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Research Article

Effect of Antioxidants on Storage Quality of Apple Sucrose Bars

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Abstract: An experiment was conducted to study the comparative effect of citric acid and ascorbic acid as antioxidants and variations in concentration of sugar (20, 30 and 35 °brix) on over-all quality of apple bars. Potassium meta-bisulphite and pectin were added as preservatives and binding agent, respectively. Quality of apple bars was evaluated within 3 months of storage, at 15-day intervals, in consideration of physicochemical and sensory aspects. In the bar samples, decrease was observed in water activity (0.69-0.64), moisture content (17.3-15.0 %), non-reducing sugars (4.12-3.92 %), pH (3.64-3.43), and ascorbic acid (3.11-0.61 mg/100 g). Increasing trends were noted in reducing sugars (17.28-17.31 %), titratable acidity (1.24-1.47%) total solids (83.26-87.38 %) and total soluble solids (63.17-68.46 °Brix) within 30 days of storage. Also, the apple bars exhibited noticeable changes in color (8.50-6.73), texture (8.50- 6.58), taste (8.50-6.51) and overall acceptability (8.00-5.68) during 90 days of storage. The bars prepared with 35° Brix and 0.1% citric acid exhibited comparatively higher stability in terms of physicochemical and sensory traits.

Keywords: Apple bar, sucrose, antioxidants, physico-chemical properties, sensory properties

1. INTRODUCTION

Apple is an important fruit and is produced mainly in central and south-western Asia. In Pakistan, it is nurtured in northern hilly areas of Khyber Pakhtunkhwa, Punjab and Baluchistan [1]. Apple is normally consumed as fresh fruit or as an ingredient in a variety of food products. Fruit bar is an intermediate moisture food (IMF) product having soft pliable texture, high moisture content (11-67% on dry weight basis) with minimum water activity of 0.60 sufficient to hold down enzymatic and microbial activities during storage at room temperature [2-5]. Fruit bar is developed by mixing proper amount of sugar, pectin, acid and color to fruit pulp, and then drying to the desired intermediate moisture content. These bars are like dried raisins having a chewy texture and are considered a natural source of dietary fiber [6]. In Pakistan, apple bars are commonly prepared in hilly areas of Gilgit-Baltistan with addition of sucrose which impart it extreme sweet taste and dark brown colour, probably due to the process of caramalization.

Sucrose, known as table sugar, is an organic compound of white color, which is odorless and crystalline with a sweet taste [7]. Earlier, sugar and preservatives were added in fresh mango and banana purees and slices to enhance their shelf-life and to minimize deterioration by using proper packaging and storage condition [8]. Application of flavoring agent citrate can extend shelf-life by preventing phenolase oxidase enzymatic reactions in sliced apple. Citric acid and ascorbic acids are found to be more useful [9-10]. Previously, it was noted that the addition of citric acid at a level of 0.6 % can improve the color, flavor and overall acceptability of the bars [11]. However, pectin in fruits act as a structural constituent but its proper integration with acids and sugar has to be maintained because it provide high ductile strength to leather [6, 12].

Food antioxidants also possess scavenging

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properties for free radicals. Previously it has been conferred that various plant extracts namely ascorbates, ascorbic acids, tocopherols, carotenoids, and phenolic compounds lessen the rancidity and discoloration of food products [13-14]. Citric acid is a phenolase oxidase chelating agent, and the inhibition of polyphenol oxidase (PPO) was attributed to the chelating action [15]. Citric acid application to the sliced apple can prevent browning and thus extends their life span but the combination of citric and ascorbic acids were proved more effective in maintaining the overall quality of IMF products [9-10]. This study was undertaken with the objective to develop apple bars with extended shelf life by the incorporation of sucrose and antioxidants at various levels. The study also aimed to investigate the effect of these additives on the physicochemical and sensory properties of apple bars during the storage period. Additionally, it offers opportunity to combat the post-harvest losses of apple fruits, consequently aids in the improvement of the farmer's economy.

