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Effect of single layer edible coating on physico chemical properties of Alphonso mango

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Abstract
Alphonso mango being an expensive commodity needs to be preserved throughout the shelf life to keep the good postharvest quality and attempt was made to preserve the Alphonso mango by use of single layer basic coating material made of polysaccharides, proteins and lipids. The results obtained from the experiment were noted and found to be better as minimum and maximum for various parameters on 15 days after treatment. The physiological weight loss was observed to be minimum in treatment E3 (6.41 %), firmness was maximum retained in treatment E7 (4.6 kg/cm^2), maximum fruit TSS was observed in treatment E2 (22.22 ˚B), maximum fruit pH was observed in treatment E2 (5.32), minimum testable acidity was found in treatment E4 (0.21 %), maximum fruit value for reducing sugar was observed in treatment E3 (5.20 %) and maximum fruit total sugars was observed in treatment E7 (14.75 %). From the results obtained treatment B2, B3, B5, B7, B9 and B11 were found to suit better for each parameter as compared to the other.

Keywords: Alphonso, single layer, edible coating, preservation, ripening

Introduction
In India, Konkan region of Maharashtra state is mainly known for its richness and versatility in fruits availability. The horticultural crops like mango, cashew, jamun, jackfruit, kokum, karonda, starfruit, guava, coconut and banana are found in this region. These fruit crops are the cash crops for people in Konkan. Among all fruits the Alphonso mangoes get the special features that make them a favorite fruit in the international market which mainly occurs due to the peculiar soil and climatic conditions of this region (Joshi *et al.*, 2016) [23].

Mango (*Mangifera indica* L.) is one of the oldest and most adored fruits in the tropical region and known as "King" of fruits. It is considered the third widely produced fruit crop after banana and citrus, mainly due to wide adaptability, high nutritive content, richness in variety, delicious taste, pleasant flavour and adorable appearance. It is a stone fruit; the skin is leathery, smooth, fairly thick, yellow-orange to reddish-pink coloured when fully ripe (Morton, 1987) [22]. The qualities of different varieties of mango are attributed to a unique combination of geographical conditions which are mainly present in Western India, especially near coastlines of Maharashtra. Out of total area under mango in Konkan, more than 80 per cent is occupied by a single largest growing mango variety "Alphonso", locally called as "Hapus" with a major share of export over 30 per cent (Burondkar, 2018) [6]. Nowadays, short shelf life of fruit and vegetables is one of the biggest trading problems for such a premium commodity. Although packaging plays a decisive role in the improvement of the shelf life, the high accumulation of plastic packing materials has been generating a growing concern in the world, as only 5% of the production of plastics are recycled (Espitia *et al.*, 2014) [21]. The biodegradable edible coatings or films are an alternative that can replace the synthetic packaging. Thus with a view to preserve the Alphonso Mango over a long periods this study was undertaken.

Materials and methods
The present research work was undertaken at Department of Agricultural Process Engineering, College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. The aim of the present investigation was to develop the single layer coating formulations. Experiments were formulated for single coating with six different basic coating materials in two concentration were as B1 (0.5% chitosan), B2 (1% chitosan), B3 (4% cassava starch), B4 (6% cassava starch), B5 (4% soy protein), B6 (6% soy protein),

B7 (5 % gluten), B8 (10 % gluten), B9 (4 % beeswax), B10 (6 % beeswax), B11 (5 % olive oil), B12 (10 % olive oil) of all the fruits graded and selected for experimentation, 30 fruits were used for each treatment. For application of coating solutions to fruits the dipping method was used where the fruits were dipped for about 10-60 seconds to give one uniform layer over the surface of fruit. To set a coat of film on the surface of mangoes, the treated fruits were air dried and stored in ambient temperature conditions along with the control samples without any coating applied which stimulate a retail market. Three replicates from each treatment were analysed at an interval of every 3 days. Analysis were conducted for the physico-chemical attributes that influenced the quality and consumer acceptability throughout the storage period.

Results and discussion

The results for effect of single layer coating of two concentrations of each basic coating material from every single group of polysaccharide, lipid and protein based for the various physico chemical properties are discussed. The data analysed for 15 days at an interval of every 3 days are depicted in the tables and figures.

