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ORIGINAL ARTICLE

Effects of edible coatings on physiochemical characteristics of apple ber (*Zizyphus mauritiana*)

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ABSTRACT
*The present experiment entitled "effects of edible coatings on physiochemical characteristics of apple ber (*Zizyphus mauritiana*)" was conducted at the horticulture laboratory of Lovely Professional University, Phagwara (Punjab) during the year 2020-21. The objective of this study was to evaluate the effect of chitosan (0.5%,1%,2%), gum arbic (6%,9%,12%),guar gum (1%,1.5%,2%), and aloe vera gel(10%,20%,30%) on physiochemical characteristics of apple ber. Parameters such as physiological loss in weight (%), spoilage(%), total soluble solid, acidity, ascorbic acid, total sugars (reducing sugar + non-reducing sugar) were evaluated after 3rd,6th,and 9th days at ambient storage. The results showed that edible coated apple ber significant delayed the change of weight loss, total soluble solid, acidity, total sugar, reducing sugar, and non-reducing sugar as compared to uncoated fruits. Physical parameters like physiological loss in weight and spoilage percentage moderately increased in coated fruits than control. Chemical parameters like titratable acidity and ascorbic acid moderately decreased while TSS, total sugar, reducing sugar, and non reducing sugar slowly increased as compared to control during storage periods.*

Keywords*- apple ber (Zizyphus mauritiana),edible coating, physiochemical characteristics*

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INTRODUCTION

Apple ber (*Zizyphus mauritiana* Lamk.) is the most valuable fruit crop in tropical and subtropical regions. The native place of apple ber is Thailand. It belongs to the family Rhamnaceae. It is developed through the grafting method of Thailand green apple with Thai local ber. This fruit resembles a green apple in its appearance and tastes like ber, hence the name apple ber. It is also called Apple plum or Jujube berry [1]. The family Rhamnaceae has 50 genera and more than six hundred species out of which *Zizyphus mauritiana* is the most important one [2]. In India more than three hundred varieties of jujube have been recorded, however, just a couple of them are monetarily significant. It is mostly consumed as fresh fruit. The pulp of apple ber with high nutrient value has been comprehensively perceived and it contains varied phytochemicals like flavonoids, sugars, phenolic acids, and nutrients like vitamin A and C, P, Ca, and Fe.
The fruit is of variable shape and size. It can be oval, round, or oblong in shape. It is a hardy fruit crop and can withstand extremely hot conditions and it starts to produce six months after plantation. The plant produces twice a year, particularly in December and January [3]. In the first year, the plant gives 25-30kg fruits and in the second year, it gives 45-50 kg fruits. The flesh is white and crisp when the fruit is slightly under ripening condition. The fruit is juicy and has a pleasing smell. The skin of the fruit is glossy, smooth, tight, and thin. Apple ber is a fast-growing fruit tree with an intermediate life period and reaches very fast up to 10-15ft in height. Apple ber is commonly referred to as "Poor man's fruit" because of the high amount of nutrients. Apple ber trees usually grow along the roads and in agricultural lands, generally, more than 600 m above mean sea level and at commercial levels, it is usually up to 1,000 meters beyond this elevation, performance decreases in terms of cultivation and economics. But wild ber trees are observed up to an elevation of 1650 meters in China and India. Nowadays orchardists prefer to grow apple ber due to the low

cost of cultivation and apple ber is highly to lerant to drought with wide adaptability and gives high economic value to the farmers.

In India cultivation of apple ber initially began in Maharashtra, later stretched out to different parts of the country like Gujarat and Telangana. In Telangana, it is cultivated in districts like Mahbubnagar, Medak, Hyderabad, Khammam, and Warangal. It is likewise famously known as "Telangana Apple" in Telangana state. The weight of each fruit is between 60-150g. It is exceptionally appealing, sweet, fresh, and succulent. In recent years farmers are showing interest in apple ber cultivation when contrasted with ber because of its one-of-a-kind qualities like thornless nature, high yielding, early harvest, and wider adaptability to grow in any type of soil with less utilization of water. It can withstand outrageous summer, heavy rains, extreme winter, and heavy winds. It begins yielding in nine months. Fruits are start production from November to March with the ostensible first harvest of 20-25 kg for each tree and the second harvest will associate with 50 kg for every tree and third-year onwards yield will be 100 kg to 200 kg for each tree.[4]

Various techniques are used nowadays such as control atmosphere storage, modified atmosphere storage, refrigeration, chemical preservatives, and packaging to reduce post-harvest loss, but all these techniques are more expensive than edible coatings [5]. The edible films and coatings are prepared from edible materials, which are thin layers on the surface of fruits and fit for human consumption. When edible coatings are applied on the surface of fruits it acts like a barrier between fruit surface and atmosphere that's why there is an exchange of gas in between fruits and atmosphere and therefore edible materials are expanding shelf life by restricting the loss of water, and respiration rate [6]. Nowadays herbs like aloe vera, cinnamon oil, ginger oil are used as edible coatings because of their nutritional (vitamins, minerals), medicinal values, and some antimicrobial activity [7].

