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Evaluation of antioxidant efficiency on physiochemical and sensory properties of sucrose bar prepared from red delicious apple (*Malus domestica*) grown in Northern areas of Pakistan

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Abstract

Red delicious apple (*Malusdomestica*) is very important fruit plant native to northern areas of Pakistan. From dietary point of view it has lot of potential. By product develops from this precious fruit also have high market as well as dietary value. This research was conducted in the PCSIR (Pakistan Council of Scientific and Industrial Research Center) research laboratory in Skardu Gilgit Baltistan, Pakistan for monitoring the effectiveness of ascorbic acid (AA),citric acid (CA) and potassium meta-bisulphite (KMS) ongeneral quality of sucrose apple bars during the periods of three months storage at room temperature. Sucrose bars were developed from the pulp of red delicious apple fruit. The finding showed that the antioxidants had major impact on physiochemical and sensory parameters and there were declining pattern was observed in all treatments, activity of water content reduced from 0.69% to 0.64%, non-reducing sugars decrease from 4.12 to 3.92 %, moisture content showed down pattern from 17.3 to 15.04 %, pH dropped from 3.64 to 3.43, and ascorbic acid decrease from 3.11 to 0.61 %. On the other hand up streaming pattern was notedin reducing sugars (17.28 to 17.31 %), Titratable acidity increase from1.24% to 1.47%,total solids increase tremendously from 83.26% to 87.38 %and total soluble solids also showed increasing pattern (63.17 to 68.46 °Brix)in the samples.We can develop different byproduct having high market values from this delicious fruit. This may leads to directly or indirectly improve the living standard of native people.

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Introduction

Apple is one of the most important fruit and is abundantly produced insouth western and central Asia. Gilgit Baltistan, Khyber Pakhtunkhwa (KPK)a nd Baluchistan are major apple producing areas of Pakistan.(Agricultural Statistics of Pakistan 2011-12). Apple fruit is normally consumed asfresh fruit and processed into different products such as jams, jelly and juice. Bar is an intermediate moisture food (IMF) product having soft pliable texture, high moisture content (11-67% ondry weight basis) with minimum water activity of 0.60 sufficient to hold down enzymatic and microbial activities during storage at room temperature.(Gould, 1996; Naz, 2012). For the development of fruit bar accurate quantity of sugar, pectin, acid and color are required and proper mixing of these items is essential and then dried to desired intermediate moisture content. Fruit bars havechewy texture and look like dried raisins and considered asource of dietary fiber naturally.(Vidhya andNarain, 2010).

Sucrose is a white, odorless, crystalline organic compound with a sweet taste commonly known as table sugar (Burghardt *et al.,* 1993). Earlier, sugar and other preserving agents were added in fresh mango and banana purees and slices to improve their shelf-life and to minimize deteriorationby using appropriate packaging and storage condition (Alzamora *et al.,* 1994).Flavoring agent citrate application can extend shelf-life by stopping enzymatic reactions of phenolase oxidase in sliced apple. For this purpose Citric acid and ascorbic acids are consider as more helpful (Santerre *et al.,* 1988; Pizzocaro *et al.,* 1993). It was previously observed that adding citric acid at a rate of 0.6% can enhance bar color, taste and general acceptability. (Parsad,2009).However, pectin is structural component of fruit but its proper integration with acids and sugar has to be maintained because it provide high ductile strength to leather(Vidhya and Narain2010; Ratphitagsanti *et al.,* 2004).

Food antioxidants also have free radicals scavenging characteristics.Previously it has been conferred that various plant extracts namelyascorbates, ascorbic acids, tocopherols, carotenoids, and phenolic compounds reduce the discoloration and rancidity of food products.(Mitsumoto *et al.*,1991;Decker andXu, 1998). Citric acid is a chelating agent of phenolase oxidase, and polyphenol oxidase (PPO) activity is inhibited due to its chelating property(Jiang *et al.*, 1999).Browning of sliced apple may prevent by application of citric acid and thus enhance their shelf life but overall qualities of IMF products weremaintained more efficiently by applyingcitric and ascorbic acids in combination(Santerre *et al.,* 1988;Pizzocaro *et al.,* 1993).Taking into account various aspects mentioned above, this research was aimed to study the effect of antioxidants on storage stability and ove

rall quality of apple fruit bars. This study was undertaken with the objective to develop a nutritious apple bar with extended shelf life by the incorporation of sucrose and antioxidants at various levels.The impact of these additives on the physicochemical and sensory characteristics of apple bars during the storage period was further explored. It also provides the chance to minimize the post-harvest losses of apple fruits, thus helping the farmer's economy to improve.