Physiological weight loss

Physiological weight loss is a very important parameter to be considered during the storage study of fruits like alphonso mango. In this study the data pertaining to PLW as significantly affected by the concentrations of coating material are depicted in Table 1 and figure 1. The final results showed that the PLW increased gradually from day 0 to day 15. The minimum weight loss was observed in treatment E3 (6.41 %) where fruits were coated with 4 % cassava starch. The maximum weight loss was observed in E10 (15.89 %) on day 15 where fruits were coated with 6 % beeswax. weight loss mainly reflects respiration rate, transpiration and some process of oxidation which are influenced due to storage period and temperature.

Table 1: Effect of single layer coating of different concentrations of edible coating on physiological weight loss

Treatment	3	6	9	12	15
B1	0.5493	1.6033	3.2114	6.9948	10.1667
B2	0.3859	1.1283	1.8554	2.8821	7.3402
B3	0.7152	1.6346	3.102	4.5574	6.41
B4	0.8548	1.4952	2.4245	3.718	8.2468
B5	1.5167	2.4998	3.8438	6.223	7.9514
B6	1.3865	2.9263	4.7582	6.6648	10.1313
B7	2.0401	3.5041	5.7197	7.9857	10.3535
B8	2.1992	5.3371	8.6647	12.5004	17.589
B9	2.581	4.8606	8.7517	11.7168	14.4357
B10	2.3973	5.2778	8.4286	12.1026	15.8919
B11	1.4674	4.0369	6.6331	8.2546	10.3269
B12	1.4604	3.0856	5.2557	7.3881	10.1931
SE±	0.270899	0.439065	0.628512	0.797593	1.054662
CD (1 %)	0.760172	1.232062	1.763672	2.238131	2.959495

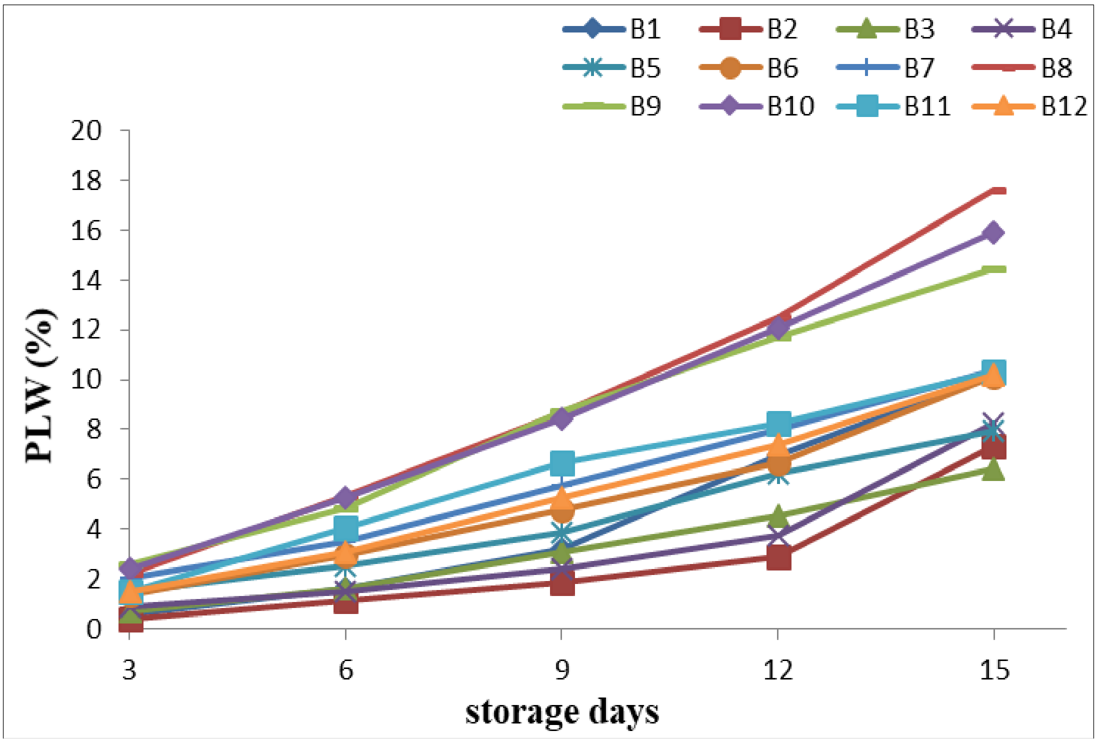

Fig 1: Effect of single layer coating of different concentrations of edible coating on Physiological weight loss

Fruit Firmness

The data pertaining to fruit firmness was significantly affected by the concentrations of coating material are depicted in Table 2 and figure 2. The final results showed that the firmness decreased gradually from day 0 to day 15. The minimum fruit firmness was found in treatment E10 (2.1 kg/cm^2) where fruits were coated with 6% beeswax. The maximum fruit firmness was retained in treatment E7 (4.6 kg/cm^2) on day 15 where fruits were coated with 5% gluten. The reason for this can be explained as the fruits remained green and hard for longer period as the ripening process was slowed down due to the coating applied.