2. MATERIALS AND METHODS

This research was carried out in the Food Processing Laboratory of Department of Food Science and Technology, The University of Agriculture, Peshawar. Apple and sugar were procured from the local market in Peshawar city for preparing apple bars. The needed chemicals were provided by the laboratory.

2.1 Preparation of Apple Bars

Sound and healthy apple fruits were rinsed carefully with tap water to remove dust and dirt particles and chemical residues to minimize the microbial load. All the fruits were peeled and cut into slices with the help of a stainless steel knife. Pulp was extracted by using pulping machine and bars were prepared as per mentioned in Table 1. The total soluble solids (TSS) of all the samples were modified with the addition of sucrose in proper amount and then the samples were acidified with addition of citric (CA) and ascorbic acid (AA) with certain modifications in previously conducted research work [16]. These prepared samples were wrapped in transparent polyethylene plastic bags and were stored at room temperature 25-35 ˚C for the period of three months (April-June) and studied for physicochemical and sensory attributes within an interval of 15 days.

2.2 Physicochemical Analysis

All apple bars samples were examined for physicochemical properties including pH, TSS, moisture content, water activity (aw), titratable acidity, ascorbic acid, total solids (TS), reducing sugars and non-reducing sugars by using standard methods of AOAC [17].

2.3 Sensory Analysis

Sensory analysis of apple bars was carried out by using the 9 point hedonic scale (1-9) of Larmond [18]. Panels of 10 judges were selected on the basis of experience in sensory analysis. The sensory properties including color, taste, texture and overall acceptability were examined by taking the mean values of the panelist scores.

2.4 Statistical Analysis

The data regarding all storage intervals and

Table 1. Plan of the study.

Treatment	Apple pulp	Sucrose (˚Brix)	Pectin (g/kg)	Antioxidant (%)	KMS (g/kg)
AB_0	500 mL	13	0	0	0
AB_1	500 mL	20	2	0.1 CA[1]	0.1
AB_2	500 mL	30	2	0.1 CA	0.1
AB_3	500 mL	35	2	0.1 CA	0.1
AB_4	500 mL	20	2	0.1 AA[2]	0.1
AB_5	500 mL	30	2	0.1 AA	0.1
AB_6	500 mL	35	2	0.1 AA	0.1

[1]CA= Citric acid
[2]AA= Ascorbic acid

treatments were statistically analyzed by CRD 2 factorial as recommended by Gomez and Gomez [19] and the means were separated by LSD test at 5% probability level as defined by Steel and Torrie [20].

3. RESULTS AND DISCUSSION

3.1 Physico-chemical Analysis

In this study the effect of added antioxidants on water activity, ascorbic acid, percent acidity, moisture content, pH, total solids, total soluble solids, reducing sugar and non-reducing sugar contents of apple bars were analyzed during storage period of three months.

3.1.1 Water Activity (a_w)

The water activity of the entire sample analyzed at an interval of 15 days during storage. Initially, the a_w of all the apple sucrose bar samples was in the range of 0.67-0.70, which decreased from 0.66 to 0.61 during 90 days of storage period (P<0.05). Decreases in a_w of all the samples might be due to the free water binding capacity of sucrose, acids and pectin while a_w level around 0.60 is considered safe for microbial proliferation in apple fruit bar [2-3]. Similar decrease was observed in a_w of pawpaw and guava fruit leather from 0.64 to 0.61 during storage [22]. Higher stability, in a_w was noted in AB_6 (0.68) in comparison with its counterparts. While mean values for storage intervals showed decrease in a_w from 0.69 to 0.64 within 90 days of storage (Table 2). Similarly, a_w of apple- black current fruit leather also decreased to 0.60 during storage interval [21].

3.1.2 Ascorbic Acid

The apple sucrose bars samples were analyzed for

Table 2. Effect of treatment and storage period on water activity (aw) of apple bars.