Materials and methods

This research work was conducted in PCSIR (Pakistan Council of Scientific and Industrial Research Center) an analytical laboratory in Skardu, Baltistan. Treatments designed for this research work are shown in Table 1.

Preparation of apple bars

Initially damaged, diseased, bruised and immature apples were separated and the sound and good quality fruits were selected for better outcomes. Then these apples were washed with tap water to remove dust particles, dirt and chemical residue which enhance the microbial activity. After this peeling of fruits with stainless steel knife was done for the preparation of Pulp by using pulper machine. Modification in TSS (Total Soluble Salt) of all the

samples was done by addition of sucrose in proper quantity and then the samples were acidified by adding ascorbic andcitric acid with certain modification in-line with prior studies (Agrahari *et al.*, 2014). These prepared samples were packed in transparent polyethylene bags and were stored for three months at room temperature i.e. 25-35˚C. After 15 days of interval physicochemical and sensory attributes were assessed.

Chemical analysis

Standard methods of AOAC was followed to analyzed physicochemical properties i.e.pH, total soluble salts, water activity (aw), moisture (%),Titratable acidity and ascorbic acidof all samples. (Ali *et al.*,2018).

Sensory analysis

The 9 point hedonic scale was used to evaluate sensory attributes of apple bars following the method described Larmond (LarmondE, 1977). These sensory properties those aretaste, color, texture and overall acceptability were explored by taking the mean values of the panelist scores. The panelists scored all the samples according to9 point hedonic scale (1-9), where 1 expresses strong disliking and 9 expresses strong liking.

Statistical analysis

SPSS 16 is used as statistical tool. Statistical analysis was performed by usingCRD two factorfactorial as suggested by Gomez and Gomez (Gomez andGomez, 1984) and the means were segregated by LSD test at 5% probability level as described by Steel and Torrie.(Steel andTorrie,1997).

Results and discussion

Physico-chemical analysis of apple sucrose bar

Water activity

During storage, antioxidants and storage intervals considerably influence the water activity of the apple sucrose bar. The original water activity of all T0 to T5 samples ranged from 0.67, 0.68, 0.70, 0.68, 0.69, 0.69, and 0.70 respectively, which reduced the storage period considerably ($p<0.05$).Similar declining pattern was observed in a of pawpaw and guava fruit leather from 0.64 to 0.61 during storage (Babalola *et al.,* 2002).

Higher constancy, in $a_w$was noticed in T_5 (0.68) while lowest retention of water activity observed in control sample. While mean storage interval values showed a decline in aw from 0.69 to 0.64 within 90 days of storage (Table 2).

Table 1. Treatments used in research works.

Treatments	Apple pulp	Antioxidant (%)	Pectin (g/Kg)	Sucrose (˚ Brix)	KMS (g/Kg)
T0	500 ml	0	0	13	0
T1	-do-	0.1	2	20	0.1
T2	-do-	0.1	2	30	0.1
T3	-do-	0.1	2	35	0.1
T4	-do-	0.1	2	20	0.1
T5	-do-	0.1	2	30	0.1
T6	-do-	0.1	2	35	0.1

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

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	0.67	0.67	0.66	0.64	0.63	0.62	0.61	0.646 a
T_1	0.68	0.68	0.67	0.65	0.64	0.63	0.62	0.657 b
T_2	0.70	0.68	0.67	0.67	0.66	0.65	0.64	0.670 de
T_3	0.68	0.68	0.67	0.66	0.66	0.65	0.65	0.668 d
T_4	0.69	0.68	0.67	0.66	0.65	0.64	0.63	0.663 c
T_5	0.69	0.68	0.68	0.67	0.66	0.65	0.65	0.672 e
T_6	0.70	0.69	0.69	0.68	0.67	0.66	0.66	0.682 f
Mean	0.69g	0.72f	0.67e	0.66d	0.65c	0.64b	0.64a	

The small letters showed significant ($p<0.05$) difference from each other.