Considering the above realities and as the apple ber is currently an arising major fruit crop around , this test was completed to decide the effect of these consumable coatings for expanding the timeframe of realistic usability just as keeping up the physico-synthetic properties of the apple ber.

MATERIAL AND METHODS

Experimental location and fruit sample

The research work was conducted in the Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara during the year 2020-2021. Apple ber fruits used for research were uniform maturity, free of blemishes, and were collected from the orchard in Ludhiana district, Punjab. The harvested fruits were cleaned in running tap water, sorted, and were dried in the shade for few minutes.

Treatment details

A set of 130 fruits were examined per one replication and there were 13 treatments. Each treatment had 3 sets of replications. Therefore 390 fruits were needed for 3 replications. Then the fruits were exposed to edible coating with following treatments: T_0=Control(water), T_1= Chitosan 0.5%, T_2= Chitosan 1%, T_3= Chitosan 2%, T_4= Gum Arabic 6%, T_5= Gum Arabic 9%, T_6= Gum Arabic 12%, T_7= Guar Gum 1%, T_8= Guar Gum 1.5%, T_9= Guar Gum 2%, T_{10}= Aloe-vera 10%, T_{11}= Aloe-vera 20%, T_{12}= Aloe-vera 30%. Both control and coated fruits were stored at ambient temperature (16±2ºC). Observations of Physico-chemical parameters were recorded at 3, 6, and 9 days intervals after storage.

Preparation of edible coating solution

Edible coating solutions were prepared as per procedure given by researchers. For Chitosan [8], gum arabic [9], Aloe-vera gel [10], and guar gum[11].

Parameters

Fruit physical measurement (PLW) was recorded using an electronic weighing scale. TSS was determined using a hand refractometer [12]. Total sugars, reducing sugars and Non-reducing sugars were estimated as per the method given by Ranganna [13]. Ascorbic acid content was estimated using the standard procedure as described by A.O.A.C. [12]. Titratable acidity was determined using a standard procedure[12].

Statistical analysis

Statistical analysis was performed using OPSTAT software.

RESULTS AND DISCUSSION

Physiological Loss in Weight (PLW%)

Observation data (Table-1) concerning physiological loss in weight increased significantly in various coating treatments, storage period, and their interaction at ambient conditions. All treatments revealed, increase in PLW with the advancement of the storage period. On the 3rd day after edible coatings minimum physiological loss of weight was recorded in (T_8) guar gum @ 1.5% (0.99%) followed by (T_9) guar gum @ 2% (1.13 %) whereas maximum physiological loss of weight was observed in (T_0) control (1.57%). After the 9th day of storage maximum physiological loss of weight was recorded in (T_0) control (5.26%) whereas minimum physiological loss of weight was observed in (T_8) guar gum @ 1.5% (3.34%) followed by (T_9) guar gum @ 2% (3.68%). In uncoated fruits, PLW % (Fig-1) was maximum than coated fruits due to an increase in respiration and transpiration rates through the skin. The decrease in weight loss in coated fruits was due to the effects of these coatings as a strong hurdle against O_2, CO_2, moisture, and solute movement, thereby decreasing respiration rates, water loss, and oxidation reaction rates [4], [14].

Spoilage %

Observation data (Table-1) concerning spoilage percentage increased significantly in various coating treatments and storage periods but their interaction had no significant effect. Minimum spoilage percentage was recorded in (T_8) guar gum @ 1.5%, (T_2) chitosan @ 1%, (T_9) guar gum @ 2% and (T_{11}) aloe vera gel @ 20 % after 3 days of storage while maximum spoilage percentage was noted in (T_0) control (10 %). After 9th day of storage maximum spoilage percentage was recorded in (T_0) control (56.67%) whereas minimum spoilage % was observed in (T_8) guar gum @ 1.5% (23.33%), (T_2) chitosan @ 1% (23.33%), (T_9) guar gum @ 2% (23.33%), and (T_{11}) aloe vera gel @ 20 %(23.33%). A comparatively lower decay percentage (Fig-2) was recorded in coated fruits as compared to uncoated. This was because edible had not only capable of reducing the rate of respiration and ripening process but also it can significantly decrease the growth of micro-organisms [4], [15].

