, 4.98, 4.87, 4.74, 3.66, 3.50 for 3% chitosan coated guavas fruits. So it is it cleared that pH was decreased as the concentration of applied chitosan solution increased from 1% to 2% and 3% and storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days.

Also from Table 5, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the pH of guava was decreased from 5.40, 5.25, 5.19, 5.11, 4.92, 4.87, 3.71, 3.16 for 0.4 ml mineral oil coated guavas, 5.40, 5.36, 5.25, 5.10, 4.90, 4.67, 4.35, 3.65 for 0.8 ml mineral oil coated guavas and 5.40, 5.28, 5.23, 5.14, 4.87, 4.70, 4.00,

3.87 for 1.2 ml mineral oil coated guavas fruits. So it is cleared that pH was decreased as the volume of applied mineral oil solution used to increased from 0.4 ml to 0.8 ml and 1.2 ml and storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days. The slight decrease in pH might have been to buffering capacity of guava pulp. These are in confirmatory with the finding of Dubey *et al*. (2011) [22].

Table 5: The pH of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	5.40	5.34	5.30	5.24	4.97	4.70	4.59	3.58
T_2: 1-MCP	5.40	5.24	5.21	5.16	4.85	4.77	3.65	3.20
T_3: Bees wax (2%)	5.40	5.10	5.05	4.94	4.86	4.78	3.81	3.15
T_4: Chitosan (1%)	5.40	5.22	5.16	5.06	4.91	4.73	3.82	3.00
T_5: Chitosan (2%)	5.40	5.14	5.11	5.02	4.78	4.50	4.39	3.68
T_6: Chitosan (3%)	5.40	5.12	5.08	4.98	4.87	4.74	3.66	3.50
T_7: Min. oil (0.4 ml)	5.40	5.25	5.19	5.11	4.92	4.87	3.71	3.16
T_8: Min. oil (0.8 ml)	5.40	5.36	5.25	5.10	4.90	4.67	4.35	3.65
T_9: Min. oil (1.2 ml)	5.40	5.28	5.23	5.14	4.87	4.70	4.00	3.87
S.D. %	0	0.09	0.07	0.09	0.05	0.10	0.36	0.30
C.V. %	0	1.78	1.44	1.85	1.09	2.13	8.90	8.77

3.6 Effect of different coating materials on reducing sugar of guava during storage

Reducing sugar for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an NIR spectrometer. From Table 6, it is observed that the reducing sugar of guava was increased and declined from 4.35, 4.50, 5.44, 6.76, 6.80 at 0 to 2, 4, 6, 8 days and 5.30, 4.39, 3.58 at 10 to 12, 14 days for control guavas, 4.35, 4.75, 5.42, 6.70, 7.83 at 0 to 2, 4, 6, 8 days and 5.45, 3.75, 3.20 at 10 to 12, 14 days for 1-MCP treated guavas, and 4.35, 4.38, 5.25, 6.47, 7.19 at 0 to 2, 4, 6, 8 days and 5.31, 3.15, 3.61 at 10 to 12, 14 days for bees wax coated guava fruit. reducing sugar of guava was increased and declined from 4.35, 4.63, 5.02, 6.35 at 0 to 2, 4, 6 days and 6.02, 5.12, 3.52, 3.00 at 8 to 10, 12, 14 days for 1% chitosan coated guavas, 4.35, 4.40, 5.38, 6.41, 7.16 at 0 to 2, 4, 6, 8 days and 5.35, 4.59, 3.68 at 8 to 10, 12, 14 days for 2% chitosan coated guavas, and 4.35, 4.64, 5.37, 6.49, 6.10, 5.58 at 0 to 2, 4, 6, 8 days and 5.58, 3.66, 3.50 at 10 to 12, 14 days for 3% chitosan coated guavas fruits.