The drop off of all samples could be due to the free water binding ability of sucrose, enzymes and pectin, whereas in apple fruit bar around 0.60 is deemed safe for microbial proliferation. (Tapia *et al.*, 2008).Likewise, apple-black present fruit leather reduced during storage to 0.60(Diamante *et al.,* 2012).

Table 3. Effect of treatment and storage period on ascorbic acid of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	2.66	1.76	1.16	0.56	0.16	0.05	0.01	0.91 a
T_1	2.66	2.16	1.66	1.46	1.26	1.16	0.76	1.59 e
T_2	2.73	2.06	1.56	1.36	1.16	1.06	0.46	1.49 c
T_3	2.66	2.56	2.56	2.46	1.76	1.56	1.46	2.14 f
T_4	3.86	1.46	0.86	0.36	0.07	0.06	0.03	0.96 b
T_5	3.66	1.86	1.36	1.26	1.06	0.96	0.36	1.51 d
T_6	3.56	3.16	2.96	2.26	1.46	1.26	1.16	2.26 g
Mean	3.11g	2.14f	1.73e	1.41d	0.99c	0.87b	0.61a	

The small letters showed significant ($p<0.05$) difference from each other.

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

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	1.20	1.30	1.38	1.44	1.49	1.52	1.59	1.42 f
T_1	1.21	1.27	1.31	1.34	1.37	1.41	1.44	1.34 b
T_2	1.33	1.37	1.40	1.43	1.46	1.48	1.52	1.43 g
T_3	1.30	1.34	1.36	1.39	1.42	1.45	1. 48	1.39 d
T_4	1.24	1.27	1.32	1.36	1.39	1.43	1.47	1.35 c
T_5	1.30	1.32	1.37	1.40	1.44	1.47	1.49	1.40 e
T_6	1.10	1.14	1.18	1.22	1.25	1.28	1.31	1.21 a
Mean	1.24 a	1.29 b	1.33 c	1.37 d	1.40 e	1.43 f	1.47 g	

The small letters showed significant ($p<0.05$) difference from each other.

Ascorbic acid

During the entire storage period, the content of ascorbic acid in apple bar samples was reduced from 0.01 to 1.16 mg/100gm. T2 (1.46) noted maximum retention of ascorbic acid content. While mean storage interval values showed a reduction in ascorbic acid content during storage from 3.11 to 0.61 mg/100g.(Table 3)Losses in the content of ascorbic acid may be due to the heat in the preparing of apple sucrose bars, changes in storage temperature and oxidation of ascorbic acid to dehydroascorbic acid(Johnson and Hessel,1982).Earlier reduction in vitamin C content of guava (176.27 to 104.87mg/100g) and pawpaw (83.33 to 74.70 mg/g)fruits leather were observed during storage.

(Jain andNema 2007;Ashaye A *et al.,* 2005).In the IMF food item, ascorbic acid content was also reduced owing to oxidation from 1.7% to 0.8%.(Gupta, 2000).

Table 5. Effect of treatment and storage period on moisture of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	16.5	16.20	15.47	15.12	14.51	14.14	13.90	15.12 a
T_1	16.95	16.84	16.42	16.14	15.97	15.48	15.21	16.14 c
T_2	16.98	16.79	16.77	15.92	15.81	15.76	15.61	16.23 c
T_3	16.90	16.88	16.79	16.76	15.90	15.82	15.76	16.40 d
T_4	17.91	16.68	16.46	15.87	15.75	15.54	15.02	16.17 c
T_5	16.97	16.74	16.26	15.84	15.48	15.12	14.96	15.91 b
T_6	16.96	16.76	16.38	15.46	15.23	15.08	14.82	15.81 b
Mean	17.03 g	16.70 f	16.36 e	15.87 d	15.52 c	15.28 b	15.04 a	

The small letters showed significant ($p<0.05$) difference from each other.