Treatment	Storage duration (days)							
	0	15	30	45	60	75	90	Mean
AB_0	0.67	0.67	0.66	0.64	0.63	0.62	0.61	0.65 a*
AB_1	0.68	0.68	0.67	0.65	0.64	0.63	0.62	0.66 b
AB_2	0.70	0.68	0.67	0.67	0.66	0.65	0.64	0.67 de
AB_3	0.68	0.68	0.67	0.66	0.66	0.65	0.65	0.67 d
AB_4	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.66 c
AB_5	0.69	0.68	0.68	0.67	0.66	0.65	0.65	0.67 e
AB_6	0.70	0.69	0.69	0.68	0.67	0.66	0.66	0.68 f
Mean	0.69g*	0.72f	0.67e	0.66d	0.65c	0.64b	0.64a	

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05)

Table 3. Effect of treatment and storage period on ascorbic acid (mg/100 g) of apple bars.

Treatment	Storage duration (days)								Decrease
	0	15	30	45	60	75	90	Mean	(%)
AB_0	2.66	1.76	1.16	0.56	0.16	0.05	0.01	0.91 a*	99.62
AB_1	2.66	2.16	1.66	1.46	1.26	1.16	0.76	1.59 e	71.42
AB_2	2.73	2.06	1.56	1.36	1.16	1.06	0.46	1.49 c	83.15
AB_3	2.66	2.56	2.56	2.46	1.76	1.56	1.46	2.14 f	45.11
AB_4	3.86	1.46	0.86	0.36	0.07	0.06	0.03	0.96 b	99.22
AB_5	3.66	1.86	1.36	1.26	1.06	0.96	0.36	1.51 d	90.16
AB_6	3.56	3.16	2.96	2.26	1.46	1.26	1.16	2.26 g	67.41
Mean	3.11g	2.14f	1.73e	1.41d	0.99c	0.87b	0.61a		

Mean values within a column or a row followed by different letters are significantly (P<0.05) different from each other.

Table 4. Effect of treatment and storage period on % acidity of apple bars.

Treatment	Storage duration (days)								Increase (%)
	0	15	30	45	60	75	90	Mean	
AB_0	1.20	1.30	1.38	1.44	1.49	1.52	1.59	1.42 f*	32.5
AB_1	1.21	1.27	1.31	1.34	1.37	1.41	1.44	1.34 b	19.00
AB_2	1.33	1.37	1.40	1.43	1.46	1.48	1.52	1.43 g	14.28
AB_3	1.30	1.34	1.36	1.39	1.42	1.45	1. 48	1.39 d	13.84
AB_4	1.24	1.27	1.32	1.36	1.39	1.43	1.47	1.35 c	18.54
AB_5	1.30	1.32	1.37	1.40	1.44	1.47	1.49	1.40 e	14.61
AB_6	1.10	1.14	1.18	1.22	1.25	1.28	1.31	1.21 a	19.09
Mean	1.24 a*	1.29 b	1.33 c	1.37 d	1.40 e	1.43 f	1.47 g		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

Table 5. Effect of treatment and storage period on moisture (%) of apple bars.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	16.5	16.20	15.47	15.12	14.51	14.14	13.90	15.12 a*	15.70
AB_1	16.95	16.84	16.42	16.14	15.97	15.48	15.21	16.14 c	10.20
AB_2	16.98	16.79	16.77	15.92	15.81	15.76	15.61	16.23 c	8.06
AB_3	16.90	16.88	16.79	16.76	15.90	15.82	15.76	16.40 d	6.74
AB_4	17.91	16.68	16.46	15.87	15.75	15.54	15.02	16.17 c	16.1
AB_5	16.97	16.74	16.26	15.84	15.48	15.12	14.96	15.91 b	11.8
AB_6	16.96	16.76	16.38	15.46	15.23	15.08	14.82	15.81 b	12.6
Mean	17.03 g*	16.70 f	16.36 e	15.87 d	15.52 c	15.28 b	15.04 a		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