Table 2: Effect of single layer coating of different concentrations of edible coating on Fruit Firmness

Basic edible coating 0	Storage days											
	0		3		6		9		12		15	
	L	U	L	U	L	U	L	U	L	U	L	U
Chitosan	19.11	18.16	16.67	16.97	9.43	8.80	6.07	6.80	3.50	4.87	2.80	3.57
Cassava	19.39	19.52	16.47	16.17	8.43	9.43	6.13	6.70	5.23	4.00	4.80	2.13
Soy Protein	19.21	18.48	17.50	14.80	8.17	6.57	7.37	5.70	5.63	3.23	4.60	2.37
Gluten	19.08	18.37	14.73	16.07	6.90	9.53	5.53	4.73	4.50	2.77	3.77	2.13
Beeswax	18.80	19.33	16.57	15.20	8.37	6.60	5.10	4.83	4.77	3.20	3.33	2.53
Olive Oil	18.53	19.30	16.13	15.63	8.80	6.33	6.80	4.60	3.33	2.50	2.80	2.00
Concentration SE±	0.05		0.07		0.05		0.05		0.03		0.04	
CD (1 %)	0.15		0.22		0.14		0.13		0.09		0.11	
Group SE±	0.09		0.13		0.08		0.08		0.05		0.06	
CD (1%)	0.26		0.37		0.24		0.23		0.16		0.19	
Interaction SE±	0.13		0.18		0.12		0.11		0.08		0.09	
CD (1 %)	0.37		0.53		0.34		0.33		0.22		0.26	

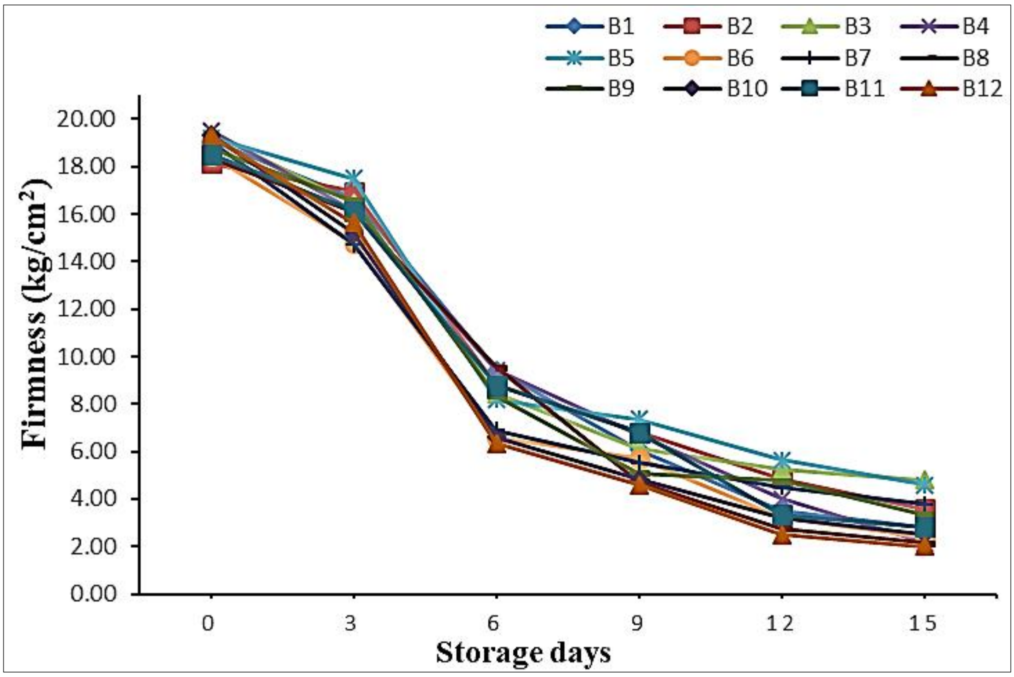

Fig 2: Effect of single layer coating of different concentrations of edible coating on Fruit Firmness

Total Soluble Solids (TSS)

The data pertaining to total soluble solids in coated fruits was significantly affected by the concentrations of coating material are depicted in Table 3 and figure 3. The final results showed that the TSS increased gradually from day 0 to day 15. The minimum TSS was found in treatment E4 (11.83˚B) where fruits were coated with 6 % cassava starch. The maximum fruit TSS was observed in treatment E2 (22.22 ˚B) on day 15 where fruits were coated with 1 % chitosan. The reason for this can be explained as the ripening process in fruits was slowed down.it can be observed that harvesting time significantly affect the quality and ripening behaviour of mango.