Tritableacidity

The mean acidity values of all To to T6 samples were 1.20, 1.21, 1.33, 1.30, 1.24, 1.30 and 1.10, which increased considerably (P<0.05) to 1.59, 1.44, 1.52, 1.48, 1.47, 1.49 and 1.31 during the 3-month storage period. Similar increase in acidity upto 1.11 and 1.66% was noted in apple fruit bar during 60 and 90 days of storage.Table 4 indicates that acidity improved in T2 (1.43) followed by To (1.42), but acidity stability can be seen in T6 (1.21) followed by T1 (1.34) for 90 days. 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 rise in % acidity from 0.42 to 0.48%and 0.37 to 0.44% in guava and mango leather was observed during storage (Jain andNema, 2007; Manu *et al.,* 2013).

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

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	3.43	3.40	3.37	3.34	3.31	3.28	3.25	3.34 b
T_1	3.25	3.21	3.17	3.13	3.06	3.05	3.01	3.13 a
T_2	3.83	3.80	3.77	3.74	3.71	3.68	3.65	3.74 f
T_3	3.95	3.93	3.91	3.87	3.86	3.85	3.83	3.88 g
T_4	3.75	3.70	3.65	3.60	3.55	3.50	3.45	3.60 e
T_5	3.55	3.51	3.47	3.43	3.36	3.35	3.31	3.43 c
T_6	3.67	3.64	3.61	3.58	3.55	3.52	3.46	3.58 d
Mean	3.64 g	3.60 f	3.57 e	3.48 d	3.48 c	3.46 b	3.43 a	

The small letters showed significant (p<0.05) difference from each other.

Table 7. Effect of treatment and storage period on Total solid of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	82.90	82.93	82.96	82.99	83.02	83.04	83.08	82.99 a
T_1	82.76	82.98	83.84	84.97	86.19	87.28	87.46	85.07 b
T_2	83.13	83.84	84.67	87.37	87.62	87.72	88.95	86.18e
T_3	84.31	85.93	86.06	85.30	86.87	86.95	88.39	86.21f
T_4	82.53	83.43	83.97	84.72	86.02	87.02	87.59	85.04 b
T_5	83.04	84.29	85.00	85.60	85.86	86.86	88.27	85.56 c
T_6	84.14	84.25	85.01	86.03	87.26	87.87	88.25	86.11 d
Mean	83.26 a	83.95 b	84.50 c	85.28 d	86.12 e	86.67 f	87.38 g	

The small letters showed significant (p<0.05) difference from each other.

Moisture content

The original moisture content of the entire sample from To to T6 was 16.5, 16.95, 16.98, 16.90, 17.91, 16.97 and 16.96 percent which, after three months, dropped considerably (P<0.05) to 13.90, 15.21, 15.61, 15.76, 15.02, 14.96 and 14.82 percent. Maximum mean values of moisture content for treatments were observed in T_3 (16.40%) followed by T_2 (16.23%), whereas the smallest mean values were observed in T_0 (15.12%) followed by T_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 sucrose 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. Earlier reduction in moisture content of pear.(12.13 to 7.97%) and durian(15.82 to 14.36 %) fruits leather was noticed during storage. (Huang and Hsieh, 2005;Irwandi *et al.*,1998).

Table 8. Effect of treatment and storage period on TSS of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	20.03	24.66	28.03	30.03	35.03	40.03	48.03	32.26 a
T_1	69.76	69.86	70.11	70.13	70.36	70.46	76.63	71.04 e
T_2	70.13	70.13	70.16	70.23	70.26	70.36	70.46	70.24 c
T_3	71.23	71.23	71.23	71.26	71.36	71.46	71.56	71.33 g
T_4	69.73	69.76	69.86	70.13	70.26	70.36	70.46	70.08 b
T_5	70.16	70.23	70.26	70.26	70.46	70.56	70.66	70.37 d
T_6	71.13	71.13	71.23	71.26	71.43	71.46	71.56	71.31 f
Mean	63.17 A	63.86 b	64.41 c	64.75 d	65.60 e	66.39 f	68.46 g	

The small letters showed significant ($p<0.05$) difference from each other.