From Table 6, it is observed that the reducing sugar of guava was increased and declined from 4.35, 4.57, 5.13, 6.52, 6.59 at 0 to 2, 4, 6, 8 days and 5.20, 3.71, 3.16 at 10 to 12, 14 days for 0.4 ml mineral oil coated guavas, 4.35, 4.47, 5.26, 6.57, 7.22 at 0 to 2, 4, 6, 8 days and 5.37, 4.35, 3.65 at 10 to 12, 14 days for 0.8 ml mineral oil coated guavas and 4.35, 4.70, 5.43, 6.62, 7.35 at 0 to 2, 4, 6, 8 days 5.67, 4.00, 3.87 and at 10 to 12, 14 days for 1.2 ml mineral oil coated guavas fruits.

Table 6: Effect of storage (at 28°C for 14 days) reducing sugar (%) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	4.35	4.50	5.44	6.76	6.20	5.30	4.39	3.58
T_2: 1-MCP	4.35	4.75	5.42	6.70	7.83	5.45	3.75	3.20
T_3: Bees wax (2%)	4.35	4.38	5.25	6.47	7.19	5.25	3.61	3.15
T_4: Chitosan (1%)	4.35	4.63	5.02	6.35	6.02	5.12	3.52	3.00
T_5: Chitosan (2%)	4.35	4.40	5.38	6.41	7.16	5.35	4.59	3.68
T_6: Chitosan (3%)	4.35	4.64	5.37	6.49	6.10	5.58	3.66	3.50
T_7: Min. oil (0.4 ml)	4.35	4.57	5.13	6.52	6.59	5.20	3.71	3.16
T_8: Min. oil (0.8 ml)	4.35	4.47	5.26	6.57	7.22	5.37	4.35	3.65
T_9: Min. oil (1.2 ml)	4.35	4.70	5.43	6.62	7.35	5.67	4.00	3.87
S.D. %	0	0.13	0.15	0.13	0.64	0.18	0.39	0.30
C.V. %	0	2.87	2.78	2.04	9.38	3.30	9.99	8.77

3.7 Effect of different coating materials on non-reducing sugar of guava during storage

Non-reducing sugar for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an NIR spectrometer. From Table 7, it is observed that the non-reducing sugar of guava was increased and declined from 4.37, 4.39, 4.58, 4.65 at 0 to 2, 4, 6 days and 4.00, 3.02, 2.15, 1.25 at 8 to 10, 12, 14 days for control guavas, 4.37, 4.51, 4.69, 5.00, 5.20 at 0 to 2, 4, 6, 8 days and 4.20, 2.25, 1.60 at 10 to 12, 14 days for 1-MCP treated guavas, and 4.37, 4.78, 5.15, 5.37, 5.45 at 0 to 2, 4, 6, 8 days and 4.28, 2.47, 2.09 at 10 to 12, 14 days for bees wax coated guava fruit. non-reducing sugar of guava was increased and declined from 4.37, 4.49, 4.54, 4.98 at 0 to 2, 4, 6, 8 days and 4.58, 3.87, 2.61, 1.89 at 10 to 12, 14 days for 1% chitosan coated guavas, 4.37, 4.43, 4.65, 4.87 at 0 to 2, 4, 6, 8 days and 4.24, 3.97, 2.58, 1.87 at 10 to 12, 14 days for 2% chitosan coated guavas, and 4.37, 4.62, 4.89, 5.10 at 0 to 2, 4, 6, 8 days and 4.50, 3.65, 2.87, 1.65 at 10 to 12, 14 days for 3% chitosan coated guavas fruits.

From Table 7, it is observed that the non-reducing sugar of guava was increased and declined from 4.37, 4.54, 4.78, 5.42 at 0 to 2, 4, 6, 8 days and 4.47, 3.51, 2.31, 1.56 at 10 to 12, 14 days for 0.4 ml mineral oil coated guavas, 4.37, 4.44, 4.75, 4.95 at 0 to 2, 4, 6, 8 days and 4.32, 3.14, 2.43, 1.74 at 10 to 12, 14 days for 0.8 ml mineral oil coated guavas and 4.37, 4.56, 4.80, 5.05 at 0 to 2, 4, 6, 8 days and 4.68, 3.45, 2.28, 1.32 at 10 to 12, 14 days for 1.2 ml mineral oil coated

guavas fruits.