Titratable acidity(TA%)

Observation during storage of apple ber fruit showed that titratable acidity significantly decreased in various coating treatments, and storage but their interaction had no significant effect (Table-1). The results had been revealed that titratable acidity decreased in all treatments with the progression of the storage period. Maximum of titratable acidity was recorded in (T_8) guar gum @ 1.5% (0.52%) followed by (T_9) guar gum @ 2% (0.5%) and (T_2) chitosan @ 1% (0.5%) on 3rd day after coatings but whereas minimum of titratable acidity was noted in (T_0) control (0.46%). After 9th day of storage minimum of titratable acidity was recorded in (T_0) control (0.34%) where as maximum titratable acidity was observed in (T_8) guar gum @ 1.5% (0.44%) followed by (T_9) guar gum @ 2%(0.41%) and (T_2) chitosan @ 1% (0.41%).At the end of the storage period coated fruits (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}) had about 1.15, 1.21,1.09, 1.12,1.18,1.09,1.12, 1.29,1.21,1.12,1.18, 1.15 times more acidity as compared to control. The results of acidity might be attributed to the fact that during the process of ripening, organic acids were used in metabolic processes and respiration of fruits which leads to a gradual decline in fruit acidity. Several studies show that titratable acidity decreases during the storage period(Fig-3). Under the current experiment, a reduction in titratable acidity was less pronounced in coated fruits as compared to uncoated fruits. The coating seemed like an effective method that decreased the rate of respiration in fruits and probably, therefore, delayed the use of organic acids [4], [16], [17].

Total soluble solid (TSS^{0}brix)

The data presented in table-1 revealed that TSS increased significantly in all treatments, and storage periods, but their interaction had non-significant. All treatments showed, increase in TSS with the progression of the storage period. On 3rd day after edible coatings minimum of TSS was recorded in (T_8) guar gum @ 1.5% (11.44 ^{0}brix) followed by (T_9) guar gum @ 2% (11.54 ^{0}brix) whereas maximum TSS was observed in (T_0) control (12.3 ^{0}brix). On the 9th day of storage maximum rise of TSS was recorded in (T_0) control (14.47 ^{0}brix) whereas the minimum rise of TSS was noted in (T_8) guar gum @ 1.5% (13.23 ^{0}brix) followed by (T_9) guar gum @ 2% (13.54 ^{0}brix). At the end of the storage period coated fruits (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}) had approximately 1.03, 1.05, 1.01,1.03, 1.04,1.0, 1.05,1.09,1.06,1.03,1.06,1.04 times less TSS as compared to uncoated fruits. Total soluble solid (Fig-4) was less rise in coated than uncoated fruits because coating provided a semi-permeable layer on fruit upper surface by which there was a barrier which modifies the inner atmosphere of fruit by which gaseous activity was minimum level which reduced the rate of respiration, evaporation, and metabolic activity of fruits. A low respiration rate slows down the synthesis and metabolites, resulting in lower soluble solids in coated fruits due to the deliberate hydrolysis of carbohydrates to sugars [16], [18], [19].

Table-1 Effects of different edible coatings on PLW, spoilage %, TSS, and titratable acidity of apple ber fruits

Treatments		PLW %			Spoilage %			Acidity %			TSS Brix		
		3rd Day	6th day	9th day	3rd Day	6th day	9th day	3rd Day	6th day	9th day	3rd day	6th day	9th day
Control		1.57	3.29	5.26	10	26.67	56.67	0.46	0.4	0.34	12.3	13.4	14.47
Chitosan	0.50 %	1.30	2.77	4.40	3.33	16.67	33.33	0.48	0.44	0.39	11.8	12.87	13.97
	1%	1.17	2.42	3.80	0.00	10.00	23.33	0.5	0.46	0.41	11.63	12.61	13.73
	2%	1.24	2.50	4.06	3.33	13.33	26.67	0.47	0.42	0.37	12.03	13.08	14.19
Gum arabic	6%	1.35	2.85	4.47	3.33	16.67	33.33	0.48	0.43	0.38	11.88	12.97	14.04
	9%	1.29	2.73	4.14	3.33	13.33	26.67	0.49	0.45	0.4	11.72	12.72	13.82
	12%	1.37	2.86	4.36	3.33	16.67	33.33	0.47	0.42	0.37	12.18	13.23	14.37
Guargum	1%	1.33	2.73	4.22	3.33	13.33	26.67	0.48	0.43	0.38	11.75	12.71	13.76
	1.50 %	0.99	2.04	3.34	0.00	10.00	23.33	0.52	0.49	0.44	11.44	12.28	13.23
	2%	1.13	2.36	3.68	0.00	10.00	23.33	0.5	0.46	0.41	11.54	12.53	13.54
Alovera gel	10%	1.44	3.09	4.82	3.33	16.67	30.00	0.46	0.42	0.38	11.78	12.81	13.93
	20%	1.18	2.45	3.92	0.00	10.00	23.33	0.49	0.44	0.4	11.63	12.55	13.57
	30%	1.36	2.79	4.54	3.33	13.33	26.67	0.48	0.43	0.39	11.72	12.76	13.83
Zero day mean		0			0			0.56			10.77		
Factors		C.D.5 %	SE(d)	SE(m)	C.D.5 %	SE(d)	SE(m)	C.D.5 %	SE(d)	SE(m)	C.D.5 %	SE(d)	SE(m)
Treatments		0.152	0.076	0.054	6.208	3.112	2.201	0.01	0.005	0.004	0.099	0.049	0.035
Days		0.073	0.037	0.026	2.982	1.495	1.057	0.005	0.003	0.002	0.047	0.024	0.017
Interaction		0.264	0.132	0.094	N/A	5.391	3.812	N/A	0.009	0.006	N/A	0.086	0.06