Table 3: Effect of single layer coating of different concentrations of edible coating on Total soluble solids

Basic edible coating	Storage days											
	0		3		6		9		12		15	
	L	U	L	U	L	U	L	U	L	U	L	U
Chitosan	7.92	8.21	8.93	11.30	10.48	15.27	13.64	18.61	14.25	20.42	16.87	22.22
Cassava	8.49	8.13	10.65	9.15	13.45	9.37	16.35	10.34	19.34	10.81	21.50	11.83
Soy Protein	7.53	8.48	8.34	8.76	11.36	9.25	14.85	9.82	17.71	10.47	21.85	11.93
Gluten	7.73	8.43	9.55	10.17	11.50	13.52	15.65	16.40	18.23	18.41	19.81	22.08
Beeswax	8.35	6.92	9.50	7.43	11.58	8.53	15.31	9.83	17.49	12.59	20.09	13.41
Olive Oil	7.13	7.43	8.24	8.37	13.41	8.74	15.52	9.41	18.55	11.33	20.78	15.42
Concentration SE±	0.01		0.02		0.02		0.04		0.03		0.02	
CD (1 %)	0.03		0.05		0.05		0.13		0.09		0.05	
Group SE±	0.02		0.03		0.03		0.08		0.05		0.03	
CD (1%)	0.06		0.09		0.08		0.22		0.15		0.09	
Interaction SE±	0.03		0.04		0.04		0.11		0.07		0.04	
CD (1 %)	0.08		0.12		0.12		0.31		0.22		0.13	

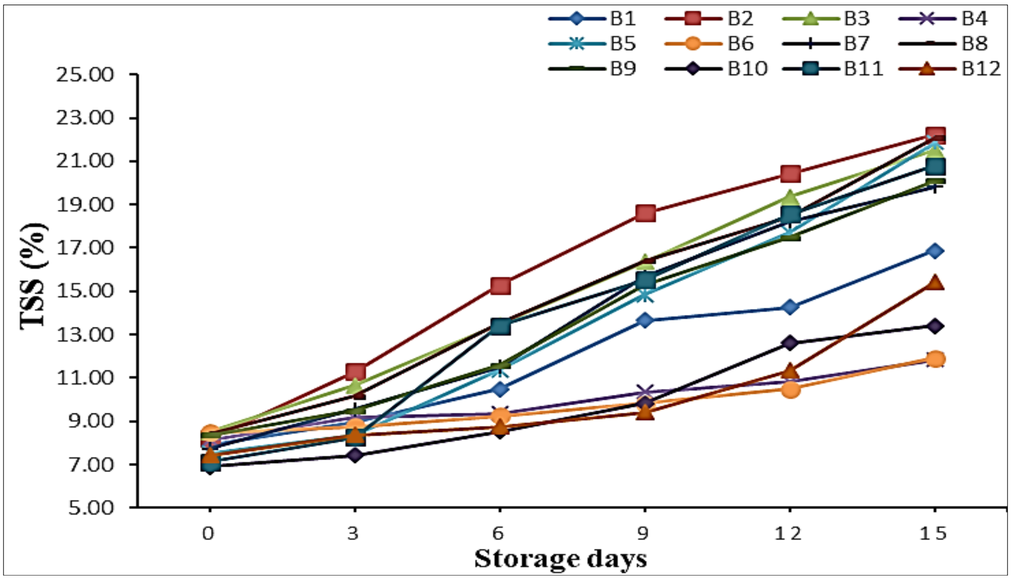

Fig 3: Effect of single layer coating of different concentrations of edible coating on Total soluble solids

pH

The data recorded for pH in coated fruits was significantly affected by the concentrations of coating material are depicted in Table 4 and figure 4. The final results showed that the pH increased gradually from day 0 to day 15. The minimum pH was found in treatment E12 (3.27) where fruits were coated with 10 % olive oil. The maximum fruit pH was observed in treatment E2 (5.32) on day 15 where fruits were coated with 1% chitosan. The reason for this can be explained as the ripening process in fruits was slowed down and fermentation of fruits occurred in treatment E12. The continuous rise in pH can be attributed to continuous fall in acidity mainly due to decrease in citrate and malate which are mainly present in high amount in unripe fruit but decrease during ripening.