From Table 7 it was observed the standard deviation and coefficient of variance related to data of non-reducing sugar observed for all treatments i.e control, coated and 1-MCP treated guava during the different storage period 0, 2, 4, 6, 8, 10, 12, 14 days were found as 0, 0.12, 0.18, 0.24, 0.48, 0.44, 0.22, 0.27 and 0, 2.60, 3.85, 4.71, 10.18, 12.01, 9.13, 16.27, respectively.

Table 7: The non-reducing sugar (%) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	4.37	4.39	4.58	4.65	4.00	3.02	2.15	1.25
T_2: 1-MCP	4.37	4.51	4.69	5.00	5.20	4.20	2.25	1.60
T_3: Bees wax (2%)	4.37	4.78	5.15	5.37	5.45	4.28	2.47	2.09
T_4: Chitosan (1%)	4.37	4.49	4.54	4.98	4.58	3.87	2.61	1.89
T_5: Chitosan (2%)	4.37	4.43	4.65	4.87	4.24	3.97	2.58	1.87
T_6: Chitosan (3%)	4.37	4.62	4.89	5.10	4.50	3.65	2.87	1.65
T_7: Min. oil (0.4 ml)	4.37	4.54	4.78	5.42	4.47	3.51	2.31	1.56
T_8: Min. oil (0.8 ml)	4.37	4.44	4.75	4.95	4.32	3.14	2.43	1.74
T_9: Min. oil (1.2 ml)	4.37	4.56	4.80	5.05	4.68	3.45	2.28	1.32
S.D. %	0	0.12	0.18	0.24	0.48	0.44	0.22	0.27
C.V. %	0	2.60	3.85	4.71	10.18	12.01	9.13	16.27

3.8 Effect of different coating materials on total sugar of guava during storage

Total sugar for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an NIR spectrometer. From Table 8, it is observed that the total sugar of guava was increased and declined from 6.21, 6.45, 6.98, 7.14 at 0 to 2, 4, 6 days and 7.00, 6.34, 5.03, 3.76 at 8 to 10, 12, 14 days for control guavas, 6.21, 6.58, 7.01, 7.68, 7.97 at 0 to 2, 4, 6, 8 days and 7.13, 5.90, 4.89 at 10 to 12, 14 days for 1-MCP treated guavas, and 6.21, 6.31, 7.25, 7.59, 8.00 at 0 to 2, 4, 6, 8 days and 7.64, 6.74, 5.00 at 10 to 12, 14 days for bees wax coated guava fruit. total sugar of guava was increased and declined from 6.21, 6.65, 6.87, 7.50, 7.83 at 0 to 2, 4, 6, 8 days and 7.01, 5.39, 4.98 at 10 to 12, 14 days for 1% chitosan coated guavas, 6.21, 6.43, 6.69, 7.65, 7.88 at 0 to 2, 4, 6, 8 days and 7.14, 5.76, 3.50 at 10 to 12, 14 days for 2% chitosan coated guavas, and 6.21, 6.29, 7.58, 8.21, 8.89 at 0 to 2, 4, 6, 8 days and 7.19, 5.81, 4.36 at 10 to 12, 14 days for 3% chitosan coated guavas fruits.

From Table 8, it is observed that the total sugar of guava was increased and declined from 6.21, 6.35, 7.54, 8.30, 8.44 at 0 to 2, 4, 6, 8 days and 7.35, 6.65, 5.45 at 10 to 12, 14 days for 0.4 ml mineral oil coated guavas, 6.21, 6.38, 7.10, 7.26, 7.32 at 0 to 2, 4, 6, 8 days and 7.25, 5.32, 4.21 at 10 to 12, 14 days for 0.8 ml mineral oil coated guavas and 6.21, 6.25, 7.25, 7.30, 7.44 at 0 to 2, 4, 6, 8 days and 7.12, 5.45, 3.56 at 10 to 12, 14 days for 1.2 ml mineral oil coated guavas fruits.