T_0=Control(water), T_1= Chitosan 0.5%, T_2= Chitosan 1%, T_3= Chitosan 2%, T_4= Gum Arabic 6%, T_5= Gum Arabic 9%, T_6= Gum Arabic 12%, T_7= Guar Gum 1%, T_8= Guar Gum 1.5%, T_9= Guar Gum 2%, T_{10}= Aloe-vera 10%, T_{11}= Aloe-vera 20%, T_{12}= Aloe-vera 30%

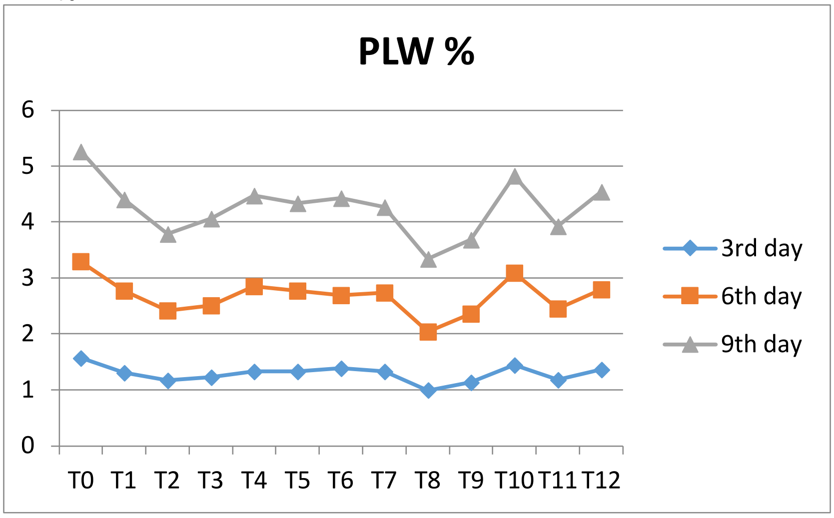

Fig.-1. Effects of edible coatings on PLW (%) in apple ber

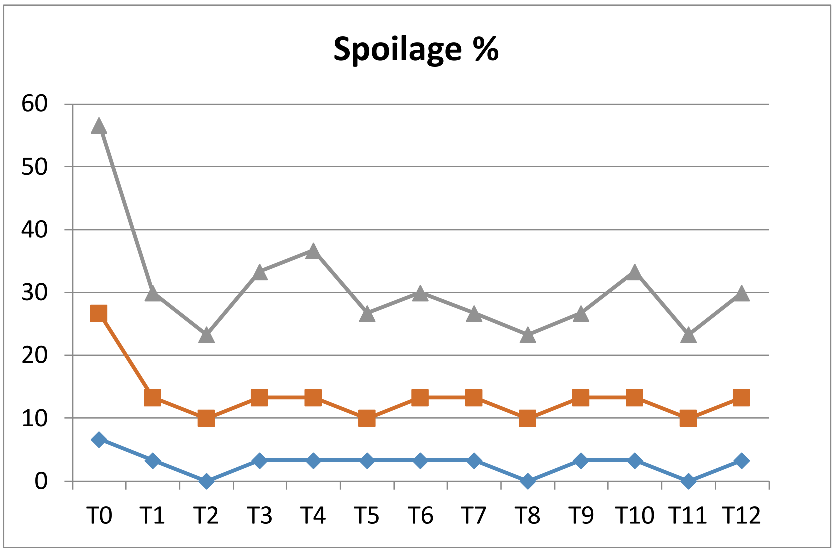

Fig.-2. Effects of edible coatings on spoilage (%) in apple ber

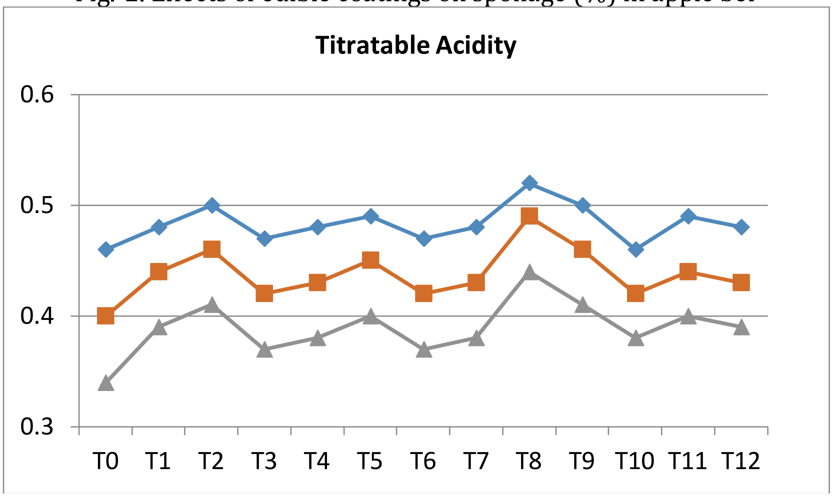

Fig.-3. Effects of edible coatings on TA (%) in apple ber

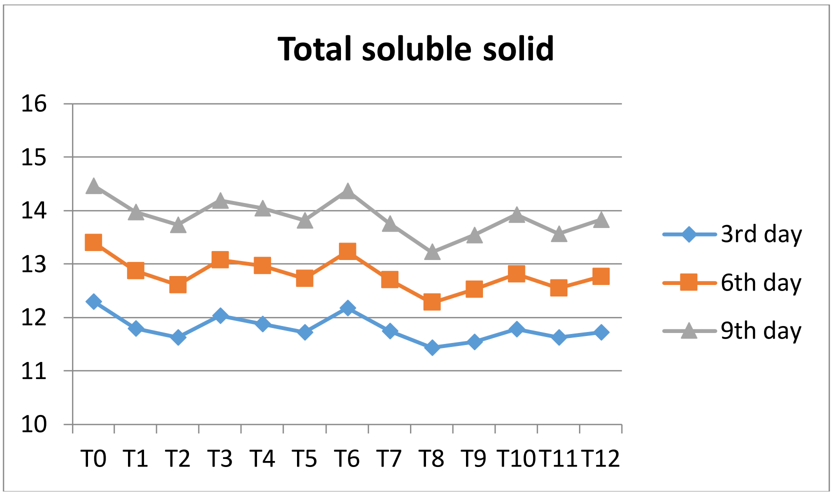

Fig.-4. Effects of edible coatings on TSS (^{0}brix) in apple ber

Table-2 Effects of different edible coatings on vitamin-c, total sugar, reducing sugar, and non reducing sugar of apple ber fruits.

