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Effect of Edible Coating and Packaging on Physiological and Sensory Attributes of Litchi (*Litchi chinensis* Sonn.) Fruits

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A B S T R A C T

An experiment was conducted to study the effect of edible coating and packaging material on physiological and sensory quality of litchi fruits. For this, mature litchi fruits were harvested from HRC, Patharchatta and the selected fruits were treated with Guar Gum, Xanthan Gum and Methyl cellulose (low viscosity and high viscosity)as edible coating at different concentration (0.5%, 1.0%, 2.0%, 2.5%) and stored at 4 ± 1 °C under 90 ± 5% RH. The results revealed that edible coating significantly influenced the fruit quality. The physiological loss in fruit weight, shrinkage in fruit length and breadth, volume and sensory characteristics was significantly improved with 0.15% guar gum along with packaging in perforated brown paper bag.

Introduction

Litchi (*Litchi chinensis* Sonn.) is an important sub-tropical fruit with high commercial value in the local as well as international market. However, once detached from the tree, the fruit loses its qualities, including sweet and juicy flesh and attractive bright red pericarp colour, within a couple of days under ambient storage temperatures. The short storage life of litchi limits the marketing of the litchi fruit and has become one of the major constraints in litchi industry, where a huge production happens in a short season from mid-May to early July (Huang, 2002). Generally, rapid cooling after harvest and storage at low temperature are one of the most prevalent methods for maintaining the appearance and quality of litchi fruit. It means that the ambient temperature is one of the most important factors affecting the litchi fruit commercial value (Lin *et al.*, 2011). Harvested litchi fruits are a living organism which breaths continuously during storage process. The respiration produces the bio-heat and causes the rise of temperature of fruit group that accelerates water loss and browning (Baldwin *et al.*, 1995). Postharvest browning of litchi fruit was generally thought to be a rapid degradation of anthocyanins

caused by polyphenol oxidase, producing brown by-products (Jiang, 2000). Postharvest treatments, including Sulphur fumigation and acid dip can effectively inhibited polyphenol oxidase activity and thus delay loss of red pericarp colour of litchi fruit (Zauberman *et al.,* 1991). Therefore, there is a need for alternative novel practices to control respiration rate of the produce which automatically reduces the bio-heat and the resulting fruit temperature change during handling, distribution and retail sale without toxic effects in harvested litchi fruits (Jiang *et al.,* 2003). Application of edible coatings is promising to improve the quality and extend shelf life of produce. There are several advantages associated with edible coatings like, they may be eaten by the consumers along with food, and their use could reduce the waste and solve the solid disposal problem. Besides, they also enhance the organoleptic, mechanical or nutritional properties of fruit, and they can reduce the cost by utilizing byproducts. Attempts to reduce crop losses and maintaining the quality of fresh fruit over a long period of time are a priority for all the producers of horticultural crops.Keeping in views the importance and perish ability nature of litchi fruits, an attempt has been made in the present study to evaluate the effect of packing and edible coating on shelf life and physical characteristics of litchi fruits by applying Xanthan gum, guar gum and methylcellulose as coating materials.

Materials and Methods

The present experiment was carried out in the Post-graduate Laboratory, Department of Horticulture, GBPU&T Pantnagar, U.S. Nagar, Uttarakhand. The fruits were collected from HRC, Patharchatta located at the North-West Plains of *Tarai* region of Uttarakhand at an altitude of 243.83 meters above the mean sea level. There was a total of 17 treatments combination i.e. without coating + without packaging material (T_0); Without coating + Perforated brown paper bag(T_1); Guar Gum 0.5% (T_2); Guar Gum 1.0% (T_3); Guar Gum 1.5% (T_4); Guar Gum 2.0% (T_5); Xanthan Gum 0.5% (T_6); Xanthan Gum 1.0 % (T_7); Xanthan Gum 1.5% (T_8); Xanthan Gum 2.0% (T_9); Methyl Cellulose (low viscosity) 0.5% (T_{10}); Methyl Cellulose (low viscosity) 1.0% (T_{11}); Methyl Cellulose (low viscosity) 1.5% (T_{12}); Methyl Cellulose (low viscosity) 2.0% (T_{13});Methyl Cellulose (high viscosity) 0.5% (T_{14}); Methyl Cellulose (high viscosity) 1.0% (T_{15}); Methyl Cellulose (high viscosity) 1.5% (T_{16}) and Methyl Cellulose (high viscosity) 2% (T_{17}) with 3 replication. Xanthan and guar gum solutions were prepared as per method given by Ruelas-Chacón *et al.,* 2017. The methyl cellulose solution (both low viscosity and high viscosity) was prepared by solubilizing the methyl cellulose powder in a mixture of water and ethyl alcohol (2: 1) at 75 ° C in a high-speed mixer (900 rpm) for 15 minutes.