Table 9. Effect of treatment and storage period on reducing sugar of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	3.277	3.967	3.967	3.967	3.977	3.977	3.987	3.874a
T_1	18.56	18.56	18.56	18.58	18.58	18.58	18.58	18.57c
T_2	19.77	19.78	19.82	19.86	19.88	19.91	19.93	19.85d
T_3	20.34	20.34	20.34	20.35	20.35	20.35	20.35	20.35g
T_4	18.01	18.03	18.05	18.08	18.12	18.15	18.16	18.22b
T_5	19.77	19.92	19.94	19.96	19.97	19.98	19.94	19.92e
T_6	20.26	20.26	20.27	20.27	20.28	20.29	20.27	20.27f
Mean	17.28b	17.26a	17.28b	17.29c	17.31d	17.31de	17.31de	

The small letters showed significant ($p<0.05$) difference from each other.

pH

The apple-sucrose bar initial pH from T_0 to T_6 was 3.43, 3.25, 3.83, 3.95, 3.75, 3.55 and 3.67 respectively, which significantly ($P<0.05$) reduced to 3.25, 3.01, 3.65, 3.83, 3.45, 3.31 and 3.46 during storage periods of three months. The maximum mean pH values were found in T3 (3.88) followed by T2 (3.74) and T4 (3.60), although in T1 (3.13) and T0 the smallest mean pH values were observed.While mean storage interval values showed a reduction in pH from 3.64 to 3.43 over 90 days of storage in rooms (Table 6).

Table 10. Effect of treatment and storage period on non-reducing sugar of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	2.34	2.31	2.28	2.26	2.23	2.22	2.18	2.26 a
T_1	2.37	2.34	2.26	2.28	2.23	2.21	2.18	2.26 a
T_2	4.48	4.46	4.43	4.41	4.38	4.34	4.33	4.41 c
T_3	6.41	6.36	6.35	6.31	6.26	6.28	6.26	6.32 d
T_4	2.41	2.36	2.36	2.33	2.26	2.28	2.25	2.32 b
T_5	4.48	4.46	4.45	4.42	4.38	4.02	4.34	4.36 c
T_6	6.38	6.36	6.34	6.31	6.28	6.26	6.23	6.30 d
Mean	4.12 e	4.09 de	4.07 de	4.04 cd	4.00 bc	3.98 ab	3.92 a	

The small letters showed significant ($p<0.05$) difference from each other.

The reduction in pH is due to an increase in acidity, which may result in a reduction in pH of all treated samples owing to the addition of citric acid and ascorbic acid in all samples. Previously decline in pH from 3.80 to 3.60 was observed mango and pine-apple fruits leather during storage (Azered *et al.,* 2006; Phimpharian *et al.*,2011).

Table 11. Effect of treatment and storage period on color of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	8.50	6.56	6.23	5.73	5.23	4.83	4.53	5.94 a
T_1	8.50	8.23	7.86	7.86	7.63	7.33	6.83	7.74 b
T_2	8.50	8.43	8.23	8.03	8.86	7.83	7.53	8.07 g
T_3	8.50	8.43	8.13	7.83	7.73	7.23	7.03	7.84 d
T4	8.50	8.43	8.03	7.83	7.73	7.43	6.86	7.81 c
T5	8.50	8.33	8.13	7.83	7.83	7.53	7.13	7.91 e
T6	8.50	8.43	8.16	7.86	7.86	7.66	7.23	7.95 f
Mean	8.50 g	7.86 d	7.95 f	7.66 e	7.45 c	7.12 b	6.73 a	

The small letters showed significant ($p<0.05$) difference from each other.

Total solids

Total solids for apple sucrose bars samples at 15 days show increasing trend Initial total solids (TS) value of apple bar with treatments T_0 to T_6 were 82.90% and 84.14% respectively 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% and mean values for treatments increase from 82.99% to 86.11% (Table 7). Increase in TS may be due to the presence of fiber content and addition of pectin in apple bar preparation.