Table 8: The total sugar (%) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	6.21	6.45	6.98	7.14	7.00	6.34	5.03	3.76
T_2: 1-MCP	6.21	6.58	7.01	7.68	7.97	7.13	5.90	4.89
T_3: Bees wax (2%)	6.21	6.31	7.25	7.59	8.00	7.64	6.74	5.00
T_4: Chitosan (1%)	6.21	6.65	6.87	7.50	7.83	7.01	5.39	4.98
T_5: Chitosan (2%)	6.21	6.43	6.69	7.65	7.88	7.14	5.76	3.50
T_6: Chitosan (3%)	6.21	6.29	7.58	8.21	8.89	7.19	5.81	4.36
T_7: Min. oil (0.4 ml)	6.21	6.35	7.54	8.30	8.44	7.35	6.65	5.45
T_8: Min. oil (0.8 ml)	6.21	6.38	7.10	7.26	7.32	7.25	5.32	4.21
T_9: Min. oil (1.2 ml)	6.21	6.25	7.25	7.30	7.44	7.12	5.45	3.56
S.D. %	0	0.13	0.30	0.40	0.57	0.35	0.58	0.71
C.V. %	0	2.09	4.13	5.27	7.30	4.87	10.10	16.03

3.9 Effect of different coating materials on ascorbic acid (Vit. C) guava during storage

Ascorbic acid for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an NIR spectrometer. From Table 9, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the ascorbic acid of guava was decreased from 200.5, 197.5, 188.0, 179.0, 170.9, 162.2, 155.4, 142.2 for control guavas, 200.5, 194.6, 187.6, 184.2, 178.4, 168.8, 159.6, 148.0 for 1-MCP treated guavas, and 200.5, 198.8, 190.1, 185.6, 179.4, 167.2, 160.3, 152.9 for bees wax coated guava due to ascorbic acid of fresh fruit is mainly due to the loss of water caused by transpiration and respiration processes. Storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the ascorbic acid of guava was decreased from 200.5, 197.1, 189.8, 183.2, 175.6, 165.0, 159.2, 146.7 for 1% chitosan coated guavas, 200.5, 197.3, 186.9, 181.3, 172.1, 169.2, 154.3, 149.1 for 2% chitosan coated guavas and 200.5, 198.2, 188.2, 185.7, 176.4, 164.9, 152.1, 145.0 for 3% chitosan coated guavas fruits.

Also from Table 9, it is observed that as the storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days, the ascorbic acid of guava was decreased from 200.5, 196.0, 186.7, 182.0, 180.2, 168.1, 150.0, 143.4 for 0.4 ml mineral oil coated guavas, 200.5, 196.4, 189.3, 183.2, 179.3, 168.0, 155.0, 146.0 for 0.8 ml mineral oil coated guavas and 200.5, 197.6, 187.4, 182.8, 177.0, 169.8, 162.2, 148.2 for 1.2 ml mineral oil coated guavas fruits. So it is cleared that

ascorbic acid was decreased as the volume of applied mineral oil solution used to increase from 0.4 ml to 0.8 ml and 1.2 ml and storage period increased from 0 days to 2, 4, 6, 8, 10, 12, 14 days.