Table 4: Effect of single layer coating of different concentrations of edible coating on pH

Basic edible coating	Storage days											
	0		3		6		9		12		15	
	L	U	L	U	L	U	L	U	L	U	L	U
Chitosan	2.39	2.88	3.29	3.45	3.86	3.76	4.30	4.60	4.44	4.89	4.56	5.32
Cassava	3.16	3.15	3.29	3.31	3.47	3.48	3.81	3.61	4.18	3.90	5.08	4.45
Soy Protein	2.81	2.64	2.92	2.82	3.08	2.95	3.16	3.05	3.44	3.21	3.58	3.40
Gluten	2.73	3.05	4.64	3.16	3.08	3.55	3.19	3.75	3.24	4.18	3.57	5.22
Beeswax	2.61	2.82	3.28	2.96	3.79	3.05	4.36	3.13	4.83	3.18	5.24	3.33
Olive Oil	2.44	3.04	2.83	3.09	3.04	3.15	3.14	3.19	3.25	3.23	4.18	3.27
Concentration SE±	0.01		0.21		0.01		0.01		0.01		7.00	
CD (1%)	0.03		0.60		0.03		0.03		0.03		20.48	
Group SE±	0.02		0.36		0.01		0.02		0.02		0.02	
CD (1%)	0.06		1.05		0.04		0.06		0.05		0.06	
Interaction SE±	0.03		0.51		0.02		0.03		0.02		0.03	
CD (1%)	0.08		1.48		0.06		0.08		0.07		0.08	

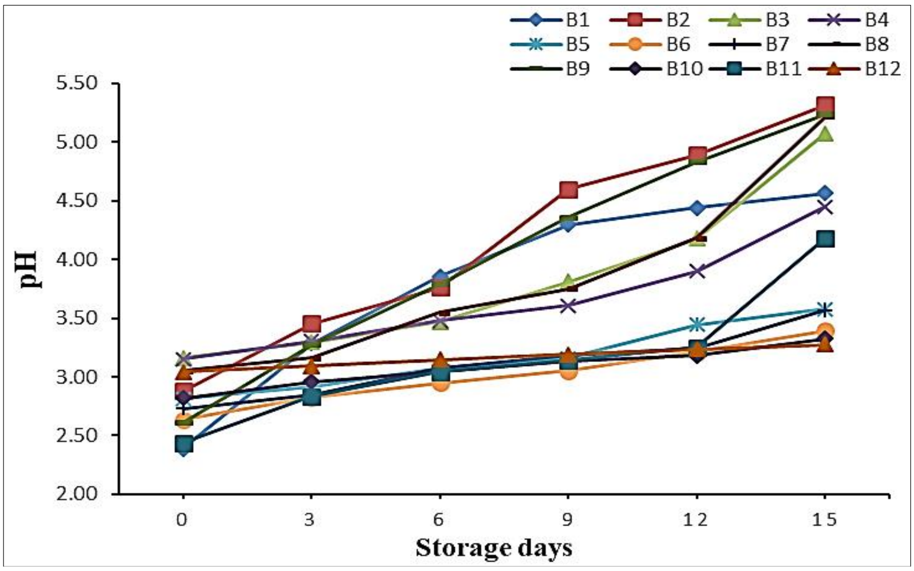

Fig 4: Effect of single layer coating of different concentrations of edible coating on pH

Titrable acidity

The data recorded for titrable acidity in coated fruits was significantly affected by the concentrations of coating material are depicted in Table 5 and figure 5. The final results showed that the titrable acidity gradually decreased from day 0 to day 15. The minimum titrable acidity was found in treatment E4 (0.21 %) where fruits were coated with 6% cassava starch which was at par with E5 where fruits were coated with 4 % soy protein. The maximum fruit acidity was observed in treatment E9 (0.86 %) on day 15 where fruits were coated with 4 % Beeswax. The reason for this can be explained as the ripening process in fruits was slowed down and uneven ripening of fruits occurred in E4 and E5. It was noticed that higher acidity in treated fruits could be attributed to reduction in respiration rates and metabolic activities thereby preventing loss of organic acids.

