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Studies on effect of storage on quality characteristics of jaggery based mixed fruit jam

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Abstract
The present experiment was carried out to study the effect of storage on jaggery based mixed fruit jam. Five different jams were formulated by substituting sugar with 0, 25, 50, 75 and 100% jaggery. Based on organoleptic evaluation, T_2 (50% mixed fruit pulp +25% sugar + 25% jaggery) was chosen and analysed for the physicochemical and organoleptic properties *viz.*, total soluble solids, acidity, pH, ascorbic acid, reducing sugars, colour, taste, texture and overall acceptability for 90 days with 30 days interval by packing them in different packaging material such as glass jar, polypropylene cup (PP) and high density polyethylene (HDPE) pouch and stored under ambient and refrigerated conditions. TSS, acidity, reducing sugars of T_0 and T_2 showed an increasing trend whereas pH, ascorbic acid content reduced during the storage period. In addition to this, a* coordinate of jam increased while L* values and b* values reduced. Taste, texture and overall acceptability reduced significantly ($p<0.05$) in all types of packaging material under both conditions. The highest TSS (71.6°Bx), acidity (0.82%), reducing sugars (24.25%) and lowest pH (2.39) and lowest ascorbic acid (31.46 mg/100 g) were recorded for T_2 sample stored in PP cup under room temperature whereas control sample (T_0) exhibited lowest changes. However, refrigerated samples showed lesser changes than ambient storage samples. Yeast and mold counts were detected only in the sample stored in PP cup under ambient conditions. It was concluded that jaggery based jam was can be stable and acceptable for 90 days under ambient and refrigerated temperatures using glass jar, HDPE pouch and PP cup.

Keywords: Sugar, jaggery, stability, polypropylene (PP) cup, high density polyethylene pouch

Introduction
Jam is a fruit product made by cooking the fruit pulp with the sugar, pectin and citric acid, (Ullah *et al*., 2018) [26-27]. According to CODEX, jam should contain at least 65% total soluble solids and 45% fruit pulp. The Bureau of Indian Standards (BIS) and the Prevention of Food Adulteration (PFA) specify that jam must contain a minimum of 45% fruit and more than 68.5% total soluble solids (PFA, 2004) [15]. Sugar is as equally important as fruits in jam because of its preservative and textural roles. But excess intake of sugar increases the risk of metabolic disorders such as diabetes, obesity, heart diseases etc. (Alkhaldi *et al*., 2021) [2]. On the other hand, Jaggery is a traditional sweetener made from the concentrated juice of sugarcane, sugar beetroot, coconut palm, date palm and palmyra (Hossain and Singh, 2018) [9] which is very nutritious and rich in minerals and vitamins. Recently, consumer awareness regarding healthy sugar alternatives has increased (Manickvasagan *et al*., 2017) [13] and the current trend in the production of jams and jellies that meet customer requirements is the development of foods with functional properties. In this context, replacing refined sugar with natural sweeteners like jaggery helps in making healthy food products. Therefore, this experiment aims to study the effect of storage on stability of jaggery based mixed fruit jam by using different packaging materials under ambient and refrigerated conditions.

Materials and Methods
The present investigation was carried out at Department of Food Process Technology, College of Food Technology, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra. Fruits used for this study *viz*., mango, papaya, banana and other ingredients such as sugar, jaggery and citric acid were procured from local market, Parbhani. Ripe sound and firm fruits were selected, washed, peeled, pulped in a mixer grinder and strained through a filter to get uniform pulp. Mixed fruit pulp was formulated with 40% papaya pulp, 40% mango and 20% banana pulps. 0.1% pectin and 0.2% citric acid were constant for all the treatments.

Pulp was taken into stainless steel vessel by adding sugar and jaggery in intervals and it was cooked with continuous stirring on low flame. When TSS reached 60°Bx, pectin and citric acid were added and cooked until TSS reaches 66-68.5^0 Bx. The prepared jams were poured hot into previously sterilized glass jars after cooling to 85 °C.

Plan of study

Five different types mixed fruit jams were formulated by substituting 0, 25, 50, 75 and 100% sugar with jaggery by keeping 0.1% pectin and 0.2% citric acid constant for all treatments.

T_0 - 50% mixed fruit pulp +50% sugar (control treatment)
T_1 - 50% mixed fruit pulp +37.5% sugar + 12.5% jaggery
T_2 - 50% mixed fruit pulp +25% sugar + 25% jaggery
T_3 - 50% mixed fruit pulp +12.5% sugar + 37.5% jaggery
T_4 - 50% mixed fruit pulp +50% jaggery

Organoleptic evaluation

Organoleptic evaluation was carried out by ten semi-trained panellists using a 9-point hedonic scale ranging from like extremely to dislike extremely for colour and appearance, flavour, texture, taste and overall acceptability (Begum *et al*., 2018) [5]. Based on this test, T_2 having 50% mixed fruit pulp, 25% sugar, 25% jaggery, 0.1% pectin and 0.2% citric acid was selected for storage study

Storage study

The selected sample (T_2) and control sample (T_0) were packaged in glass jars, polypropylene (PP) cups and high density poly ethylene (HDPE) pouches and stored at both ambient and refrigerated temperatures. No chemical preservatives were added to any of the treatment samples and they were evaluated for storage stability by evaluating the physicochemical properties such as TSS, titratable acidity, pH, ascorbic acid, reducing sugars and organoleptic properties.

Physicochemical analysis

Total soluble solids (TSS), acidity and pH were analysed by the methods described by Ranganna (2007) [19]. Ascorbic acid and reducing sugars were estimated by using 2, 6 – dichlorophenolindophenol dye method Lane and Eynon method respectively as described in (AOAC, 2007) [1].

Colour analysis

Colour analysis of jam was carried out by using Hunter lab colorimeter (Color Flex, Hunter Associates Laboratory Inc., Reston, VA, USA). Colour is indicated by L* a* b* of colour system where L* indicates lightness of the food product ranging from 0-100 for black to white colour. The chromatic coordinates a*, which vary from green (-) to red (+) and b*, which ranges from blue (-) to yellow (+) respectively, describe the proportion of redness and yellowness, respectively (Pathare *et al*., 2013) [14].

Yeast and mold count

Yeast and mold count of the sample were analyzed by using potato dextrose agar. Serial dilutions were made (10^{-1} and 10^{-2} for yeast and mold count) for each sample and 1 ml of dilution was poured on selective media and incubated at 37±2 °C for 48-72 hr for yeast and mold count. Developed colonies were expressed as colony forming units per gram (CFU /g) of sample (Aneja, 1996) [3].