Table 6. Effect of treatment and storage period on pH of apple bars.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	3.43	3.40	3.37	3.34	3.31	3.28	3.25	3.34 b*	5.24
AB_1	3.25	3.21	3.17	3.13	3.06	3.05	3.01	3.13 a	7.38
AB_2	3.83	3.80	3.77	3.74	3.71	3.68	3.65	3.74 f	4.69
AB_3	3.95	3.93	3.91	3.87	3.86	3.85	3.83	3.88 g	3.03
AB_4	3.75	3.70	3.65	3.60	3.55	3.50	3.45	3.60 e	8.00
AB_5	3.55	3.51	3.47	3.43	3.36	3.35	3.31	3.43 c	6.76
AB_6	3.67	3.64	3.61	3.58	3.55	3.52	3.46	3.58 d	5.72
Mean	3.64 g*	3.60 f	3.57 e	3.48 d	3.48 c	3.46 b	3.43 a		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

ascorbic acid content initially the ascorbic acid for treatments from AB_0 to AB_6 was 2.66 to 3.56 mg/100 gm which significantly (P<0.05) decreased to 0.01 and 1.16 mg/100 g during the entire storage period. Maximum stability in ascorbic acid content was observed in AB_3 (1.46 mg/100 g). While mean values for storage intervals showed decrease in ascorbic acid content from 3.11 to 0.61 mg/100g during three months of storage (Table 3). The losses in the ascorbic acid content might be due to high temperature provided in apple bar preparation, variation in storage temperature and oxidation of ascorbic acid to dehydro-ascorbic acid [26]. Previously, reduction in vitamin C content of guava (176.27 to 104.87 mg/100 g) and pawpaw (83.33 to 74.70 mg/g) fruits leather were observed during storage [24-25]. Similarly, reduction in ascorbic acid content due to oxidation was noted from 1.7 to 0.8% in IMF food product [27].

3.1.3 Acidity

The samples were tested for percent acidity at 15 days interval during storage and the initial values for the treatments AB_0 to AB_6 were 1.20 and 1.10%, respectively, which significantly (P<0.05) increased finally to 1.59 and 1.31% during 90 days of storage period. Similar increase in percent acidity up to 1.11% and 1.66% was noted in apple fruit bar during 60 and 90 days of storage [6]. Table 4 shows that higher increase in acidity was observed in AB_2 (1.43%) followed by AB_0 (1.42%) however, stability in acidity was observed in AB_6 (1.21%) followed by AB_1 (1.34%) during 90 days of storage. Increase in acidity of all the samples might be due to the addition of citric and ascorbic acid and also due to break down of sugar into acids during dehydration and storage. Similarly, percent acidity increased during storage from 0.42 to 0.48% in guava and 0.37 to 0.44% in mango leather [24-28].

3.1.4 Moisture Content

The moisture content of the apple sucrose bars declined during storage. The initial moisture content of the entire sample from AB_0 to AB_6 was 16.5 and 16.96%, which significantly (P<0.05) decreased to 13.90, 15.76% after 90 days of storage time. Maximum mean values of moisture content were noticed in AB_3 (16.40%) followed by AB_2 (16.23%), while the lowest mean values were observed in AB_0 (15.12%) followed by AB_6 (15.81%) in table 5. While mean values for storage intervals showed decrease in moisture content from 17.03 to 15.04% during 90 days. Decrease in moisture content is responsible for lower a_w of apple bar and it may be attributed to the water binding capacity of sucrose, pectin and also due to rise in environmental and room temperature at the onset of summer season. Similarly, reduction in moisture content of pear from (12.13 to 7.97%) and durian (15.82 to 14.36 %) fruit leathers was noticed during storage [29-30].