In all the treatments, glycerol (1%) was added as plasticizer and ascorbic acid (1%) as an antioxidant. After uniform application of all the coating materials, fruits were placed in the perforated brown paper bags. There after packaged fruits were stored at low temperature (4°C±l°C) and 85-90% related humidity in a refrigerator for further studies. Observations were recorded at two days interval (0, 2, 4, 6, 8, 10 and 12th day). Fruit length and breadth was measured with the help of digital Vernier calipers. The water displacement method was used to measured volume of the litchi fruits. On initial day fruits were weighed on an electronic weighing balance and were reweighed at 2 days interval. The weight loss was determined and expressed as percent loss from initial weight. Organoleptic evaluation was carried out on the basis of fruit appearance (colour), taste and flavor. It was assessed on the basis of scoring, as per the hedonic scale ranging from

9 to 1, where 9 being the most favorable one noted as "like extremely" and 1 being the least acceptable determined as "dislike extremely". The data was analyzed on two factorial completely randomized design (Factorial C.R.D.) as described by Snedecor and Cochran (1987).

Results and Discussion

Physiological loss in weight (%)

In the present experiment, it was observed that packaging and edible coatings significantly affected the physiological loss in weight with the advancement of the storage duration (Table 1). The maximum loss in the physiological weight (7.17 %) was recorded in T_0*i.e.* fruits without coating and packaging, followed by T_1 *i.e.* fruits without coating and packed in perforated brown paper bag (7.08%); whereas, the minimum physiological loss in weight (5.41%) was recorded in fruits coated with 1.5 per cent guar gum and packed in perforated brown paper bags.

The mean values regarding storage period revealed that there was sharp increase in per cent physiological loss in weight from 6th to 12thday. The reduction in physiological loss in weight in coated fruits was probably due to the effect of these coating materials acting as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration rate, water loss and oxidation reaction rates (Baldwin *et al.*, 1999).

Table.1 Effect of different treatments and storage intervals on the physiological loss in weight (%) of litchi fruits

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A
T_0	0.00	2.52	4.40	6.51	10.22	12.63	13.88	7.17
T_1	0.00	2.25	4.34	6.30	10.10	12.66	13.72	7.08
T_2	0.00	2.52	4.26	6.12	8.43	11.44	12.60	6.48
T_3	0.00	1.19	3.11	5.23	8.93	11.27	12.30	6.00
T_4	0.00	1.14	2.96	4.99	7.73	10.06	10.98	5.41
T_5	0.00	2.17	4.09	6.21	9.91	12.25	13.27	6.84
T_6	0.00	1.88	3.80	5.92	9.62	11.96	12.99	6.60
T_7	0.00	2.52	4.26	6.12	8.43	11.44	12.60	6.48
T_8	0.00	1.65	3.57	5.69	9.39	11.73	12.76	6.40
T_9	0.00	1.17	3.00	4.99	7.99	10.32	11.29	5.54
T_{10}	0.00	2.44	4.36	6.48	10.18	12.52	13.55	7.05
T_{11}	0.00	1.35	3.27	5.39	9.09	11.43	12.46	6.14
T_{12}	0.00	1.24	3.16	5.28	8.98	11.32	12.35	6.05
T_{13}	0.00	2.16	4.08	6.20	9.90	12.24	13.27	6.84
T_{14}	0.00	2.36	4.28	6.40	10.10	12.44	13.47	7.01
T_{15}	0.00	1.55	3.47	5.59	9.29	11.63	12.66	6.31
T_{16}	0.00	1.90	3.82	5.94	9.64	11.98	12.88	6.60
T_{17}	0.00	2.12	4.04	6.16	9.86	12.20	13.23	6.80
Mean B	0.00	1.90	3.79	5.86	9.32	11.75	12.79	