Statical analysis of experimental results

With the use of statistical software (CVstat), a Factorial Completely Randomised Design (FCRD) was used to conduct statistical analysis to examine the impact of various factors on all dependent variables. At the $p< 0.05$ level, analyses of variance (ANOVA) were used to identify any significant effects. Reports of the critical difference (CD) and standard error (SE) at the five percent level were made wherever required.

Results and Discussion

Total soluble solids (TSS)

Initial TSS of the T_2 and T_0 were 68.0±0.0°Bx and 66.0±0.0°Bx which increased to 70.8±0.13°Bx, 71.6±0.01°Bx, 71.2±0.25°Bx and 68.8±0.21°Bx, 69.3±0.33°Bx, 69.0±0.45°Bx when packed in glass jar, PP cup and HDPE respectively under ambient temperature. Similarly, TSS of the T_2 and T_0 increased from 68.0±0.22°Bx and 66.0±0.04°Bx to 69.0±0.10°Bx, 70.7±0.04°Bx, 70.4±0.37°Bx and 67.0±0.32°Bx, 67.7±0.02°Bx and 67.5±0.34°Bx when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature (Table 1). Maximum TSS was found for T_2 stored in PP cup (71.6±0.01) followed by T_2 stored in HDPE pouch (71.6±0.01) under ambient temperature whereas the minimum TSS was observed in T_0 stored in glass jar (67.0±0.32) under refrigerated temperature. Increase in TSS during storage may be due to formation of the monosaccharides through hydrolysis of complex sugars (Ullah *et al*., 2018) [26-27]. These findings were in line with the results reported by Singh *et al*. (2008) [24], Jat *et al*. (2022) [11], Rana *et al*. (2021) [18] and Yaseen *et al*. (2018) [28].

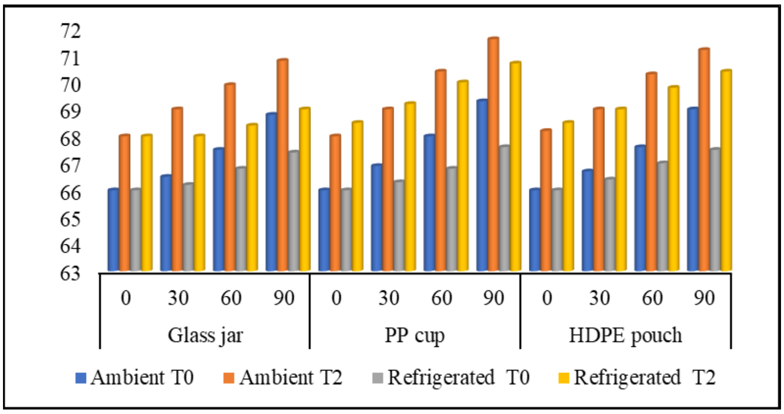

Fig 1: Effect of storage on total soluble solids of mixed fruit jam

Table 1: Effect of storage on TSS and pH of mixed fruit jam

		TSS				pH			
		Ambient		Refrigerated		Ambient		Refrigerated	
	Days	**T_0**	**T_2**	**T_0**	**T_2**	**T_0**	**T_2**	**T_0**	**T_2**
Glass jar	0	66.0±0.13	68.0±0.0	66.0±0.04	68.0±0.22	3.92±0.01	3.68±0.02	3.92±0.01	3.68±0.01
	30	66.5±0.08	69.0±0.22	66.2±0.14	68.0±0.15	3.81±0.02	3.63±0.01	3.83±0.01	3.36±0.02
	60	67.5±0.04	69.9±0.15	66.6±0.25	68.4±0.04	3.69±0.01	3.57±0.02	3.71±0.04	3.02±0.01
	90	68.8±0.21	70.8±0.13	67.0±0.32	69.0±0.10	3.56±0.02	3.52±0.03	3.58±0.01	2.67±0.13
PP cup	0	66.0±0.00	68.0±0.52	66.0±0.01	68.5±0.05	3.93±0.00	3.68±0.01	3.92±0.02	3.68±0.03
	30	66.9±0.26	69.0±0.12	66.3±0.31	69.2±0.16	3.74±0.01	3.23±0.02	3.76±0.01	3.33±0.04
	60	68.0±0.16	70.4±0.40	66.8±0.16	70.0±0.24	3.53±0.08	2.77±0.12	3.58±0.02	2.97±0.02
	90	69.3±0.33	71.6±0.01	67.7±0.02	70.7±0.04	3.29±0.05	2.99±0.23	3.39±0.12	2.60±0.02
HDPE pouch	0	66.0±0.00	68.2±0.35	66.0±0.26	68.5±0.36	3.92±0.05	3.68±0.01	3.92±0.05	3.68±0.02
	30	66.7±0.12	69.0±0.12	66.4±0.68	69.0±0.01	3.88±0.04	3.28±0.01	3.77±0.01	3.35±0.03
	60	67.6±0.0	70.3±0.01	67.0±0.15	69.8±0.22	3.81±0.02	2.85±0.14	3.61±0.03	3.01±0.01
	90	69.0±0.45	71.2±0.25	67.5±0.34	70.4±0.37	3.75±0.03	2.42±0.01	3.43±0.11	2.66±0.04

*Each value is the mean score of three determinations

pH

pH of the fresh T_2 and T_0 were 3.68±0.01 and 3.92±0.01 which decreased to 2.67±0.13, 2.39±0.23, 2.42±0.01 and 3.56±0.02, 3.29±0.05, 3.32±0.03 respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature. Similarly, pH of the T_2 and T_0 decreased to 3.52±0.03, 2.60±0.02, 2.66±0.04 and 3.58±0.01, 3.39±0.12, 3.43±0.11 when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature. Maximum decrease in pH was found for T_2 stored in PP cup (2.39±0.23) followed by T_2 stored in HDPE pouch (2.42±0.01) under ambient temperature whereas the minimum decrease was observed in T_0 packed in glass jar (3.58±0.01) and kept at refrigerated temperature (Table 1). According to Rahman *et al*. (2018) [16], the drop in pH of jam samples over time may be related to an increase in hydrogen ion concentration, which could result in an increase in acidity with time. These results were in line with the reports obtained by Jat *et al*. (2022) [11], Yaseen *et al*. (2018) [28], and Singh *et al*. (2016) [22].