Table 9: Effect of storage (at 28°C for 14 days) ascorbic acid (Vit. C) (mg/100 g) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	200.5	197.5	188.0	179.0	170.9	162.2	155.4	142.2
T_2: 1-MCP	200.5	194.6	187.6	184.2	178.4	168.8	159.6	148.0
T_3: Bees wax (2%)	200.5	198.8	190.1	185.6	179.4	167.2	160.3	152.9
T_4: Chitosan (1%)	200.5	197.1	189.8	183.2	175.6	165.0	159.2	146.7
T_5: Chitosan (2%)	200.5	197.3	186.9	181.3	172.1	169.2	154.3	149.1
T_6: Chitosan (3%)	200.5	198.2	188.2	185.7	176.4	164.9	152.1	145.0
T_7: Min. oil (0.4 ml)	200.5	196.0	186.7	182.0	180.2	168.1	150.0	143.4
T_8: Min. oil (0.8 ml)	200.5	196.4	189.3	183.2	179.3	168.0	155.0	146.0
T_9: Min. oil (1.2 ml)	200.5	197.6	187.4	182.8	177.0	169.8	162.2	148.2
S.D. %	0	1.25	1.24	2.11	3.26	2.49	4.09	3.21
C.V. %	0	0.63	0.66	1.15	1.85	1.49	2.61	2.19

3.10 Effect of different coating materials on pectin of guava during storage

Pectin for all treatments i.e control, coated and 1-MCP treated guava during the storage period was measured by using an NIR spectrometer. From Table 10, it is observed that the pectin of guava was increased and declined from 0.69, 0.72, 0.78, 0.90 at 0 to 2, 4, 6 days and 0.87, 0.75, 0.60, 0.55 at 8 to 10, 12, 14 days for control guavas, 0.69, 0.75, 0.80, 0.82, 0.88 at 0 to 2, 4, 6, 8 days and 0.85, 0.75, 0.60 at 10 to 12, 14 days for 1-MCP treated guavas, and 0.69, 0.71, 0.75, 0.80, 0.91, 0.93 at 0 to 2, 4, 6, 8, 10 days and 0.80, 0.71 at 12 and 14 days for bees wax coated guava fruit. pectin of guava was increased and declined from 0.69, 0.78, 0.80, 0.85 at 0 to 2, 4, 6 days and 0.81, 0.78, 0.65, 0.59 at 8 to 10, 12, 14 days for 1% chitosan coated guavas, 0.69, 0.76, 0.81, 0.84, 0.84 at 0 to 2, 4, 6, 8 days and 0.82, 0.71, 0.61, at 10 to 12, 14 days for 2% chitosan coated guavas, and 0.69, 0.75, 0.85, 0.87, 0.90 at 0 to 2, 4, 6, 8 days and 0.87, 0.74, 0.58 at 10 to 12, 14 days for 3% chitosan coated guavas fruits. It is observed that the pectin of guava was increased and declined from 0.69, 0.72, 0.83, 0.89 at 0 to 2, 4, 6 days and 0.85, 0.81, 0.69, 0.55 at 8 to 10, 12, 14 days for 0.4 ml mineral oil coated guavas, 0.69, 0.70, 0.84, 0.86, 0.89 at 0 to 2, 4, 6, 8 days and 0.85, 0.70, 0.62 at 10 to 12, 14 days for 0.8 ml mineral oil coated guavas and 0.69, 0.78, 0.87, 0.89, 0.93, 0.94 at 0 to 2, 4, 6, 8, 10 days and 0.85, 0.63 at 12 and 14 days for 1.2 ml mineral oil coated guavas fruits.

Table 10: The pectin (%) of control and coated fresh guava fruit during storage period

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	0.69	0.72	0.78	0.90	0.87	0.75	0.60	0.55
T_2: 1-MCP	0.69	0.75	0.80	0.82	0.88	0.85	0.75	0.60
T_3: Bees wax (2%)	0.69	0.71	0.75	0.80	0.91	0.93	0.80	0.71
T_4: Chitosan (1%)	0.69	0.78	0.80	0.85	0.81	0.78	0.65	0.59
T_5: Chitosan (2%)	0.69	0.76	0.81	0.84	0.84	0.82	0.71	0.61
T_6: Chitosan (3%)	0.69	0.75	0.85	0.87	0.90	0.87	0.74	0.58
T_7: Min. oil (0.4 ml)	0.69	0.72	0.83	0.89	0.85	0.81	0.69	0.55
T_8: Min. oil (0.8 ml)	0.69	0.70	0.84	0.86	0.89	0.85	0.70	0.62
T_9: Min. oil (1.2 ml)	0.69	0.78	0.87	0.89	0.93	0.94	0.85	0.63
S.D. %	0	0.03	0.04	0.03	0.04	0.06	0.08	0.05
C.V. %	0	4.02	4.56	3.94	4.28	7.49	10.43	8.02