Factors	C.D.	SE(m)
Factor(A)	0.14	0.05
Factor(B)	0.09	0.03
Factor (A X B)	0.38	0.14

Table.2 Effect of different treatments and storage intervals on fruit length (mm) of litchi

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A	Shrinkage %
T_0	34.64	34.61	34.54	34.46	34.41	34.39	33.24	34.33	**4.04**
T_1	34.14	33.94	33.75	33.44	33.29	33.09	32.89	33.51	**3.66**
T_2	34.41	34.24	34.03	33.73	33.57	33.40	33.19	33.80	3.55
T_3	34.64	34.47	34.26	33.96	33.79	33.63	33.42	34.02	3.52
T_4	34.71	34.66	34.50	34.36	34.23	34.05	33.86	34.34	**2.45**
T_5	34.75	34.58	34.37	34.07	33.91	33.74	33.53	34.14	3.51
T_6	35.14	34.97	34.76	34.46	34.30	34.13	33.92	34.53	3.47
T_7	34.27	34.10	33.90	33.60	33.43	33.26	33.05	33.66	3.56
T_8	34.31	34.14	33.93	33.63	33.47	33.30	33.10	33.70	3.53
T_9	35.10	34.93	34.72	34.42	34.26	34.09	33.88	34.49	3.48
T_{10}	34.71	34.54	34.33	34.03	33.87	33.70	33.49	34.10	3.51
T_{11}	34.67	34.50	34.30	34.00	33.83	33.66	33.48	34.06	3.43
T_{12}	35.32	35.15	34.95	34.65	34.48	34.31	34.10	34.71	3.45
T_{13}	34.51	34.34	34.14	33.84	33.67	33.51	33.32	33.91	3.45
T_{14}	34.21	34.04	33.84	33.54	33.37	33.20	32.99	33.60	**3.57**
T_{15}	35.10	34.93	34.73	34.43	34.26	34.09	33.88	34.49	3.48
T_{16}	34.73	34.56	34.36	34.06	33.89	33.72	33.51	34.12	3.51
T_{17}	35.40	35.23	35.03	34.73	34.56	34.39	34.18	34.79	3.45
Mean B	34.71	34.55	34.36	34.08	33.92	33.76	33.50		

Factors	C.D.	SE(m)
Factor(A)	0.54	0.19
Factor(B)	0.33	0.12
Factor (A X B)	N/A	0.51

Table.3 Effect of different treatments and storage intervals on the fruit breadth (mm) of litchi

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A	Shrinkage %
T_0	32.09	31.98	31.78	31.48	31.28	31.11	30.00	31.39	**6.51**
T_1	32.08	31.97	31.77	31.47	31.27	31.11	30.02	31.39	**6.42**
T_2	32.05	31.94	31.74	31.44	31.24	31.07	30.95	31.49	3.43
T_3	32.07	31.96	31.76	31.46	31.26	31.09	30.97	31.51	3.43
T_4	31.90	31.81	31.72	31.63	31.54	31.45	31.34	31.63	**1.76**
T_5	31.56	31.45	31.25	30.95	30.75	30.58	30.46	31.00	3.49
T_6	31.93	31.82	31.62	31.32	31.12	30.95	30.83	31.37	3.45
T_7	32.14	32.03	31.83	31.53	31.33	31.16	31.04	31.58	3.42
T_8	32.33	32.22	32.02	31.72	31.52	31.35	31.23	31.77	3.40
T_9	32.08	31.97	31.77	31.47	31.27	31.11	30.99	31.52	3.40
T_{10}	32.07	31.91	31.75	31.59	31.43	31.27	31.12	31.59	**2.96**
T_{11}	31.55	31.44	31.24	30.94	30.74	30.58	30.45	30.99	3.49
T_{12}	31.90	31.79	31.59	31.29	31.09	30.92	30.80	31.34	3.45
T_{13}	32.42	32.31	32.11	31.81	31.61	31.44	31.34	31.86	3.33
T_{14}	32.06	31.95	31.75	31.45	31.25	31.09	30.97	31.50	3.40
T_{15}	31.88	31.77	31.57	31.27	31.07	30.90	30.78	31.32	3.45
T_{16}	32.09	31.98	31.78	31.48	31.28	31.11	30.99	31.53	3.43
T_{17}	31.85	31.74	31.54	31.24	31.04	30.88	30.76	31.29	3.42
Mean B	32.00	31.89	31.70	31.42	31.23	31.07	30.84		