Table 12. Effect of treatment and storage period on texture of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	8.50	5.63	5.13	4.73	4.63	4.43	4.13	5.31 a
T_1	8.50	8.43	8.13	7.63	7.23	6.86	6.63	7.63 c
T_2	8.50	8.43	8.33	8.23	8.03	7.73	7.53	8.11 g
T_3	8.50	8.47	8.33	8.03	7.73	7.33	6.86	6.75 b
T_4	8.50	8.43	8.23	7.73	7.33	7.03	6.73	7.71 d
T_5	8.50	8.43	8.33	8.23	7.83	7.43	7.03	7.96 e
T_6	8.50	8.43	8.43	8.26	7.86	7.46	7.16	8.00 f
Mean	8.50 g	8.03 f	7.84 e	7.54 d	7.23 c	6.89 b	6.58 a	

The small letters showed significant ($p<0.05$) difference from each other.

Total Soluble Solids

The initial TSS of T_0 to T_6 were 20.03, 69.76, 70.13, 71.23, 69.73, 70.16 and 71.13 which significantly ($P<0.05$) increased to 48.03, 76.63, 70.46, 71.56, 70.46, 70.66, and 71.56 °brix during storage. Maximum mean values for treatment were observed in T_3 (71.33) followed by T_6 (71.31), whereas the minimum mean values were noted in T_0 (32.26) followed by T_2 (70.25).The mean storage interval values showed an increase in TSS during the storage period from 63.17 to 68.46 ° brix Table 8. Steady increase in TSS may be attributed to the addition of

sucrose which converted into glucose and fructose and also due loss of moisture content which aided in increasing the shelf life of apple-sucrose fruit bars. (Ayub *et al.,*1996) It is evident from earlier research work that TSS of IMF products including fruits jam, jellies, marmalade and leather minimally increases during storage, which stabilized the shelf life of these *products (*Riaz *et al.,1999;*Ehsan *et al., 2003).*

Reducing sugar

The apple sucrose bars samples were tested for reducing sugars at 15 days of interval. Initially at T_0 it is recorded as 3.277% and at T_6 it is recorded as 20.26%. Which statistically ($P<0.05$) increased up to (20.27%) during storage period. Maximum mean value was observed for treatment at T_3 (20.35%) followed by T_6 (20.27% as shown in Table 9.

Increasing trend was observed in reducing sugar of all the apple bars. The increase in reducing sugar attributed to conversion of polysaccharides and disaccharides to monosaccharaides.

Table 13. Effect of treatment and storage period on taste of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	8.50	5.06	4.73	4.53	4.23	3.86	3.53	4.92 a
T_1	8.50	8.43	8.13	7.73	7.33	6.86	6.63	8.02 d
T_2	8.50	8.43	8.43	8.13	7.83	7.53	7.33	8.00 c
T_3	8.50	8.46	8.23	7.86	7.73	7.26	6.86	8.12 f
T_4	8.50	8.43	8.13	7.76	7.43	7.03	6.73	7.71 b
T_5	8.50	8.43	8.43	8.13	7.83	7.63	7.23	8.02 d
T_6	8.50	8.43	8.41	8.20	7.86	7.73	7.26	8.05 e
Mean	8.50 g	7.95 f	7.78 e	7.47 d	7.17 c	6.84 b	6.51 a	

The small letters showed significant ($p<0.05$) difference from each other.

Non- Reducing sugar

Increasing trend was observed in non-reducing sugar. At To it is recorded as 2.34% and at T6 it is recorded as 6.38%. At 90 days of interval it was increase from 2.18% to 6.23%. Highest mean value was observed at T3 followed by T6 (Table 10). While the mean value for storage interval was decrease from 4.12% to 3.92%.

Sensory evaluation

The apple bar sample was analyzed sensory attributes during 3 months of storage.