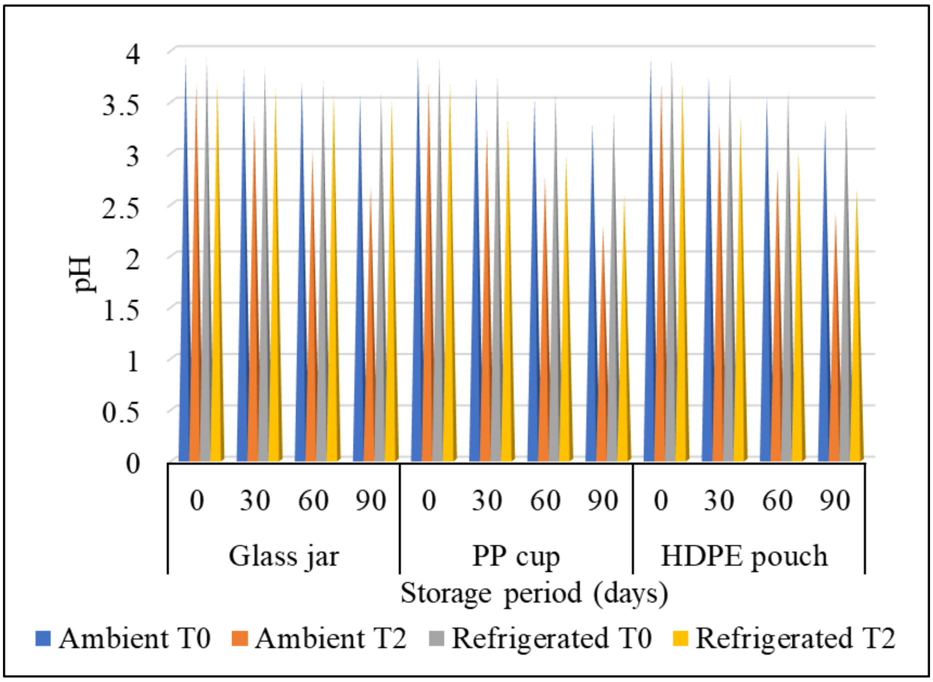

Fig 2: Effect of storage on pH of mixed fruit jam

Titratable acidity

Titratable acidity of the fresh T_2 and T_0 were 0.42% and 0.32% which increased to 0.73%, 0.82%, 0.79% and 0.55%, 0.64%, 0.56% respectively when packed in glass jar, PP cup and HDPE under ambient temperature. Similarly, titratable acidity of the T_2 and T_0 increased to 0.60%, 0.71%, 0.66% and 0.47%, 0.53%, 0.48% when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature. Highest titratable acidity was found for T_2 stored in PP cup (0.82%) and HDPE pouch (0.79%) under ambient temperature whereas the lowest titratable acidity was found for T_0 stored in glass jar (0.47%) under refrigerated temperature (Table 2). The increase in acidity may be due to the degradation of ascorbic acid, weekly ionized acids and their salts during storage, formation of acids by breakdown of polysaccharides like pectin and oxidation of reducing sugars (Jat *et al*., 2022; Rana *et al*., 2021; Rahman *et al*., 2018) [11, 18, 16]. Similar results were obtained by Yaseen *et al*. (2018) [28] and Singh *et al*. (2008) [24].

Table 2: Effect of storage on acidity of mixed fruit jam

		Ambient		Refrigerated	
	Days	**T_0**	**T_2**	**T_0**	**T_2**
Glass jar	0	0.32±0.05	0.42±0.03	0.32±0.06	0.42±0.02
	30	0.38±0.01	0.51±0.04	0.36±0.02	0.47±0.03
	60	0.46±0.03	0.60±0.05	0.41±0.03	0.53±0.01
	90	0.55±0.02	0.73±0.04	0.47±0.03	0.60±0.05
PP cup	0	0.32±0.04	0.42±0.01	0.32±0.04	0.42±0.01
	30	0.41±0.02	0.55±0.05	0.38±0.02	0.52±0.03
	60	0.53±0.05	0.70±0.03	0.45±0.03	0.60±0.01
	90	0.64±0.03	0.82±0.02	0.53±0.05	0.71±0.04
HDPE pouch	0	0.32±0.03	0.42±0.03	0.3±0.05	0.42±0.02
	30	0.39±0.01	0.52±0.03	0.35±0.01	0.49±0.02
	60	0.47±0.04	0.65±0.05	0.41±0.04	0.57±0.03
	90	0.56±0.03	0.79±0.02	0.48±0.04	0.66±0.03
*Each value is mean score of three determinations					