3.1.5 pH

The pH of the samples decreased during storage. Initially, the pH value with treatments AB_0 to AB_6 were 3.4 and 3.67, which declined to 3.25 and 3.46 (P<0.05) during three months of storage time. The highest mean value for pH was observed in AB_3 (3.88) followed by AB_2 (3.74) and AB_4 (3.60), while lowest mean value for pH was observed in AB_1 (3.13) and AB_0. While mean values for storage intervals showed decrease in pH from 3.64 to 3.43 throughout 90 days of room storage conditions (Table 6). Decrease in pH is always due to rise in acidity, while in apple bar samples decrease in pH might be due to the addition of citric acid and ascorbic acid. Previously, decline in pH from 3.80 to 3.60 was observed in mango and pine-apple fruits during storage [31-32].

3.1.6 Total Solids

The apple sucrose bars samples were analyzed at 15 days of interval for total solids. Initial total solids (TS) value of apple bar with treatments AB_0 to AB_6 were 82.90 and 84.14 which significant (P<0.05) increased to 83.08% and 88.27% within 3 months of storage at room temperature. Mean total solids for all the storage intervals increased from 83.26 to 87.38% (Table 7). Increase in TS may be due to the presence of fiber content and addition of pectin in apple bar preparation. Previous study showed that total solids increased from 69.66 to 70.77 in fruit bar during storage [23].

Table 7. Effect of treatment and storage period on total solid (%) of apple bars.

Treatment	Storage duration (days)								Increase (%)
	0	15	30	45	60	75	90	Mean	
AB_0	82.90	82.93	82.96	82.99	83.02	83.04	83.08	82.99 a*	0.21
AB_1	82.76	82.98	83.84	84.97	86.19	87.28	87.46	85.07 b	5.67
AB_2	83.13	83.84	84.67	87.37	87.62	87.72	88.95	86.18e	6.54
AB_3	84.31	85.93	86.06	85.30	86.87	86.95	88.39	86.21f	4.61
AB_4	82.53	83.43	83.97	84.72	86.02	87.02	87.59	85.04 b	6.13
AB_5	83.04	84.29	85.00	85.60	85.86	86.86	88.27	85.56 c	6.29
AB_6	84.14	84.25	85.01	86.03	87.26	87.87	88.25	86.11 d	4.65
Mean	83.26 a*	83.95 b	84.50 c	85.28 d	86.12 e	86.67 f	87.38 g		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

Table 8. Effect of treatment and storage period on TSS (°brix) of apple bars.

Treatment	Storage duration (days)								Increase (%)
	0	15	30	45	60	75	90	Mean	
AB_0	20.03	24.66	28.03	30.03	35.03	40.03	48.03	32.26 a*	139.8
AB_1	69.76	69.86	70.11	70.13	70.36	70.46	76.63	71.04 e	9.84
AB_2	70.13	70.13	70.16	70.23	70.26	70.36	70.46	70.24 c	0.47
AB_3	71.23	71.23	71.23	71.26	71.36	71.46	71.56	71.33 g	0.46
AB_4	69.73	69.76	69.86	70.13	70.26	70.36	70.46	70.08 b	1.04
AB_5	70.16	70.23	70.26	70.26	70.46	70.56	70.66	70.37 d	0.71
AB_6	71.13	71.13	71.23	71.26	71.43	71.46	71.56	71.31 f	0.60
Mean	63.17 A*	63.86 b	64.41 c	64.75 d	65.60 e	66.39 f	68.46 g		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

Table 9. Effect of treatment and storage period on reducing sugar (%) of apple bars.

Treatment	Storage duration (days)								Increase (%)
	0	15	30	45	60	75	90	Mean	
AB_0	3.277	3.967	3.967	3.967	3.977	3.977	3.987	3.874a*	17.8
AB_1	18.56	18.56	18.56	18.58	18.58	18.58	18.58	18.57c	0.10
AB_2	19.77	19.78	19.82	19.86	19.88	19.91	19.93	19.85d	0.80
AB_3	20.34	20.34	20.34	20.35	20.35	20.35	20.35	20.35g	0.04
AB_4	18.01	18.03	18.05	18.08	18.12	18.15	18.16	18.22b	0.82
AB_5	19.77	19.92	19.94	19.96	19.97	19.98	19.94	19.92e	0.85
AB_6	20.26	20.26	20.27	20.27	20.28	20.29	20.27	20.27f	0.04
Mean	17.28b*	17.26a	17.28b	17.29c	17.31d	17.31de	17.31de		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