3.11 Effect of different coating materials on total plate count of guava during storage

Total plate counts were found absent before all treatments of guava fruit at initial stage. From the Table 11, it is clear that total plate counts of the fruit increased with increase in storage period in control, coated and 1-MCP treated. However, it was found present in the control, coated and 1-MCP treated throughout storage period. During the storage period, early total plate count was found for control sample at 4^{th} day of storage followed by chitosan (1%) at 8^{th} day of storage, chitosan (3%) at 10^{th} day of storage, chitosan (2%) at 10^{th} day of storage, mineral oil (0.4 ml) at 12^{th} day of storage, mineral oil (0.8 ml) at 12^{th} day of storage, 1-MCP at 12^{th} day of storage and mineral oil (1.2 ml) at 14^{th} day of storage. Minimum total plate counts was recorded in bees wax coated guava fruit (7×10^2 cfu/g) and maximum total plate counts was recorded in control at room temperature (9×10^4 cfu/g) at the end of storage period. These results for total plate counts are in agreement with Bialka and Demirci (2007) [23] in raspberry and strawberry.

Table 11: The total plate count (cfu/g) of control and coated fresh guava fruit during storage period:

Treatments	Storage period (days)							
	0	2	4	6	8	10	12	14
T_1: Control	Ab	Ab	2×10^2	9×10^2	11×10^2	4×10^4	8×10^4	9×10^4
T_2: 1-MCP	Ab	Ab	Ab	Ab	Ab	Ab	10×10^2	13×10^2
T_3: Bees wax (2%)	Ab	Ab	Ab	Ab	Ab	Ab	Ab	7×10^2
T_4: Chitosan (1%)	Ab	Ab	Ab	Ab	4×10^2	8×10^2	15×10^2	30×10^2
T_5: Chitosan (2%)	Ab	Ab	Ab	Ab	Ab	9×10^2	18×10^2	35×10^2
T_6: Chitosan (3%)	Ab	Ab	Ab	Ab	Ab	10×10^2	19×10^2	25×10^2
T_7: Min. oil (0.4 ml)	Ab	Ab	Ab	Ab	Ab	Ab	25×10^2	33×10^2
T_8: Min. oil (0.8 ml)	Ab	Ab	Ab	Ab	Ab	Ab	21×10^2	30×10^2
T_9: Min. oil (1.2 ml)	Ab	Ab	Ab	Ab	Ab	Ab	Ab	29×10^2

Conclusions

The edible coatings 1-MCP, chitosan, mineral oil and beeswax (BW) applied to guavas harvested green and stored for 15 days at 35 °C from natural origin with low cost could be a good option to increase the shelf-life of guava.

The results of permeability to water vapour and to aroma showed that the efficiency of edible packaging preserving guava depend on retention of hydrophobic elements more than water vapour. 1-MCP and Mineral oil coatings not only better improved the visual attributes of guava but also efficiently retained the nutritional parameters by retarding

the respiration rate and thereby delaying senescence than the control sample and the other coating like chitosan and bee wax. The effect on fruit ripening was indicated by retarded respiratory climacteric, delayed peel colour development, TSS accumulation and changes in titratable acidity, decreased fruit softening and weight loss, retained ascorbic acid content and maintained overall quality of the fruits The main benefits were the reduction in mass loss, maintenance of green colour and firmness retention. 1-MCP and Mineral oil coatings not only better improved the visual attributes of guava but also efficiently retained the nutritional parameters in term of the sensorial characteristics by retarding the respiration rate and thereby delaying senescence. Maximum increased in shelf life of the edible coatings 1-MCP, mineral oil, chitosan and beeswax as compared to control sample days (2 days) was found 8,8,6,4 days respectively.