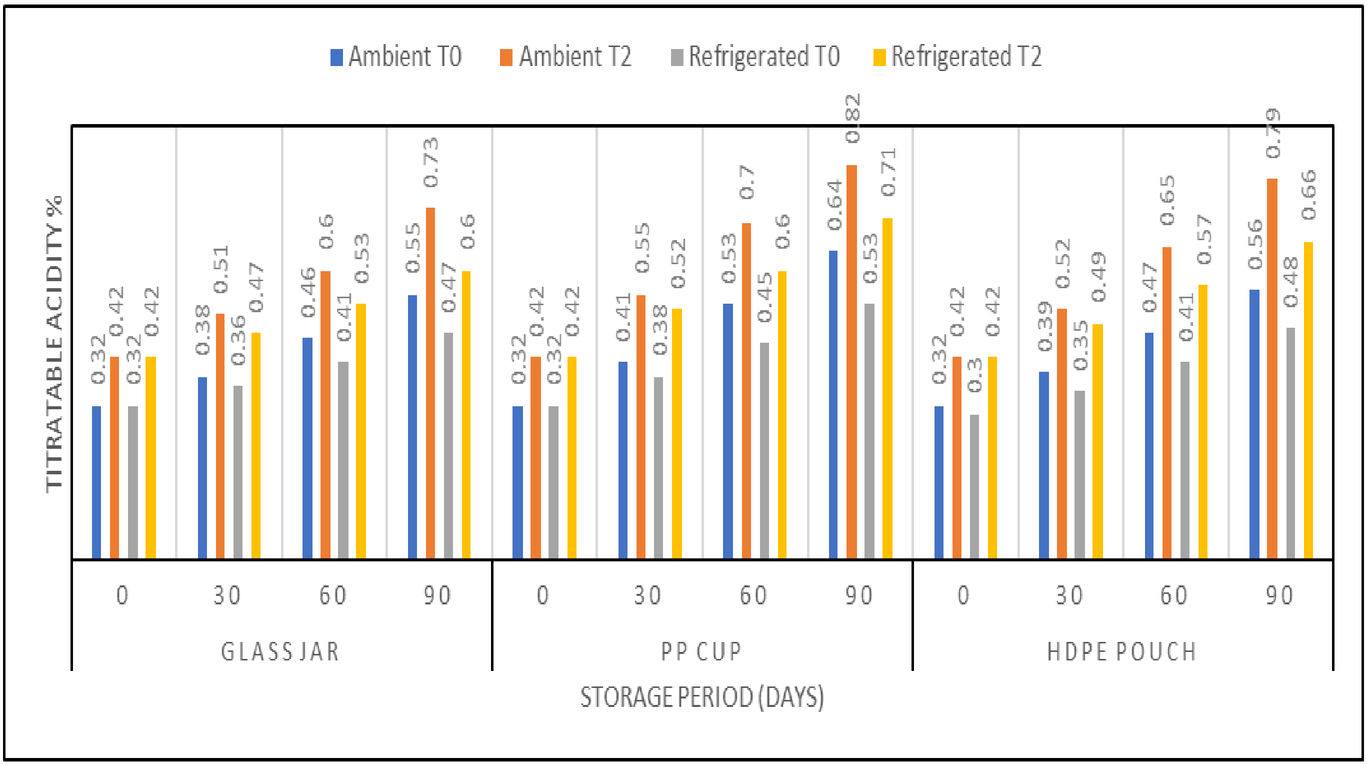

Fig 3: Effect of storage on titratable acidity of mixed fruit jam

Ascorbic acid (mg/100 g)

Ascorbic acid content of the fresh T_2 and T_0 were 33.36 mg/100 g and 33.30 mg/100 g which decreased to 31.57±0.29 mg/100 g, 31.46±0.26 mg/100 g, 31.50±0.32 mg/100 g and 32.25±0.49 mg/100 g, 32.15±0.13 mg/100 g, 32.20±0.17 mg/100 g respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature. Similarly, amount of ascorbic acid of the T_2 and T_0 decreased to 31.81±0.43 mg/100 g, 31.61±0.28 mg/100 g, 31.71±0.36 mg/100 g and 32.48±0.30 mg/100 g, 32.29±0.26 mg/100 g, 32.31±0.29 mg/100 g when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature (Table 3). Maximum decrease in ascorbic acid was found for T_2 stored in PP cup (31.46±0.26 mg/100 g) followed by T_2 stored in HDPE pouch (31.50±0.32 mg/100 g) under ambient temperature whereas the minimum decrease was observed in T_0 stored in glass jar (32.48±0.30 mg/100 g) under refrigerated temperature. This may be attributed to the barrier properties of the packaging material. Moreover, the decreasing trend became slow with increasing storage. This may be due to the effect of pH on the degradation of ascorbic acid (Herbig and Renard, 2017) [10]. The reduction of ascorbic acid during storage may be caused by the oxidation of ascorbic acid to dehydroascorbic acid in the presence of light, oxygen and enzymes. It is mostly degraded due to the availability of residual oxygen in the head space of the packaging material (Rahman *et al*., 2018) [16]. T_2 showed more degradation of ascorbic acid because it is unstable in the presence of oxygen, temperature and metal ions (Herbig and Renard, 2017) [10]. Similar results were observed in reports by Jat *et al*. (2022) [11] and Yaseen *et al*. (2018) [28].

Table 3: Effect of storage on ascorbic acid of mixed fruit jam

		Ambient		Refrigerated	
	Days	**T_0**	**T_2**	**T_0**	**T_2**
Glass jar	0	33.30±0.20	33.36±0.22	33.35±0.35	33.36±0.40
	30	32.92±0.15	32.74±0.20	33.02±0.29	32.81±0.29
	60	32.58±0.26	32.15±0.35	32.75±0.38	32.3±0.20
	90	32.25±0.49	31.57±0.29	32.48±0.30	31.81±0.43
PP cup	0	33.3±0.35	33.4±0.15	33.33±0.4	33.36±0.22
	30	32.90±0.66	32.73±0.34	32.97±0.33	32.76±0.33
	60	32.52±0.42	32.08±0.25	32.64±0.28	32.18±0.36
	90	32.15±0.13	31.46±0.26	32.29±0.26	31.61±0.28
HDPE pouch	0	33.3±0.23	33.37±0.18	33.36±0.24	33.35±0.35
	30	32.91±0.36	32.73±0.15	33.01±0.36	32.78±0.30
	60	32.55±0.51	32.11±0.32	32.66±0.24	32.24±0.25
	90	32.20±0.17	31.50±0.32	32.31±0.29	31.71±0.36