3.1.7 Total Soluble Solids

The initial readings for TSS from AB_0 to AB_6 were 20.03 and 71.13º Brix, which significantly (P<0.05) increased up to 48.03 and 71.56° Brix during storage period. Highest mean values for treatment were noted in AB_3 (71.33° Brix) followed by AB_6 (71.31° Brix), while the lowest mean values were noted in AB_0 (32.26° Brix) followed by AB_2 (70.25° Brix). The mean values of the storage interval increased from 63.17 to 68.46° Brix during storage (Table 8). Steady increase in TSS may be attributed to the addition of sucrose which was converted into glucose and fructose and also due to the loss of moisture content, which aided in increasing the shelf life of apple fruit bars [33]. Previous research work showed that TSS of IMF products including fruits jam, jellies, marmalade and leather minimally increases during storage, which stabilized the shelf life of these products [34-35].

3.1.8 Reducing Sugars

The apple sucrose bars samples were tested for reducing sugars at 15 days of interval. Initially the reducing sugar value for the sample AB_0 (3.27%) to AB_6 (20.26%) were recorded, which statistically (P<0.05) increased up to (20.27%) during storage period. Maximum mean values for treatment were noticed in AB_3 (20.35%) followed by AB_6 (20.27%). While mean values for storage interval showed increase in reducing sugar from 17.28 to 17.33% in (Table 9). Reducing sugar of all the apple bars might be increased due to conversion of polysaccharides and disaccharides to monosaccharaides. Previously researchers showed that reducing sugar content of strawberry jam and grape fruit-apple marmalade increased at par with apple sucrose bar during 3 months of storage at room temperature [34-35].

Table 10. Effect of treatment and storage period on non-reducing sugar (%) of apple bars.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	2.34	2.31	2.28	2.26	2.23	2.22	2.18	2.26 a*	6.83
AB_1	2.37	2.34	2.26	2.28	2.23	2.21	2.18	2.26 a	8.01
AB_2	4.48	4.46	4.43	4.41	4.38	4.34	4.33	4.41 c	3.34
AB_3	6.41	6.36	6.35	6.31	6.26	6.28	6.26	6.32 d	2.34
AB_4	2.41	2.36	2.36	2.33	2.26	2.28	2.25	2.32 b	6.63
AB_5	4.48	4.46	4.45	4.42	4.38	4.02	4.34	4.36 c	3.12
AB_6	6.38	6.36	6.34	6.31	6.28	6.26	6.23	6.30 d	2.35
Mean	4.12 e*	4.09 de	4.07 de	4.04 cd	4.00 bc	3.98 ab	3.92 a		

**Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

Table 11. Effect of treatment and storage period on color (using the 1–9 point hedonic scale of Larmond [18]) of apple bars.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	8.50	6.56	6.23	5.73	5.23	4.83	4.53	5.94 a*	46.70
AB_1	8.50	8.23	7.86	7.86	7.63	7.33	6.83	7.74 b	19.64
AB_2	8.50	8.43	8.23	8.03	8.86	7.83	7.53	8.07 g	11.41
AB_3	8.50	8.43	8.13	7.83	7.73	7.23	7.03	7.84 d	17.29
AB_4	8.50	8.43	8.03	7.83	7.73	7.43	6.86	7.81 c	19.29
AB_5	8.50	8.33	8.13	7.83	7.83	7.53	7.13	7.91 e	16.11
AB_6	8.50	8.43	8.16	7.86	7.86	7.66	7.23	7.95 f	14.94
Mean	8.50 g*	7.86 d	7.95 f	7.66 e	7.45 c	7.12 b	6.73 a		

*Mean values within a column or a row followed by different letters are significantly different from each other (P<0.05).