Table 5: Effect of single layer coating of different concentrations of edible coating on Titrable acidity

Basic edible coating	Storage days											
	0		3		6		9		12		15	
	L	U	L	U	L	U	L	U	L	U	L	U
Chitosan	2.83	3.50	2.47	2.53	2.05	2.32	1.96	1.45	1.74	0.75	0.82	0.25
Cassava	3.46	3.17	3.24	3.03	3.09	2.84	2.15	2.36	1.55	1.26	0.82	0.21
Soy Protein	2.86	3.19	2.62	3.17	2.05	2.50	1.25	1.86	0.65	1.06	0.21	0.45
Gluten	3.18	3.44	2.74	2.56	2.23	2.19	1.48	1.75	1.26	1.14	0.55	0.53
Beeswax	3.29	2.84	3.14	2.55	2.75	2.24	2.67	1.82	1.34	1.45	0.86	0.83
Olive Oil	3.17	3.17	2.84	2.89	2.46	2.56	2.34	1.36	1.31	1.22	0.46	0.46
Concentration SE±	0.02		0.01		0.01		0.01		0.01		0.01	
CD (1 %)	0.07		0.03		0.04		0.03		0.02		0.03	
Group SE±	0.04		0.02		0.02		0.01		0.01		0.02	
CD (1%)	0.11		0.05		0.06		0.04		0.04		0.05	
Interaction SE±	0.06		0.03		0.03		0.02		0.02		0.03	
CD (1 %)	0.16		0.08		0.09		0.06		0.05		0.07	

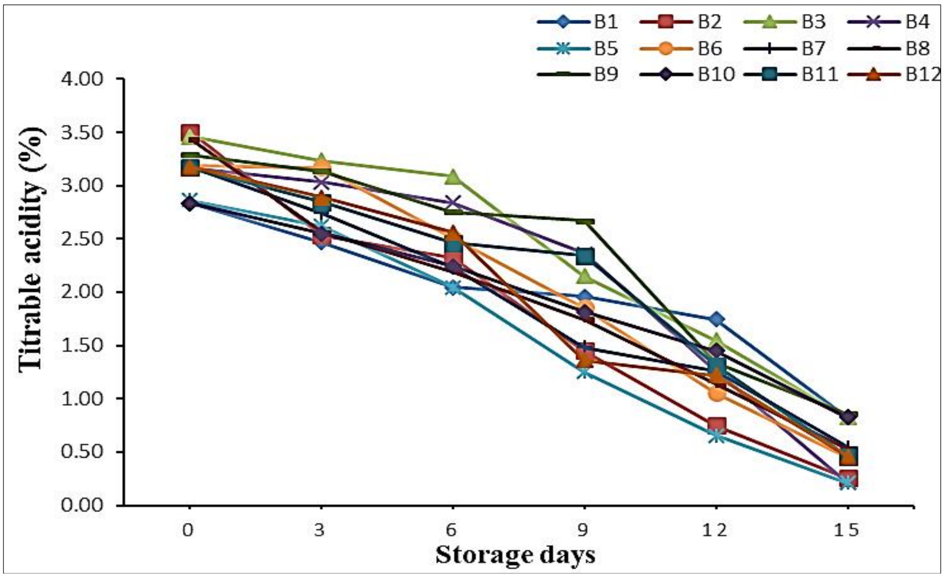

Fig 5: Effect of single layer coating of different concentrations of edible coating on Titrable acidity

Reducing sugars

The data recorded for reducing sugars in coated fruits was significantly affected by the concentrations of coating material are depicted in Table 6 and figure 6. The final results showed that the reducing sugars increased gradually from day 0 to day 15. The minimum value for reducing sugar was found in treatment E1 (3.12 %) where fruits were coated with 0.5 % chitosan. The maximum fruit value for reducing sugar was observed in treatment E3 (5.20 %) on day 15 where fruits were coated with 4 % cassava starch. The reducing sugars increased at faster rate in till the complete ripening process occurred and then a decrease in value for reducing sugars is observed as the conversion of starch into sugars gets retarded.