*Each value is a mean score of three determinations

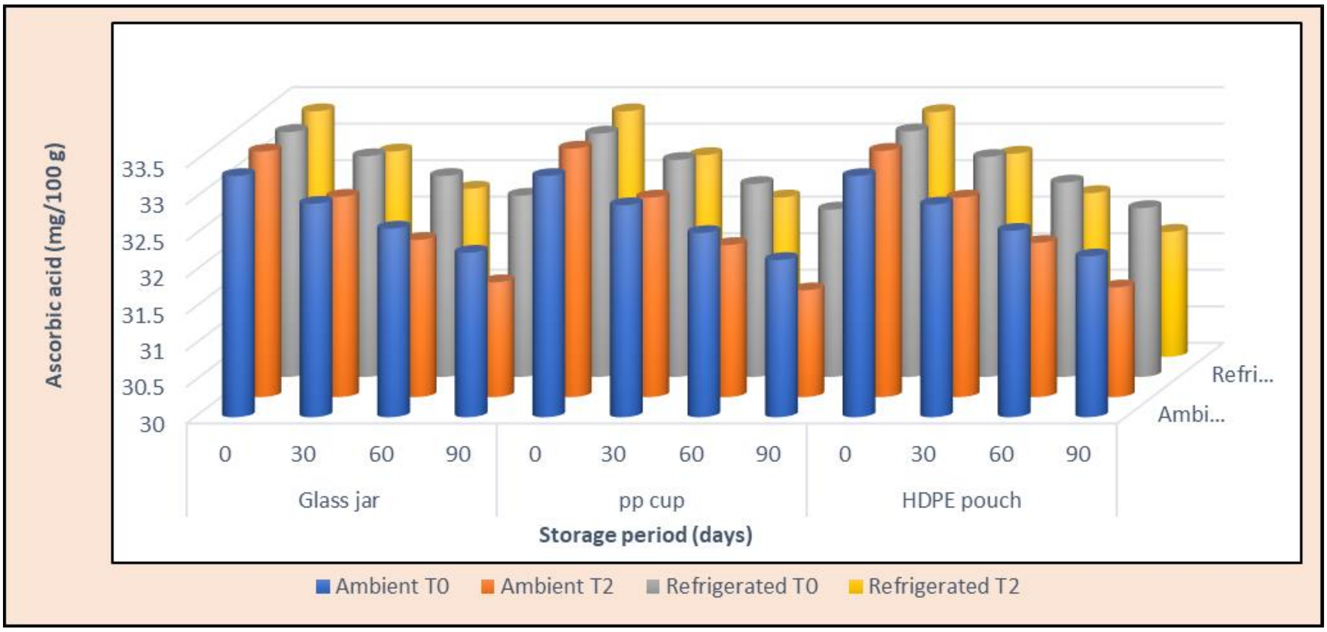

Fig 4: Effect of storage on ascorbic acid of mixed fruit jam

Reducing sugars

Initial reducing sugars per cent of the T_2 and T_0 were 14.06±0.42% and 9.98±0.67% which increased to 24.4±0.67%, 25.4±0.81%, 24.46±1.01% and 15.23±1.12%, 16.95±0.53%, 16.89±0.73% respectively when packed in glass jar, PP cup and HDPE under ambient temperature. Similarly, reducing sugars per cent of the T_2 and T_0 increased to 22.54±0.56%, 24.25±1.03%, 23.89±1.22% and 14.71±0.91%, 16.39±1.13%, 16.30±0.69% when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature (Table 4). Maximum reducing sugars per cent was recorded for T_2 stored in PP cup (25.4±0.81%) and HDPE pouch (24.46±1.01%) under ambient temperature whereas the lowest titratable acidity was found for T_0 stored in glass jar (14.71±0.91%) under refrigerated temperature. The increase in reducing sugars with increasing storage time may be due to the hydrolysis of polysaccharides and the inversion of non-reducing sugars to reducing sugars. These results were inline with reports of Jat *et al.*, (2022) [11] and Ullah *et al.* (2018) [26-27]

Table 4: Effect of storage on reducing sugars of mixed fruit jam

		Ambient		Refrigerated	
		T_0	T_2	T_0	T_2
Glass jar	0	9.980±0.67	14.06±0.42	9.98±0.87	14.06±0.58
	30	11.86±1.02	18.04±0.85	11.59±0.79	17.89±1.12
	60	13.58±0.97	21.1±1.03	13.24±0.44	19.92±0.92
	90	15.23±1.12	24.4±0.67	14.71±0.91	22.54±0.56
PP cup	0	9.980±0.16	14.06±0.71	9.98±0.66	14.06±0.38
	30	12.04±0.10	18.75±1.05	11.85±0.53	18.35±0.88
	60	14.45±0.45	21.9±0.73	14.19±0.61	21.25±0.76
	90	16.95±0.53	25.4±0.81	16.39±1.13	24.25±1.03
HDPE Pouch	0	9.98±1.12	14.06±0.60	9.98±1.08	14.06±0.50
	30	11.93±0.43	18.28±0.49	11.76±0.65	18.17±0.96
	60	14.29±0.92	21.37±0.68	14.05±1.22	20.77±0.83
	90	16.89±0.73	24.46±1.01	16.3±0.69	23.89±1.22
*Each value is the mean score of three replications					

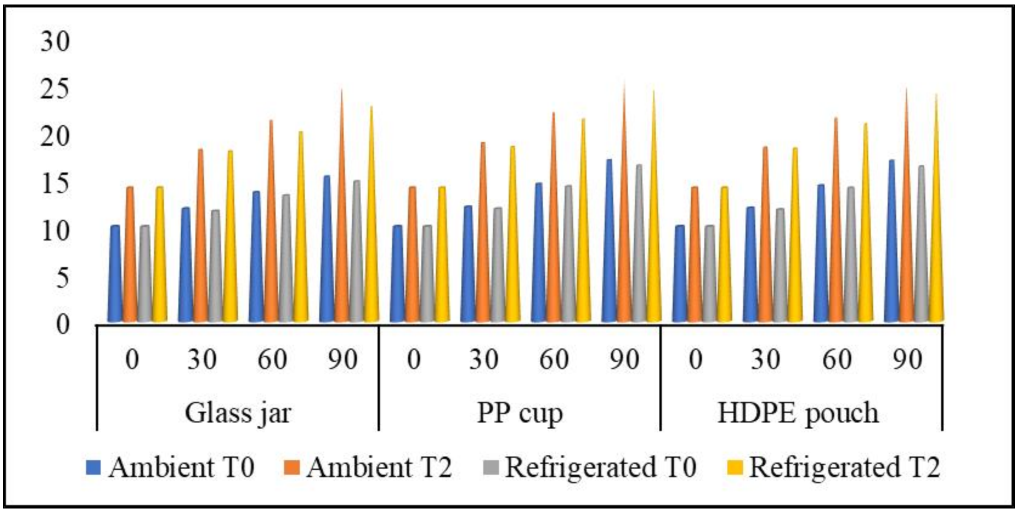

Fig 5: Effect of storage on reducing sugars of mixed fruit jam

Colour

L* values of the fresh T_2 and T_0 were 8.93 and 24.5 which decreased to 3.45, 2.39, 2.88 and 17.4, 16.9, 17.2 respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature. Similarly, L* values of the T_2 and T_0 decreased to 6.75, 6.54, 6.69 and 21.3, 20.6, 21.04 when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature. Again, Initial a* values of the T_2 and T_0 were 7.65 and 14.2 which increased to 12.3, 11.2, 10.62 and 17.3, 17.5, 17.3 respectively when packed in glass jar, PP cup and HDPE under ambient temperature. Similarly, a* values of the T_2 and T_0 increased to 9.29, 10.59, 9.65 and 16.4, 17.2, 16.6 when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature.

The b* values of the fresh T_2 and T_0 were 10.4 and 25.9 which decreased to 8.83, 8.75, 8.82 and 24.1, 23.3, 23.7 respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature. Similarly, b* values of the T_2 and T_0 decreased to 9.4, 9.1, 9.19 and 25.0, 24.7, 24.7 when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature (Figure 6). These changes may be due to browning reactions such as Maillard reaction, caramelization and ascorbic acid browning during storage (Suradkar, 2018) [25]. These changes resulted in jams becoming darker. Refrigerated samples showed less change than samples stored at ambient temperature. Jat *et al*. (2022) [11] and Cervera *et al*. (2021) [6] reported similar results for rose petal jam made with different natural sweeteners and strawberry-kiwi jam.