Treatments		Vitamin-c (mg/100g)			Total sugar (%)			Reducing sugar (%)			Non reducing sugar (%)		
		3rd day	6th day	9th day	3rd day	6th day	9th day	3rd day	6th day	9th day	3rd day	6th day	9th day
Control		84.41	80.48	76.09	8.87	9.86	10.86	4.54	5.07	5.57	4.28	4.79	5.29
Chitosan	0.5 %	86.88	83.41	79.32	8.43	9.40	10.37	4.3	4.76	5.24	4.14	4.63	5.13
	1%	88.42	84.82	81.44	8.37	9.33	10.29	4.31	4.78	5.22	4.07	4.55	5.07
	2%	87.31	83.80	80.44	8.52	9.48	10.45	4.33	4.8	5.31	4.19	4.69	5.18
Gum arabic	6%	85.78	82.46	78.64	8.56	9.52	10.49	4.42	4.85	5.34	4.13	4.66	5.16
	9%	87.29	84.06	80.52	8.50	9.45	10.41	4.35	4.82	5.28	4.14	4.64	5.14
	12%	86.05	82.51	78.66	8.57	9.54	10.51	4.4	4.88	5.35	4.18	4.65	5.15
Guargum	1%	87.36	84.64	81.31	8.36	9.31	10.27	4.28	4.75	5.22	4.08	4.57	5.05
	1.5 %	89.61	86.79	83.67	8.02	8.87	9.80	4.12	4.49	4.94	3.93	4.38	4.86
	2%	88.14	85.72	81.99	8.17	9.09	10.05	4.14	4.58	5.05	4.03	4.52	5.00
Alovera gel	10%	85.72	82.40	79.06	8.38	9.34	10.30	4.26	4.73	5.2	4.12	4.62	5.16
	20%	87.87	85.18	81.85	8.21	9.16	10.11	4.13	4.58	5.07	4.08	4.58	5.05
	30%	86.17	83.25	80.14	8.32	9.28	10.25	4.21	4.68	5.16	4.11	4.60	5.11
Zero day mean		92.37			7.68			3.87			3.81		
Factors		**C.D.5 %**	**SE (d)**	**SE (m)**	**C.D. 5%**	**SE (d)**	**SE (m)**	**C.D.5 %**	**SE(d)**	**SE (m)**	**C.D.5 %**	**SE (d)**	**SE (m)**
Treatments		0.760	0.381	0.269	0.049	0.024	0.017	0.037	0.018	0.013	0.039	0.019	0.013
Days		0.365	0.183	0.129	0.023	0.012	0.008	0.018	0.009	0.006	0.019	0.009	0.007
Interaction		N/A	0.660	0.466	N/A	0.042	0.030	N/A	0.032	0.022	N/A	0.032	0.023

T_0=Control(water), T_1= Chitosan 0.5%, T_2= Chitosan 1%, T_3= Chitosan 2%, T_4= Gum Arabic 6%, T_5= Gum Arabic 9%, T_6= Gum Arabic 12%, T_7= Guar Gum 1%, T_8= Guar Gum 1.5%, T_9= Guar Gum 2%, T_{10}= Aloe-vera 10%, T_{11}= Aloe-vera 20%, T_{12}= Aloe-vera 30%