Table 6: Effect of single layer coating of different concentrations of edible coating on reducing sugars

Basic edible coating	Storage days											
	0		3		6		9		12		15	
	L	U	L	U	L	U	L	U	L	U	L	U
Chitosan	1.74	1.66	1.93	1.92	2.13	2.15	2.36	2.41	2.81	2.73	3.12	3.53
Cassava	1.83	1.76	2.08	1.96	2.34	2.49	3.64	2.85	4.17	3.76	5.20	3.94
Soy Protein	1.55	1.84	2.44	2.76	2.63	3.17	3.20	3.54	4.20	3.93	5.14	4.15
Gluten	1.67	1.49	2.27	2.15	3.11	2.69	3.49	2.96	3.63	3.06	3.82	3.74
Beeswax	1.58	1.59	2.09	2.35	2.90	2.71	3.05	3.11	3.24	3.52	3.52	3.83
Olive Oil	1.84	1.76	2.44	2.16	2.56	2.51	2.88	2.52	3.76	3.33	4.07	4.10
Concentration SE±	0.01		0.01		0.01		0.01		0.01		0.01	

CD (1 %)	0.02	0.02	0.03	0.04	0.04	0.04
Group SE+	0.01	0.01	0.02	0.02	0.03	0.02
CD (1 %)	0.03	0.04	0.05	0.07	0.08	0.06
Interaction SE+	0.01	0.02	0.03	0.03	0.04	0.15
CD (1 %)	0.04	0.05	0.07	0.09	0.11	0.09

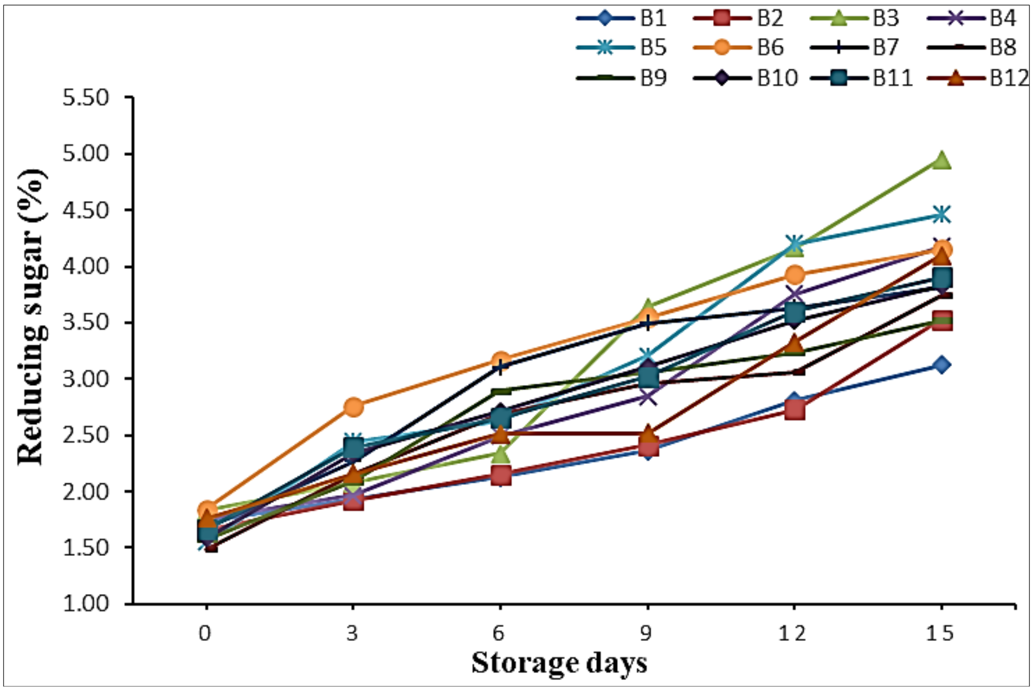

Fig 6: Effect of single layer coating of different concentrations of edible coating on reducing sugars

Total Sugar

The data recorded for total sugar in coated fruits was significantly affected by the concentrations of coating material are depicted in Table 7 and figure 7. The final results showed that the Total sugar increased gradually from day 0 to day 15. The minimum total sugars was found in treatment E12 (13.67 %) where fruits were coated with 10% olive oil. The maximum fruit total sugars was observed in treatment E7 (14.75 %) on day 15 where fruits were coated with 5 % gluten. The reason for this can be explained as the ripening process in fruits was slowed down and the fruits remained green for longer time. Lower values for reducing and total sugars may occur due to spoilage in fruits.