Factors	C.D.	SE(m)
Factor (A)	0.46	0.17
Factor (B)	0.29	0.10
Factor (A X B)	N/A	0.44

Table.4 Effect of different treatments and storage intervals on the volume (ml) of litchi fruits

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A	% decrease
T_0	21.25	20.90	20.35	20.05	19.78	19.36	18.98	20.10	**10.68**
T_1	21.23	20.95	20.48	20.13	19.85	19.44	19.14	20.17	**9.84**
T_2	21.12	20.84	20.39	20.07	19.79	19.38	19.17	20.11	9.23
T_3	21.19	21.02	20.82	20.65	20.39	20.15	19.89	20.59	6.13
T_4	21.27	21.07	20.86	20.64	20.48	20.24	20.11	20.67	**5.45**
T_5	21.21	20.94	20.49	20.17	19.89	19.48	19.27	20.21	9.15
T_6	21.12	20.84	20.39	20.08	19.79	19.38	19.18	20.11	9.19
T_7	21.24	20.96	20.51	20.19	19.91	19.50	19.29	20.23	9.18
T_8	21.13	20.85	20.41	20.09	19.81	19.40	19.19	20.13	9.18
T_9	21.29	21.12	20.92	20.75	20.49	20.25	20.13	20.71	**5.45**
T_{10}	21.34	21.06	20.61	20.29	20.01	19.60	19.39	20.33	9.14
T_{11}	21.02	20.74	20.29	19.97	19.69	19.28	19.07	20.01	9.28
T_{12}	21.15	21.02	20.88	20.67	20.45	20.18	19.96	20.62	5.63
T_{13}	21.28	21.00	20.55	20.23	19.95	19.54	19.33	20.27	9.16
T_{14}	21.32	21.04	20.59	20.27	19.99	19.58	19.37	20.31	9.15
T_{15}	20.91	20.65	20.20	19.88	19.60	19.19	18.98	19.92	9.23
T_{16}	21.15	20.87	20.42	20.10	19.82	19.41	19.20	20.14	9.22
T_{17}	21.22	20.94	20.49	20.18	19.90	19.49	19.28	20.21	9.14
Mean B	21.19	20.93	20.54	20.25	19.98	19.60	19.39		

Factors	C.D.	SE(m)
Factor(A)	0.33	0.12
Factor(B)	0.21	0.07
Factor (A X B)	N/A	0.31

Table.5 Effect of different treatments and storage intervals on appearance of litchi fruits

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A
T_0	9.00	6.42	6.14	5.92	5.80	5.69	4.45	**6.20**
T_1	9.00	7.02	6.68	6.34	5.78	5.34	4.20	**6.34**
T_2	9.00	7.75	7.48	7.25	7.08	6.93	5.89	7.34
T_3	9.00	7.54	7.28	7.05	6.88	6.73	5.69	7.17
T_4	9.00	8.21	7.94	7.71	7.54	7.39	6.40	**7.74**
T_5	9.00	7.23	6.97	6.65	6.48	6.33	5.25	6.85
T_6	9.00	7.12	6.86	6.63	6.46	6.31	5.27	6.81
T_7	9.00	7.52	7.26	7.03	6.86	6.71	5.67	7.15
T_8	9.00	7.44	7.18	6.95	6.78	6.63	5.59	7.08
T_9	9.00	8.05	7.79	7.56	7.39	7.24	6.25	**7.61**
T_{10}	9.00	7.82	7.56	7.33	7.16	7.01	5.97	7.41
T_{11}	9.00	7.74	7.48	7.25	7.08	6.93	5.89	7.34
T_{12}	9.00	7.98	7.72	7.49	7.32	7.17	6.20	**7.56**
T_{13}	9.00	6.98	6.72	6.49	6.32	6.17	5.13	6.69
T_{14}	9.00	7.47	7.21	6.98	6.81	6.66	5.62	7.11
T_{15}	9.00	7.23	6.97	6.76	6.59	6.44	5.40	6.91
T_{16}	9.00	7.04	6.78	6.55	6.38	6.23	5.19	6.74
T_{17}	9.00	7.13	6.87	6.64	6.47	6.32	5.28	6.82
Mean B	9.00	7.43	7.16	6.92	6.73	6.57	5.52	