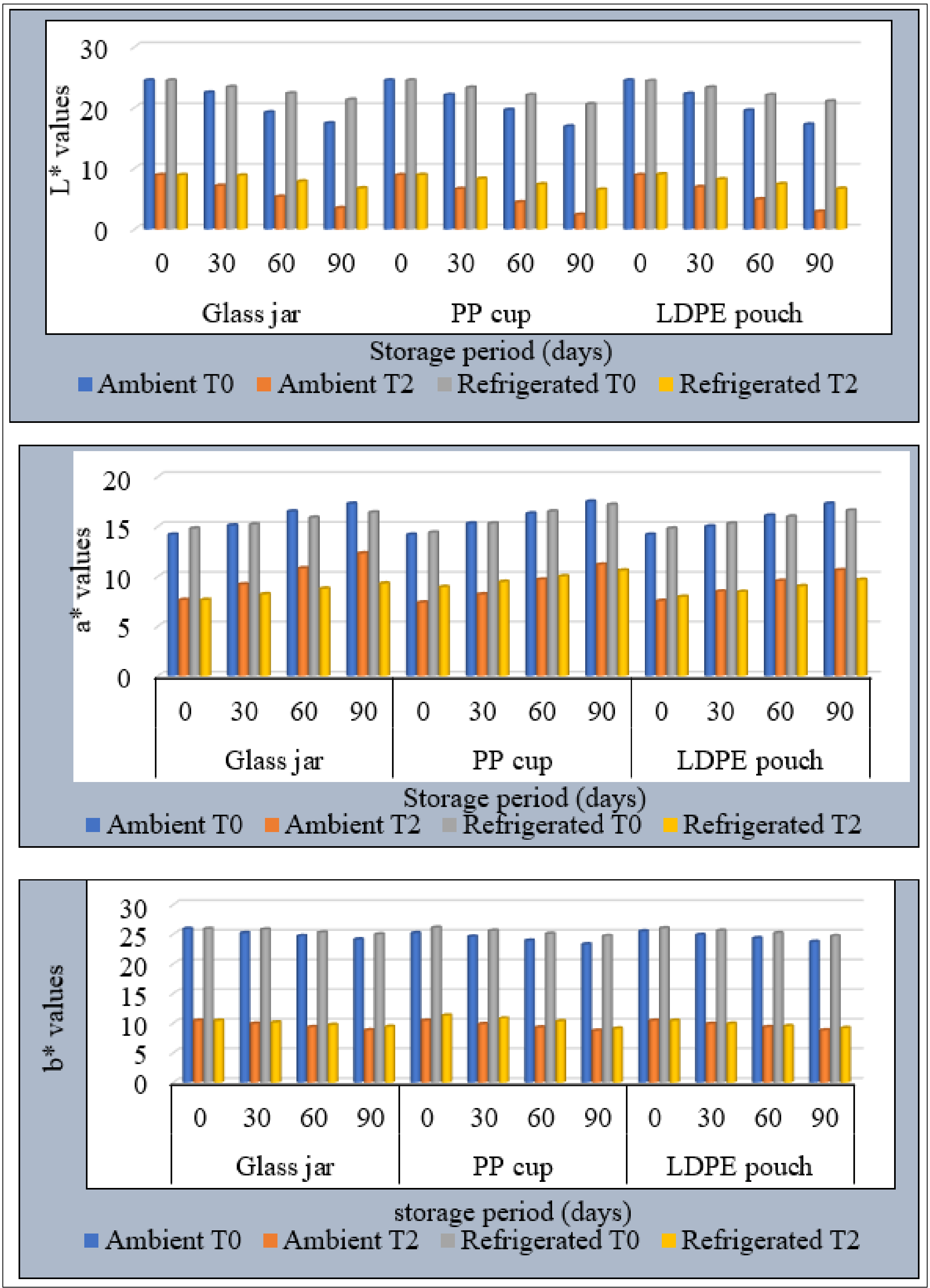

Fig 6: Effect of storage on colour (L* a* b*) of mixed fruit jam

Taste

Taste score of the fresh T_2 and T_0 were 8.3 and 8.2 which decreased significantly to 7.5, 7.3, 7.4 and 7.6, 7.4, 7.5 at (p<0.05) respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature. Similarly, taste score of the T_2 and T_0 decreased to 7.9, 7.7, 7.8 and 8.0, 7.8, 7.9 when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature at (p<0.05). Maximum decrease of taste score was found for T_2 stored in PP cup (7.3) followed by T_2 stored in HDPE pouch (7.4) under ambient temperature whereas the minimum decrease was observed in T_0 stored in glass jar (8.0) under refrigerated temperature (Table 5). The decrease in taste score with increase in storage may be due to increased sourness which may be due to increased acidity during storage. Therefore, the taste score of T_2 stored at ambient temperature was reduced. Similar results were obtained by Jat *et al*. (2022) [11], Ullah *et al*. (2018) [26-27], Yaseen *et al*. (2018) [28].

Table 5: Effect of storage on taste of mixed fruit jam

		Ambient		Refrigerated	
	Days	**T_0**	**T_2**	**T_0**	**T_2**
Glass jar	0	8.2	8.3	8.2	8.3
	30	8.1	8.1	8.2	8.3
	60	7.8	7.8	8.1	8.2
	90	7.6	7.5	8.0	7.9
	SE	0.05	0.03	0.06	0.07
	CD@5%	0.17	0.10	0.22	0.23
PP Cup	0	8.2	8.3	8.2	8.3
	30	8.1	8.1	8.2	8.3
	60	7.7	7.6	8.0	8.1
	90	7.4	7.3	7.8	7.7
	SE	0.06	0.06	0.03	0.07
	CD@5%	0.22	0.2	0.09	0.24
HDPE Pouch	0	8.2	8.3	8.2	8.3
	30	8.1	8.1	8.2	8.3
	60	7.8	7.7	8.1	8.1
	90	7.5	7.4	7.9	7.8
	SE	0.06	0.06	0.06	0.03
	CD@5%	0.22	0.19	0.20	0.10
*Each value is the mean score of three determinations					