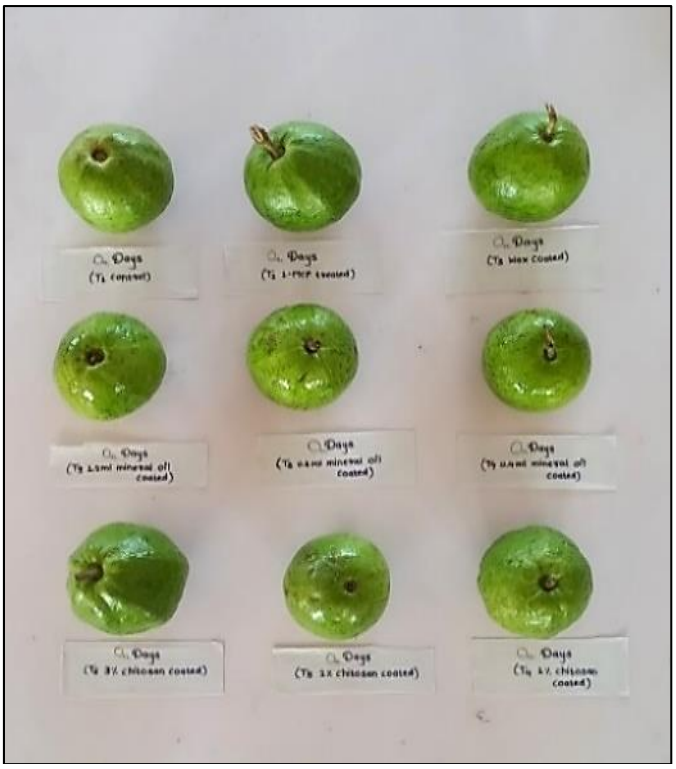

Plate 1(a): 0th Day

Plate 1(b): 2th Day

Plate 1(c): 4th Day

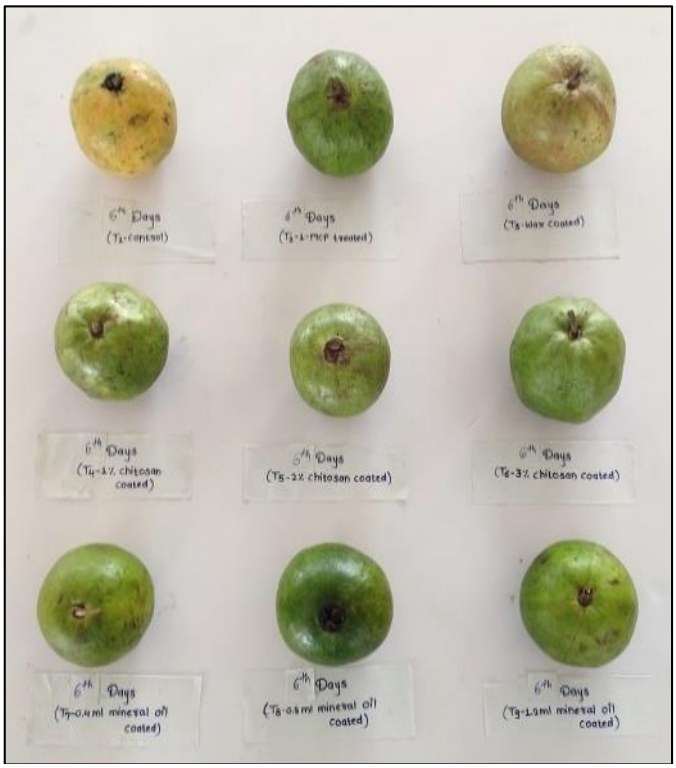

Plate 1(d): 6th Day

Plate 1(e): 8th Day

Plate 1(f): 10th Day

Plate 1(g): 12th Day

Plate 1(h): 14th Day

Plate 1: Photographs of stored sample during storage study

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