Factors	C.D.	SE(m)
Factor(A)	0.10	0.03
Factor(B)	0.06	0.02
Factor (A X B)	0.25	0.09

Table.6 Effect of different treatments and storage intervals on the taste of litchi fruits

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A
T_0	9.00	6.42	6.14	5.92	5.80	5.69	4.45	**6.20**
T_1	9.00	6.89	6.71	6.52	6.33	6.12	4.92	**6.64**
T_2	9.00	7.24	7.10	6.93	6.77	6.56	5.52	7.02
T_3	9.00	7.44	7.29	7.13	6.97	6.76	5.72	7.19
T_4	9.00	8.27	8.12	7.95	7.79	7.58	6.75	**7.92**
T_5	9.00	7.64	7.49	7.32	7.16	6.95	5.91	7.35
T_6	9.00	7.08	6.93	6.76	6.60	6.39	5.35	6.87
T_7	9.00	7.55	7.40	7.23	7.07	6.86	5.82	7.28
T_8	9.00	7.22	7.07	6.90	6.74	6.53	5.49	6.99
T_9	9.00	8.02	7.87	7.70	7.54	7.33	6.35	**7.69**
T_{10}	9.00	7.74	7.60	7.43	7.27	7.06	6.02	7.45
T_{11}	9.00	7.34	7.20	7.03	6.87	6.66	5.62	7.10
T_{12}	9.00	7.98	7.83	7.66	7.50	7.29	6.27	7.65
T_{13}	9.00	7.68	7.53	7.36	7.20	6.99	5.95	7.39
T_{14}	9.00	7.23	7.09	6.92	6.76	6.55	5.51	7.01
T_{15}	9.00	6.98	6.83	6.66	6.50	6.29	5.25	6.79
T_{16}	9.00	7.51	7.36	7.21	7.05	6.84	5.80	7.25
T_{17}	9.00	7.62	7.47	7.30	7.14	6.93	5.89	7.34
Mean B	9.00	7.44	7.28	7.11	6.95	6.74	5.70	

Factors	C.D.	SE(m)
Factor (A)	0.10	0.04
Factor (B)	0.06	0.02
Factor (A X B)	0.26	0.09

Table.7 Effect of different treatments and storage intervals on the colour of litchi fruits

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A
T_0	9.00	7.14	6.52	5.62	5.18	4.92	4.10	6.07
T_1	9.00	6.45	6.13	5.92	5.80	5.68	4.50	6.21
T_2	9.00	7.54	7.31	7.10	6.98	6.87	5.83	7.23
T_3	9.00	7.81	7.58	7.37	7.25	7.14	6.08	7.46
T_4	9.00	8.84	8.85	8.32	8.18	8.08	6.98	**8.32**
T_5	9.00	7.94	7.71	7.50	7.38	7.27	6.23	7.58
T_6	9.00	7.51	7.28	7.07	6.95	6.84	5.80	7.21
T_7	9.00	6.84	6.61	6.40	6.28	6.17	5.13	6.63
T_8	9.00	7.98	7.75	7.54	7.42	7.31	6.27	7.61
T_9	9.00	8.64	8.41	8.20	8.08	7.97	6.98	**8.18**
T_{10}	9.00	7.32	7.09	6.88	6.76	6.65	5.61	7.05
T_{11}	9.00	7.67	7.48	7.27	7.15	7.04	6.00	7.37
T_{12}	9.00	8.12	7.89	7.68	7.56	7.45	6.43	7.73
T_{13}	9.00	7.71	7.48	7.27	7.15	7.04	6.01	7.38
T_{14}	9.00	6.78	6.55	6.34	6.22	6.11	5.07	6.58
T_{15}	9.00	7.42	7.19	6.98	6.86	6.75	5.71	7.13
T_{16}	9.00	7.52	7.29	7.08	6.96	6.85	5.81	7.22
T_{17}	9.00	6.81	6.58	6.37	6.25	6.14	5.10	6.61
Mean B	9.00	7.56	7.32	7.05	6.91	6.79	5.76	