Color

It was observed in sensory evaluation studies that the score for the characteristic reddish brown color of all the apple-sucrose bar samples significantly ($P<0.05$) decreased from T_0(8.50) to AB_6 (4.53, 6.83, 7.53, 7.03, 6.86, 7.13 and 7.23) during three months of storage. Highest mean values for the color of treatments as shown in Table11 was obtained by T_2 (8.07) followed by T_6 (7.95), whereas the lowest mean values were noted in T_0 (5.94) followed by T_2 (7.74) and the mean values for storage interval 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 dehydro-ascorbic 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. (Jain and Nema, 2007; Naz,2012).

Texture

It was observed that the mean score for apple sucrose bar texture decreased significantly ($P<0.05$) from T_0 8.50 to T_6 to 4.13, 6.63, 7.53, 6.86, 6.73, 7.03 and 7.16 within 3 months of storage intervals.The highest mean texture values were noted in T2 (8.11) followed

by T6 (8.00) and the smallest mean values were noted in T0 5.31 followed by T3 6.75, while the mean texture value of the apple sucrose bar decreased from 8.50 to 6.58 (Table 12) during 3 months of storage .Several ways are might be used to note the texture of fruit leather but human mouth is more complex in evaluating the texture of fruit bars in comparison with penetrometer which normally measures only one aspect of texture(Huang and Hsieh,2005; Pomeranz and Meloan,2000).

Table 14. Effect of treatment and storage period on overall acceptability of apple bar.

Treatments	Storage intervals (days)							
	0	15	30	45	60	75	90	Mean
T_0	8.00	6.76	4.55	4.01	3.86	3.52	3.05	4.82 a
T_1	8.00	7.26	6.86	6.46	6.16	5.86	5.66	6.61 b
T_2	8.00	7.16	6.86	6.66	6.76	6.46	6.36	6.90 e
T_3	8.00	7.26	7.06	6.86	6.53	6.16	6.06	6.85 d
T_4	8.00	7.06	6.86	6.66	6.46	6.16	5.96	6.74 c
T_5	8.00	7.16	6.96	6.86	6.66	6.46	6.26	6.91 f
T_6	8.00	7.36	7.16	6.66	6.66	6.46	6.36	6.95 g
Mean	8.00 g	7.15 f	6.62 e	6.31 d	6.16 c	5.87 b	5.68 a	

The small letters showed significant ($p<0.05$) difference from each other.

Taste

Similarly decreasing trend for taste of apple-sucrose bar was observed the mean score significantly ($P<0.05$) decreased from $T_0$8.50 to T_6 3.53, 6.63, 7.33, 6.86, 6.73, 7.23 and 7.26 within 3 months of storage period. As shown in Table 13 that highest mean values for treatments were attained by T_3(8.12) followed by T_6(8.05) and T_1(8.02) and the lowest mean values were observed in T_0 (4.92) followed by T_4(7.71). Consequently, mean values for storage decreased from 8.50 to 6.51, respectively. Differences in taste of apple sucrose fruit leather might be due to variation in the amount of sugar and acids which require optimization (Jain and Nema, 2007) but the sweetness and acid ratio also depends upon type of fruit and may vary during storage (Ashaye *et al.,* 2005).

Overall acceptability

It is evident from the sensory analysis related to color, flavor and taste that mean scores for overall acceptability of apple-sucrose bar also significantly ($P<0.05$) decreased from $T_0$8.00 to T_6 (3.05, 5.66, 6.36, 6.06, 5.96, 6.26 and 6.36 during storage period of three months. The maximum mean values for treatments were observed in T_6 (6.95) followed by T_5 (6.91) and T_2 (6.90), and the minimum mean value was noted in T_0 (4.82) followed by T_1 (6.61) and T_4 (2.32), whereas the mean values for storage interval showed declining patternin overall acceptability from 8.00 to 5.68 (Table14). 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. (Adedeji *et al.,* 2008).

Conclusion

During the storage period, physicochemical properties such as water activity, moisture content, non-reducing sugar, ascorbic acid and pH reduced, while percent titratable acidity, reducing sugar, TS and TSS increased significantly. Similarly, sensory properties such as taste, color, texture and overall acceptability degraded up to certain extent during storage. It was found that storage period significantly affected the overall stability and quality of apple-sucrose bar. However, the samples T_2 and T_1 showed best result in comparison with other samples and are recommended for the preparation of fruit bar.

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