Table 7: Effect of single layer coating of different concentrations of edible coating on total sugars

Basic edible coating	Storage days											
	0		3		6		9		12		15	
	L	U	L	U	L	U	L	U	L	U	L	U
Chitosan	3.66	3.16	5.69	4.75	6.83	7.30	9.30	11.19	12.58	12.44	14.14	13.94
Cassava	3.21	4.63	5.14	6.18	7.87	8.33	9.46	9.69	12.57	11.69	14.26	14.37
Soy Protein	4.54	3.74	7.80	7.24	10.55	9.53	11.45	11.55	12.57	13.18	13.82	14.62
Gluten	3.66	4.48	5.07	6.37	8.17	9.54	10.81	10.74	13.25	13.46	14.75	14.11
Beeswax	3.54	3.76	5.85	6.34	10.19	8.84	11.49	12.13	12.58	12.75	13.71	13.91
Olive Oil	4.14	3.93	6.21	7.24	8.54	9.83	9.17	9.94	10.99	10.46	14.12	13.67
Concentration SE+	0.01		0.01		0.02		0.02		0.04		0.02	
CD (1%)	0.02		0.04		0.06		0.06		0.11		0.05	
Group SE+	0.01		0.02		0.04		0.04		0.06		0.03	
CD (1%)	0.04		0.07		0.11		0.10		0.18		0.08	
Interaction SE+	0.02		0.03		0.05		0.05		0.09		0.04	
CD (1%)	0.06		0.10		0.16		0.14		0.26		0.11	

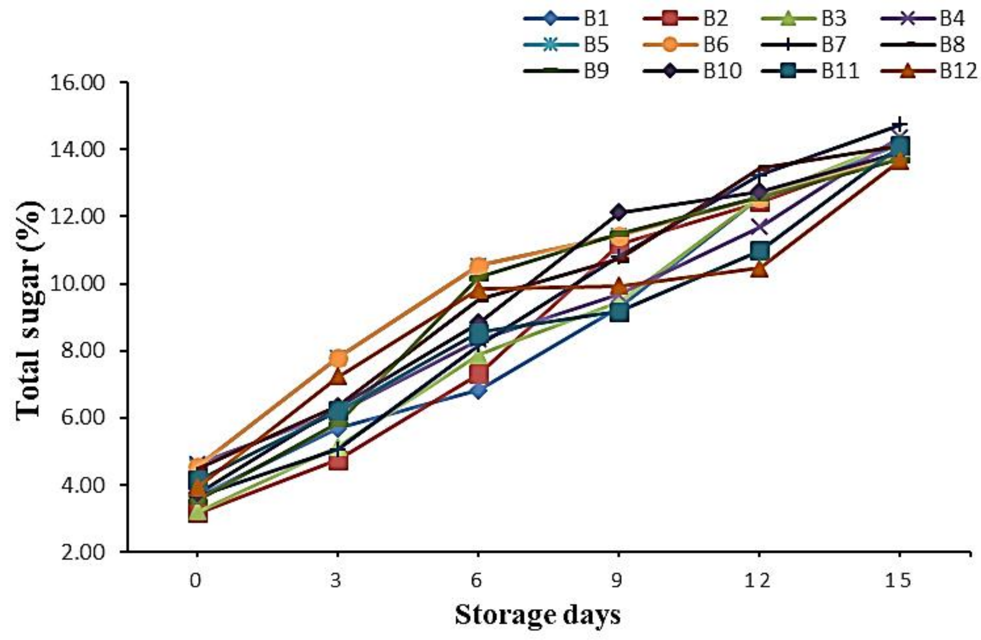

Fig 7: Effect of single layer coating of different concentrations of edible coating on total sugar

Conclusions

Treatment B2, B3, B5, B7, B9 and B11 were found to suit better for each parameter as compared to the other. There is some or the other drawback in every single treatment which can be overcome by counter balancing the benefits and deficiencies of individual coating. Beeswax is an antioxidant and antimicrobial as well as hydrophobic in nature. Chitosan and waxes cause anaerobic fermentation due to low permeability to O_2 and CO_2. Starch are brittle and susceptible to water adsorption. Lipids based may have negative impact on sensory quality of fruits because they give a greasy appearance to fruits or may undergo oxidative rancidity. Therefore a combination of coating material may be promising for the shelf life extension as it can optimize the coating performance by counter balancing the benefits and deficiencies of individual coating. The success of developed basic coating depends on feasibility of its application at industrial scale.

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