Factors	C.D.	SE(m)
Factor (A)	0.10	0.04
Factor (B)	0.06	0.02
Factor (A X B)	0.27	0.10

Table.8 Effect of different treatments and storage intervals on the Overall acceptability of litchi fruits

Treatments	Day-0	Day-2	Day-4	Day-6	Day-8	Day-10	Day-12	Mean A
T_0	9.00	6.42	6.14	5.92	4.92	4.10	3.92	5.77
T_1	9.00	7.01	6.68	6.35	5.78	5.32	4.21	6.34
T_2	9.00	7.66	7.42	7.12	6.81	6.36	5.31	7.10
T_3	9.00	8.02	7.78	7.43	7.11	6.66	5.62	7.37
T_4	9.00	8.84	8.54	8.32	7.96	7.82	6.75	8.18
T_5	9.00	7.54	7.30	6.95	6.63	6.18	5.14	6.96
T_6	9.00	7.92	7.68	7.33	7.01	6.56	5.52	7.29
T_7	9.00	8.12	7.88	7.53	7.21	6.76	5.72	7.46
T_8	9.00	7.82	7.58	7.23	6.91	6.46	5.42	7.20
T_9	9.00	8.62	8.33	8.15	7.96	7.51	6.40	8.00
T_{10}	9.00	7.68	7.44	7.09	6.77	6.32	5.28	7.08
T_{11}	9.00	7.75	7.51	7.16	6.84	6.39	5.35	7.14
T_{12}	9.00	8.12	8.25	7.90	7.58	7.13	6.08	7.72
T_{13}	9.00	7.76	7.52	7.17	6.85	6.40	5.36	7.15
T_{14}	9.00	7.45	7.21	6.86	6.54	6.09	5.05	6.89
T_{15}	9.00	7.23	6.99	6.64	6.32	5.87	4.83	6.70
T_{16}	9.00	7.26	7.02	6.67	6.36	5.91	4.87	6.73
T_{17}	9.00	7.17	6.93	6.58	6.26	5.81	4.77	6.65
Mean B	9.00	7.69	7.46	7.13	6.77	6.31	5.31	

Factors	C.D.	SE(m)
Factor (A)	0.10	0.04
Factor (B)	0.06	0.02
Factor (A X B)	0.27	0.10

The above findings are in accordance with the findings of Bilawal *et al.,* (2017), who reported a minimum decrease in physiological loss in weight in guava fruits coated with 2% calcium lactate, 2% xanthan gum and 4% glycerin during the 30 days of storage period.

Fruit length

Data depicted in table 2 indicates that packaging and edible coatings significantly affected the fruit length with the advancement of storage duration. The maximum shrinkage in length (4.04%) was recorded in T_0 *i.e.* fruits without coating and packaging, followed by T_1*i.e.*fruits without coating and packed in perforated brown paper bag (3.66%), while the minimum shrinkage (2.45%) was observed in treatment T_4 *i.e.* fruits coated with guar gum1.5% and packed in perforated brown paper bags. It might be due to the fact that coating the fruits with guar gum 1.5% and packed in perforated brown paper bag effectively prevented the moisture loss and reduced respiration rate of the fruits. The above findings are in agreement with the findings of Dutta *et al.,* (2016) and Tiwary (2011), who reported that coating of fruit significantly, prevented reduction in fruit length during the storage in ber and mango, respectively.

Fruit breadth

Fruit breadth gradually decreased in all the treatments with the advancement of the storage period (Table 3). The maximum shrinkage in breadth (6.51%) was recorded in T_0*i.e.* fruits without coating and packaging, followed by T_1 *i.e.* fruits without coating and packed in perforated brown paper bag(6.42%),while the minimum shrinkage (1.76%) was observed in treatment T_4 *i.e.* fruits coated with guar gum1.5% and packed

in perforated brown paper bags, followed by T_{10} *i.e.* methyl cellulose (low viscosity) 0.5% and packed in perforated brown paper bag (2.96%). The results showed that there was least fluctuation in fruit breadth in the treatment T_4 indicating that coating the fruits with guar gum 1.5% along and packed in perforated brown paper bag effectively prevented the moisture loss and reduced respiration rate of the fruits. Cell degradation was also prevented which in turn facilitated reduced moisture loss and lesser respiratory gaseous exchange delaying senescence and decreasing the shrinkage percentage. The above findings are in agreement with the findings of Dutta *et al.*, (2016),who reported that coating of fruit significantly prevented reduction in fruit breadth during the storage in ber.