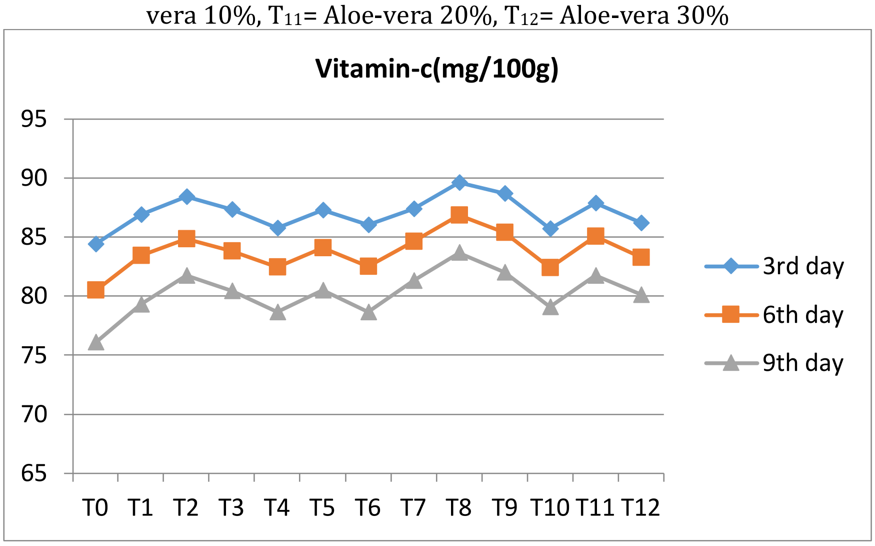

Fig-5. Effects of edible coatings on ascorbic acid in apple ber

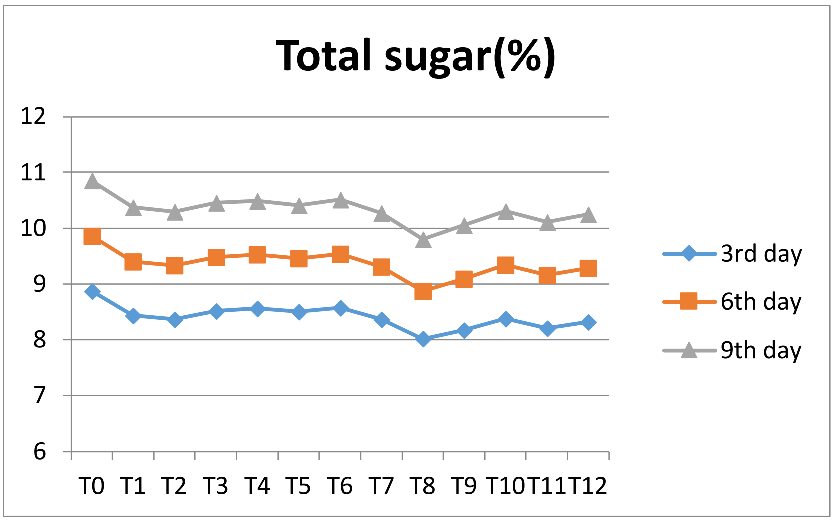

Fig-6. Effects of edible coatings on total sugar (%) in apple ber

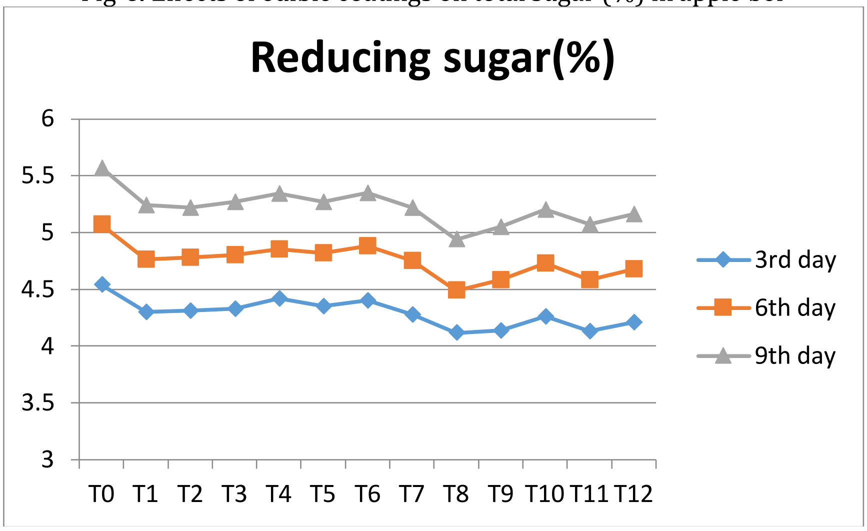

Fig-7.Effects of edible coatings on non-reducing sugar in apple ber

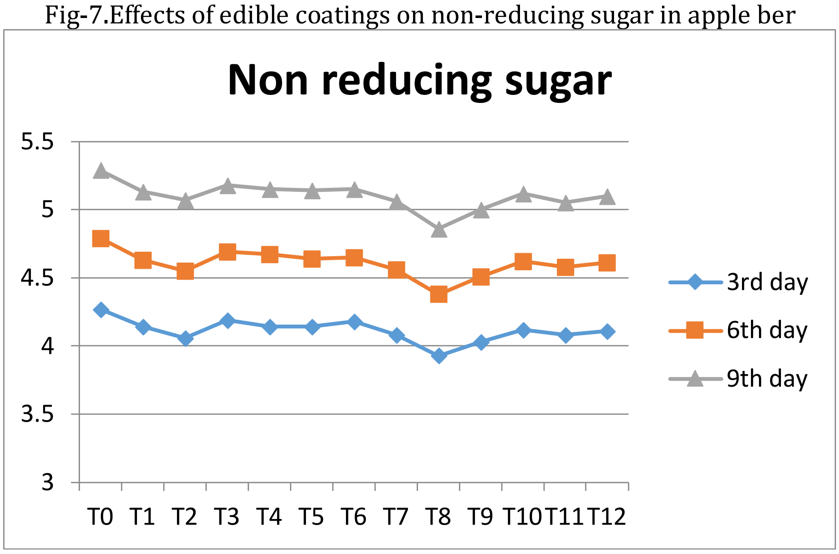

Fig-8. Effects of edible coatings on reducing sugar in apple ber

Vitamin-c

The data shown in (Table-2) regarding the effect of coatings on apple ber showed vitamin C was significantly decreased in all coating treatments, and the storage period, but their interaction had non-significant. The results had been revealed that ascorbic acid decreased in both the coated and the uncoated apple ber fruits with the progression of the storage period. On the 3rd day after edible coatings maximum vitamin-c was noted in (T_8) guar gum @ 1.5% (89.61mg/100g)) followed by (T_9) guar gum @ 2% (88.14 mg/100g) whereas minimum vitamin-c was observed in (T_0) control (84.41mg/100g). On the 9th day of after storage minimum, vitamin-c was noted in (T_0) control (76.09 mg100g) whereas maximum vitamin-c was noted in (T_8) guar gum @ 1.5% (83.67mg/100g) followed by (T_9) guar gum @ 2% (81.99 mg/100g). At the end of the storage period coated fruits (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}) had about 1.04, 1.07,1.06 ,1.03,1.06,1.03,1.07,1.10,1.08,1.04,1.07,1.05 times more ascorbic acid as compared to uncoated fruits. The maximum ascorbic acid (Fig-5) content in coated fruits as compared to uncoated ones can be due to that O_2 would not enter deep inside the fruit tissue so it may stop the oxidative breakdown of ascorbic acid. Later stage ascorbic acid was lost due to the enzyme activities of phenoloxidase and ascorbic acid oxidase during storage [4], [20], [21],[19].