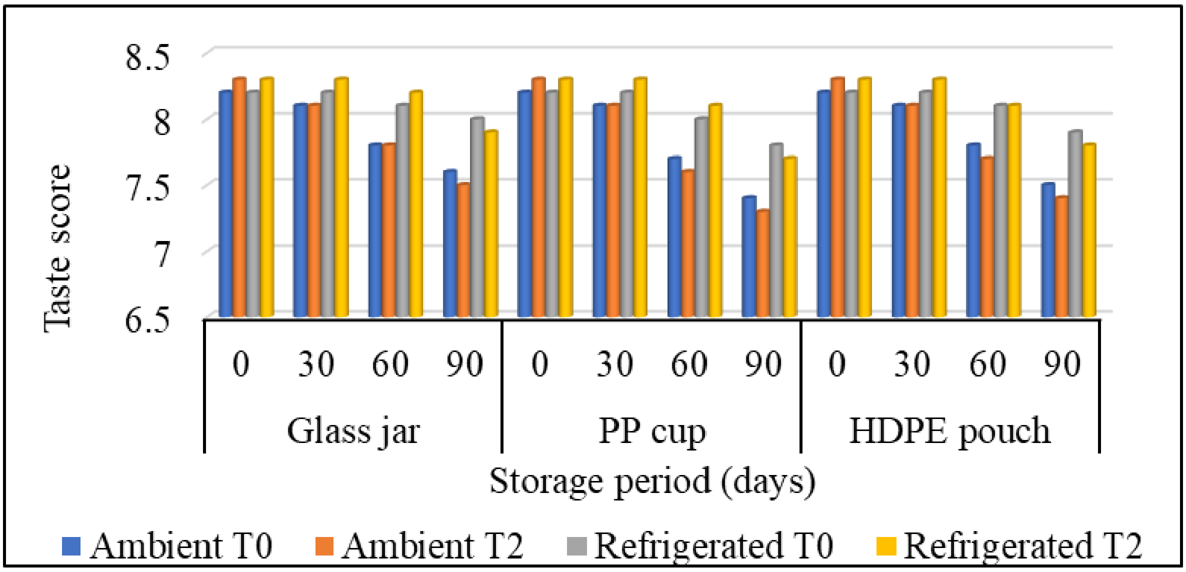

Fig 7: Effect of storage on taste score of mixed fruit jam

Texture

Texture score of the fresh T_2 and T_0 were 7.9 and 8.1 which decreased significantly to 7.2, 7.0, 7.2 and 7.4, 7.2, 7.4 at (p<0.05) respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature. Similarly, texture score of the T_2 and T_0 decreased to 7.4, 7.3, 7.4 and 7.6, 7.5, 7.6 when stored in glass jar, PP cup and HDPE pouch respectively, under refrigerated temperature at (p<0.05). The maximum decrease was found for T_2 stored in PP cup (7.0) under ambient temperature whereas the minimum decrease was found in T_0 stored in glass jar (7.6) and HDPE pouch (7.6) under refrigerated temperature (Table 6). The decrease was significant for samples stored in PP cup when compared to glass jar and HDPE pouch at (p< 0.05). The decrease in texture score may be due to the increase in acidity, degradation of pectin polysaccharide and inversion of sugars. These results can be co-relatable with the reports of Jat *et al.* (2022) [11], Rana *et al.* (2021) [18] and Yaseen *et al.* (2018) [28].

Table 6: Effect of storage on texture of mixed fruit jam

		Ambient		Refrigerated	
	Days	T_0	T_2	T_0	T_2
Glass jar	0	8.1	7.9	8.1	7.9
	30	8.0	7.8	8.1	7.9
	60	7.8	7.5	7.9	7.7
	90	7.4	7.2	7.6	7.4
	SE	0.02	0.07	0.05	0.02
	CD	0.07	0.23	0.17	0.06
PP cup	0	8.1	7.9	8.1	7.9
	30	7.9	7.8	8.0	7.8
	60	7.8	7.7	7.9	7.7
	90	7.2	7.0	7.5	7.3
	SE	0.03	0.02	0.06	0.06
	CD@5%	0.09	0.07	0.21	0.20
HDPE Pouch	0	8.1	7.9	8.1	7.9
	30	8.0	7.9	8.1	7.9
	60	7.8	7.7	7.9	7.7
	90	7.4	7.2	7.6	7.4
	SE	0.03	0.02	0.03	0.08
	CD@5%	0.09	0.06	0.12	0.26