Fruit volume

Packaging and edible coatings also affected the fruit volume with the advancement of storage duration (table 4). The maximum decrease in fruit volume percentage (10.68%) was recorded in T_0*i.e.* fruits without coating and packaging, followed by T_1*i.e.* fruits without coating and packed in perforated brown paper bag (9.48%), while there was the minimum change in fruit volume(5.45%) in the treatment T_4, followed by T_9*i.e.*2% xanthum gum coated fruit packed in perforated brown paper bag (5.45%). Coating and packaging help in reducing moisture loss from the fruits and thus prevents shrinkage and maintains better volume in the coated and packed fruits. Present study also revealed a gradual decrease in fruit volume with the increasing storage interval. As the storage interval increased, the reduction in per cent shrinkage also increased due to moisture loss. Decrease in fruit volume with the advancement of storage period has also been reported in mango (Tiwary, 2011).

Appearance of litchi fruits

Data in the table 5 revealed that the appearance of coated and uncoated litchi fruits packed in brown paper bag slowly decreased during storage period. The maximum appearance score (7.74) was obtained in the fruits coated with the guar gum 1.5% and packed in perforated brown paper bag (T_4), followed by T_9*i.e.*2% xanthum gum coated fruit packed in perforated brown paper bag(7.61). The minimum score (6.20) was recorded in T_0*i.e.* fruits without coating and packaging, followed by T_1*i.e.*fruits without coating and packed in perforated brown paper bag (6.34). The results showed that there was minimum change in appearance of litchi fruits from day zero to day twelve of storage in the treatment T_4 indicating that fruits coated with 1.5 per cent guar gum and packed in perforated brown paper bag effectively conserved the quality and appearance.

Fruit taste

Data presented in table 6 indicates that the coatings and packaging significantly affected the taste of fruits with the advancement of storage duration. Maximum score in fruit taste (7.92) was obtained in the fruits coated with 1.5 per cent guar gum and packed in perforated brown paper bag, followed by T_9*i.e.*2% xanthum gum coated fruit packed in perforated brown paper bag (7.69).

The minimum score (6.20) was recorded in T_0 (fruits without coating and packaging). The results showed that there was minimum change in taste of fruits from day Zero to day twelve of storage, in the treatment T_4indicating that fruits coated with 1.5 per cent guar gum and packed in perforated brown paper bags effectively conserved the quality and taste of litchi fruits.

Fruit colour

All the treatments exerted a significant influence on fruit colour (table 7). The highest colour score of litchi fruits (8.32) was recorded in fruits coated with 1.5 per cent guar gum and packed in perforated brown paper bag, followed by T_9*i.e.* 2% xanthum gum coated fruit packed in perforated brown paper bag (8.18), while the least score in colour (6.07) was recorded in T_0*i.e.* fruits without coating and packaging. Modified atmosphere created by the coating and packaging retarded ethylene production rate. Therefore, delayed ripening, chlorophyll degradation, anthocyanin accumulation and carotenoid synthesis, thus ultimately delayed colour change of fruits. The above results supported the findings of Brishti *et al.,* (2013) and Tripathi and Dubey (2004), who found better retention in colour when papaya fruits were treated with Aloe vera base edible coatings.

Overall Acceptability of Fruit

In the present study, the overall acceptability of coated and uncoated litchi fruits packed in brown paper bag was slowly decreased during storage (table 8). Highest overall acceptability of fruits score (8.18) was recorded in T_4*i.e.*followed by T_9 (8.00), while the minimum score (5.77) was recorded in T_0i.e. fruits without coating and packaging (control).These results supported the findings of Brishti *et al.,* (2013)and Martinez *et al.,* (2006) in papaya and cherry fruits, respectively.

In conclusion the pericarp browning is the major post-harvest problem of litchi fruits, which reduced commercial value of the fruit. Generally, visual quality was lost at ambient temperature when fruit were removed from storage as result of browning. We successfully optimized some physiological and sensory characteristics of litchi during storage by coating and packaging. By this study, there will be an alternative approach to prolong shelf-life of litchi fruits during post-harvest.

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