Total sugar

Observation data (Table-2) concerning total sugar significantly increased in various coating treatments, and storage periods but their interaction between treatments, & storage periods had no significant effect. Various treatments showed total sugar increased with the increased storage period. On the 3rd day of storage minimum rise of total sugar was noted in (T_8) guar gum @ 1.5% (8.02%) followed by (T_9) guar gum @ 2%(8.17%) whereas the maximum increase of total sugar was observed in (T_0) control. Subsequently the 9th day of storage highest total sugar was recorded in (T_0) control (10.85%) whereas least total sugar was noted in (T_8) guar gum @ 1.5%(9.8%) followed by (T_9) guar gum @ 2%(10.05%). At the end of the storage period coated fruits (T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}) had 1.04, 1.05, 1.03,1.03, 1.04,1.03,1.05,1.10,1.08,1.05,1.07,1.05 times less total sugar as compared to untreated fruits. Fig-6 showed maximum value of total sugar in control treatment during storage period because there was no protective coating in control conditions, therefore tremendous gaseous exchange between the fruit and the external environment that might have led to increased total sugar levels. With the increasing storage period, the metabolic activities considerably high and that might be increased the total sugar levels of fruit. Increasing in total sugar during the storage period was attributed to the increase in the enzymatic activity for starch hydrolysis and reduces the rate of sugar breakdown during respiration [19], [22], [23].

Reducing sugars

Observation data (Table-2) concerning reducing sugar increased significantly in various coating treatments, and storage periods but their interaction between treatments and storage periods were found non-significant. All coated and uncoated fruits showed reduction in reducing sugar increase with the advancement of the storage period. Least reducing sugar was recorded in (T_8) guar gum @ 1.5% (4.12%) followed by (T_9) guar gum @ 2%(4.14%) on 3rd day after coatings but whereas highest reducing sugar was noted in (T_0) control(4.54%). On the 9th day after treatments highest reducing sugar was noted in (T_0) control(5.57%) whereas least reducing sugar was observed in (T_8)guar gum @ 1.5% (4.94%) followed by (T_9) guar gum @ 2%(5.05%). Fig-7 showed increase in reducing sugar content was recorded due to a higher rate of respiration and enzymatic activity in untreated fruits as compared to other coated treatments which trigger the starch into sugar during the storage period [19], [22], [23].

Non-reducing sugars

The data regarding the effect of coating treatment on non-reducing sugars of apple ber fruits (Table 2) revealed that non-reducing sugars increased significantly in all the treatments and storage periods but their interaction between treatments and storage period was found non-significant. After 3rd days of storage highest non reducing sugar was observed in (T_0) control (4.28%) whereas a least non-reducing sugar was noted in (T_8) guar gum @ 1.5% (3.93%) followed by (T_9) guar gum @ 2%(4.03%). On the 9th day after treatments maximum non-reducing sugar was noted in (T_0) control whereas minimum non-reducing sugar was observed in (T_8) guar gum @ 1.5%(4.86%) followed by (T_9) guar gum @ 2% (5%).Fig-8 showed increase in non-reducing sugar content was recorded due to a higher rate of respiration and enzymatic activity in untreated fruits as compared to other coated treatments which trigger the starch into sugar during the storage period [19], [22], [23].

CONCLUSION

The results of the contemporary study indicate that apple ber fruits coated with chitosan (0.5%, 1%, 2%), gum arabic (6%, 9%, 12%), guar gum (1%, 1.5%, 2%), and aloe vera gel(10%,20%,30%) significant delayed in the change of weight loss, spoilage percentage, total soluble solids, vitamin-c, titrable acidity, total sugars(reducing sugar + non-reducing sugar) as compared to control ones. Chemical parameters like titratable acidity and ascorbic acid moderately decreased while TSS, total sugar, reducing sugar, and non reducing sugar slowly increased as compared to control. Among all treatments guar gum @ 1.5% was more efficacy as a protective coating on apple ber fruits by maintaining the quality characteristics, reduce spoilage % during the storage periods.

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