*Each value is the mean score of three determinations

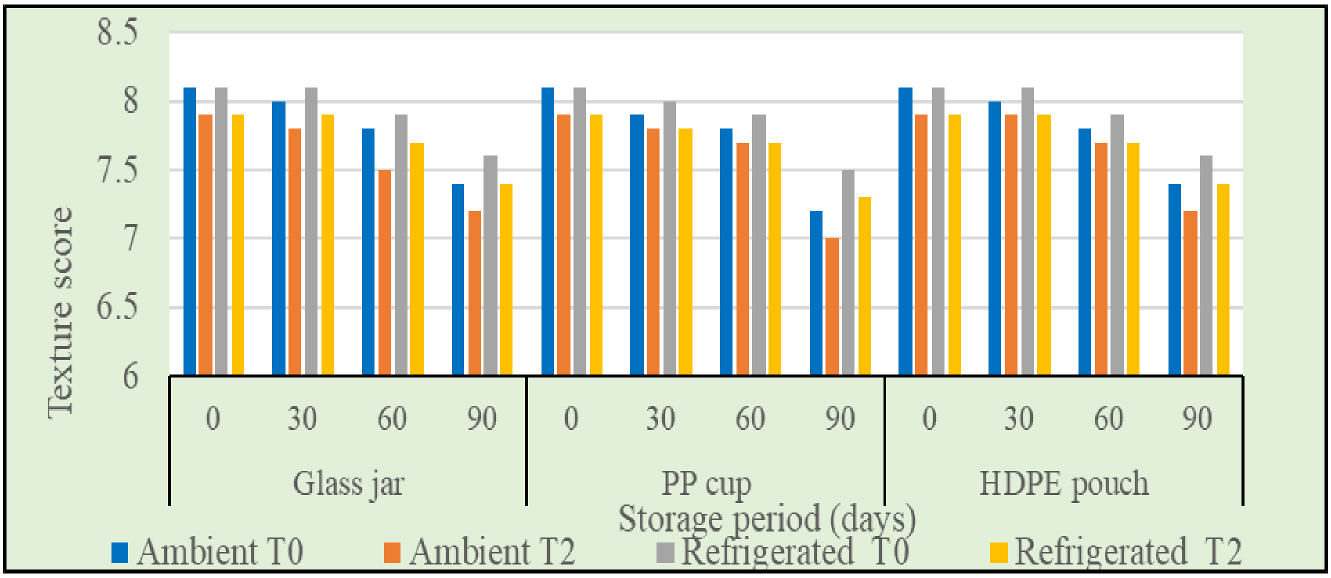

Fig 9: Effect of storage on overall acceptability of mixed fruit jam

Overall acceptability

Overall acceptability score of the fresh T_2 and T_0 were 8.4 and 8.5 which decreased significantly to 7.7, 7.5, 7.6 and 7.9, 7.7, 7.8 at (p<0.05) respectively when packed in glass jar, PP cup and HDPE pouch under ambient temperature (Table 7). Similarly, overall acceptability score of the T_2 and T_0 decreased to 8.0, 7.9, 7.8 and 8.1, 8.0, 8.0 when stored in glass jar, PP cup and HDPE pouch respectively under refrigerated temperature at (p<0.05). Maximum decrease was found in T_2 stored in PP cup (7.5) followed by T_2 stored in HDPE pouch (7.6) under ambient temperature whereas the minimum decrease was observed in T_0 stored in glass jar (8.1) under refrigerated temperature at (p< 0.05). The decrease in overall acceptability of jam may be due to the decrease in colour, texture and taste during the storage period. Similar results were obtained by Jat *et al*. (2022) [11] and Yaseen *et al*. (2018) [28].

Table 7: Effect of storage on overall acceptability of mixed fruit jam

		Ambient		Refrigerated	
	Days	**T_0**	**T_2**	**T_2**	**T_2**
Glass jar	0	8.5	8.4	8.5	8.4
	30	8.3	8.3	8.5	8.4
	60	8.1	8.1	8.3	8.2
	90	7.9	7.7	8.1	8.0
	SE	0.01	0.04	0.05	0.02
	CD@5%	0.03	0.15	0.17	0.07
PP cup	0	8.5	8.4	8.5	8.4
	30	8.3	8.2	8.4	8.3
	60	8	7.9	8.2	8.1
	90	7.7	7.5	8.0	7.9
	SE	0.06	0.05	0.06	0.06
	CD@5%	0.20	0.16	0.21	0.20
HDPE Pouch	0	8.5	8.4	8.5	8.4
	30	8.3	8.1	8.2	8.2
	60	8	7.9	8.1	8
	90	7.8	7.6	8.0	7.8
	SE	0.02	0.02	0.06	0.02
	CD@5%	0.06	0.07	0.20	0.06
*Each value is the mean score of three determinations					

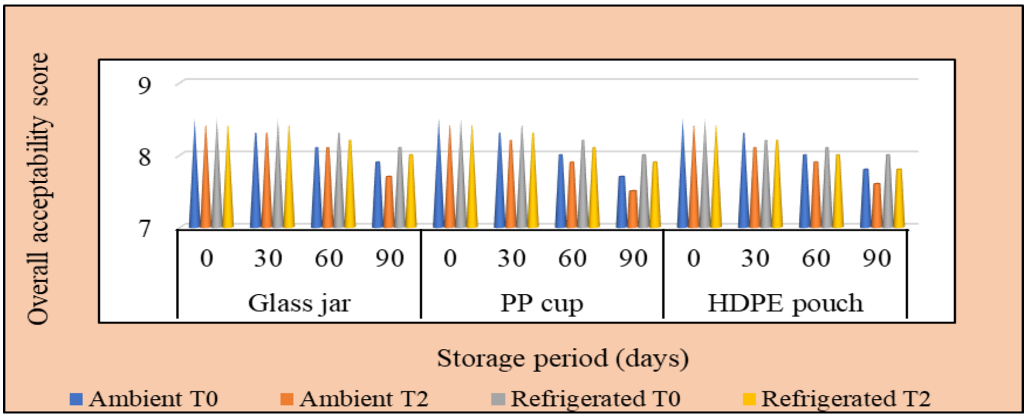

Fig 9: Effect of storage on overall acceptability of mixed fruit jam

Yeast and mold count

No microbial growth was observed at refrigerated conditions and at ambient temperature except for the sample stored in the PP cup (0.1 x 10^2 CFU/g) (Table 8). In thermally processed fruits and vegetable products, the maximum allowable level of yeast and mould count is 1x102/g, under the FSSAI, Food Safety and Standards (Food Products Standards and Food Additives), 2018. Therefore, T_2 samples would be safe to eat for up to 90 days after storage. The shelf life of T_2 may be due to heat treatment (Cervera *et al*., 2021) [6], high sugar content that exerts osmotic pressure (Jat *et al*., 2022) [11], higher acidity and low pH. Relatively higher microbial growth in the PP cup among all packaging materials may be due to its barrier properties, improper filling, no airtight treatment. (Rana *et al*., 2021) [18]. Similar results were reported by Jat *et al*. (2022) [11], Cervera *et al*. (2021) [6], Rana *et al*. (2021) [18], Aruna *et al*. (2017), Singh *et al*. (2016) [22] and Sharma (2016)

Table 8: Effect of storage on microbial growth (×10^2 CFU/g) of mixed fruit jam

		Ambient		Refrigerated	
	Days	**T_0**	**T_2**	**T_0**	**T_2**
Glass jar	0	ND	ND	ND	ND
	30	ND	ND	ND	ND
	60	ND	ND	ND	ND
	90	ND	ND	ND	ND
PP cup	0	ND	ND	ND	ND
	30	ND	ND	ND	ND
	60	ND	ND	ND	ND
	90	ND	0.1	ND	ND
HDPE Pouch	0	ND	ND	ND	ND
	30	ND	ND	ND	ND
	60	ND	ND	ND	ND
	90	ND	ND	ND	ND
*Each value is a mean score of three determinations					

Conclusion

Effect of storage on the jaggery based jam made with 50% mixed fruit pulp +25% sugar + 25% jaggery, packaged in glass container, PP cup, HDPE pouch and stored at refrigerated temperature showed greater stability than the same samples at ambient temperature during the storage period. Although there were some physicochemical and organoleptic changes, the jam was found to be spreadable and stable for 3 months. Samples stored in glass jar found best among them followed by high density polyethylene pouch and polypropylene cup. Therefore, from these results, it can be concluded that mixed fruit jam made with 50% jaggery can be stored for 3 months at ambient temperature and refrigerated temperature by using glass jar, high density polyethylene pouch and polypropylene cup.

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