3.1.9 Non-Reducing Sugars

The non-reducing sugar of apple bars decreased during storage. Initial values for the treatments from AB_0 to AB_6 were 6.38% which statistically *(P<0.05)* decreased to 2.18 and 6.23% during 90 days of storage. Higher mean values for treatments were observed in AB_3 (6.32) followed by AB_6 (6.30) and AB_2 (4.41) %. While mean values of storage intervals showed decrease in non-reducing sugar from 4.12 to 3.92% as shown in table 10. Earlier, decrease in non-reducing sugar of apple fruit bar samples were noted which might be due to the modification or conversion of starch and other insoluble carbohydrates into sugar [36]. Similarly, many researchers observed decreasing trend in reducing sugars of IMF food products including guava slices, strawberry jam and in grape fruit apple blended marmalade [33-35].

3.2 Sensory Evaluation

The apple bars were evaluated at 15-day intervals during storage period, for sensory analysis such as color, texture, taste and overall acceptability.

3.2.1 Color

The samples of the apple sucrose bars observed for color at 15 days interval during storage at room temperature. It was noticed in sensory evaluation studies that the score for the characteristic reddish brown color of all the apple bar samples significantly ($P<0.05$) decreased from during three months of storage. Maximum mean values for the color of treatments (Table 11) was obtained by AB_2 (8.07) followed by AB_6 (7.95), while the minimum mean values were observed in AB_0 (5.94) followed by AB_2 (7.74) and the mean values for storage interval

Table 12. Effect of treatment and storage period on texture (using the 1–9 point hedonic scale of Larmond [18]) of apple bars.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	8.50	5.63	5.13	4.73	4.63	4.43	4.13	5.31 a*	51.41
AB_1	8.50	8.43	8.13	7.63	7.23	6.86	6.63	7.63 c	22.00
AB_2	8.50	8.43	8.33	8.23	8.03	7.73	7.53	8.11 g	11.41
AB_3	8.50	8.47	8.33	8.03	7.73	7.33	6.86	6.75 b	19.29
AB_4	8.50	8.43	8.23	7.73	7.33	7.03	6.73	7.71 d	20.82
AB_5	8.50	8.43	8.33	8.23	7.83	7.43	7.03	7.96 e	17.29
AB_6	8.50	8.43	8.43	8.26	7.86	7.46	7.16	8.00 f	15.76
Mean	8.50 g*	8.03 f	7.84 e	7.54 d	7.23 c	6.89 b	6.58 a		

*Mean values within a column or a row followed by different letters are significantly different from each other ($P<0.05$).

Table 13. Effect of treatment and storage period on taste (using the 1–9 point hedonic scale of Larmond [18]) of apple bar.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	8.50	5.06	4.73	4.53	4.23	3.86	3.53	4.92 a*	58.47
AB_1	8.50	8.43	8.13	7.73	7.33	6.86	6.63	8.02 d	22.00
AB_2	8.50	8.43	8.43	8.13	7.83	7.53	7.33	8.00 c	13.76
AB_3	8.50	8.46	8.23	7.86	7.73	7.26	6.86	8.12 f	19.29
AB_4	8.50	8.43	8.13	7.76	7.43	7.03	6.73	7.71 b	20.82
AB_5	8.50	8.43	8.43	8.13	7.83	7.63	7.23	8.02 d	14.94
AB_6	8.50	8.43	8.41	8.20	7.86	7.73	7.26	8.05 e	14.58
Mean	8.50 g*	7.95 f	7.78 e	7.47 d	7.17 c	6.84 b	6.51 a		

*Mean values within a column or a row followed by different letters are significantly different from each other ($P<0.05$).

also showed decrease in color from 8.50 to 6.73. The slight conversion in typical apple sucrose bar might be due to the activation of Maillard browning and oxidation of ascorbic acid into dehydroascorbic acid. Similarly, decrease in color score of apple and guava leather was observed from 6.00 to 5.00 and 7.10 to 6.16 during storage [5, 24].

3.2.2 Texture

Study showed significant effect of treatments and storage interval on texture of apple sucrose bars during storage period. It was noted that mean score of judges for texture of apple sucrose bar decreased significantly ($P<0.05$) from AB_0 8.50 to AB_6 to 4.13, 6.63, 7.53, 6.86, 6.73, 7.03 and 7.16 within 3 months of storage intervals. Highest mean value for texture was observed in AB_2 (8.11) followed by AB_6 (8.00) and the lowest mean values were recorded in AB_0 (5.31) followed by AB_3 (6.75). Concurrently, the mean values for texture of apple bar during 90 days of storage decreased from 8.50 to 6.58 (Table 12). Several ways can be used to note the texture of fruit leather but human taste buds are more complex in evaluating the texture of fruit bars in comparison with penetrometer which normally measures only one aspect of texture [29, 37].

3.2.3 Taste

As it is shown in table 13 that maximum mean values for taste among all the treatments were obtained by AB_3 (8.12) followed by AB_6 (8.05) and AB_1 (8.02) and the minimum mean values were observed in AB_0 (4.92) followed by AB_4 (7.71) (Table 13). Consequently, mean values for storage decreased from 8.50 to 6.51, respectively. Changes in taste of apple sucrose fruit leather might be due to variation in the amount of sugar and acids which require optimization [24] but the sweetness and acid ratio also depends upon type of fruit and may vary during storage [25].

3.2.4 Overall Acceptability

The overall acceptability score based on others sensory characteristics and it is evident from the sensory analysis related to color, flavor and taste that mean scores for over all acceptability of apple bar also significantly *($P<0.05$)* decreased from AB_0 to AB_6 during 3 months of storage period. The highest mean values for treatments were found in AB_6 (6.95) followed by AB_5 (6.91) and AB_2 (6.90), and the lowermost mean values were observed in AB_0 (4.82) followed by AB_1 (6.61) and AB_4 (2.32), while the mean values for storage interval showed decrease in overall acceptability from 8.00 to 5.68 (Table 14). Decreasing trend in overall acceptability of fruit bar might be influenced by the addition of acid, sucrose, conversion of color, consistency, storage time period and fluctuation in temperature [38].

4. CONCLUSIONS

The apple bars prepared with addition of citric acid and ascorbic acid along with pectin exhibited relatively higher shelf life on the basis of physicochemical analysis. Addition of ascorbic

Table 14. Effect of treatment and storage period on overall acceptability (using the 1–9 point hedonic scale of Larmond [18]) of apple bars.

Treatment	Storage duration (days)								Decrease (%)
	0	15	30	45	60	75	90	Mean	
AB_0	8.00	6.76	4.55	4.01	3.86	3.52	3.05	4.82 a*	61.87
AB_1	8.00	7.26	6.86	6.46	6.16	5.86	5.66	6.61 b	29.25
AB_2	8.00	7.16	6.86	6.66	6.76	6.46	6.36	6.90 e	20.5
AB_3	8.00	7.26	7.06	6.86	6.53	6.16	6.06	6.85 d	24.25
AB_4	8.00	7.06	6.86	6.66	6.46	6.16	5.96	6.74 c	25.5
AB_5	8.00	7.16	6.96	6.86	6.66	6.46	6.26	6.91 f	21.75
AB_6	8.00	7.36	7.16	6.66	6.66	6.46	6.36	6.95 g	20.5
Mean	8.00 g*	7.15 f	6.62 e	6.31 d	6.16 c	5.87 b	5.68 a		

*Mean values within a column or a row followed by different letters are significantly different from each other ($P<0.05$).

acid enhanced availability of vitamin C in the bars. Further, specific red brown colour of apple bars persisted during 3-month storage period and addition of acids minimized sweetness of the bars, by imparting mild sourness, compared with non-acidified bars, which resulted in higher acceptability of the product.

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