Optimization of Juice and Total Soluble Solids concentration for the preparation of wild jamun syrup: Effect of packaging materials and temperature conditions on nutritional quality during storage.

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Authors' contributions

This work was carried out by author Kanchan Bhatt during M.Sc. in Food Technology under the guidance of Author N.S. Thakur. All authors have helped in preparation of manuscript and approved the final manuscript.

ABSTRACT: Jamun (*Syzygium cumini* L.) is a wild fruit with major importance due to its antioxidant activity, anthocyanins content and exotic taste besides high medicinal value. This fruit is known for its antidiabetic properties as its seeds contain glucoside "Jamboline". Due to its perishable nature and neutraceutical importance present studies have been conducted for the preparation of syrup. Various TSS (65 and 70 °B) and juice (25, 30, 35 and 40%) ratios have been attempted to optimize proper syrup combination. The two packaging materials i.e. glass and PET (Polyethylene terephthalate) bottles were used to pack jamun syrup prepared by the best selected combination and stored for 6 months under ambient (18-22 °C) and refrigerated temperature conditions (4–7 °C). Based on organoleptic and some physico-chemical characteristics, syrup prepared with 35% jamun juice, 65 °B TSS and 1.50% acid was considered best among 8 different treatment combinations of juice and TSS. Jamun syrup could be stored safely for a duration of six months under both the ambient and refrigerated conditions without any difference in various quality parameters. Nevertheless, both PET and glass bottles have been considered appropriate as packaging material, with reasonably fewer changes taking place in glass bottles kept in refrigerated conditions.

Key Words: Antidiabetic fruit, Glass, Jamun, PET, Refrigerated conditions, Syrup.

1. INTRODUCTION

Jamun (*Syzygium cumini* L.) is a wild evergreen fruit which belongs to Myrtaceae family [1]. It is considered indigenous to India and West Indies and found growing throughout the Asian subcontinent, Eastern Africa, South America and Madagascar to USA [2, 3]. In India, however, it is found growing throughout the country upto an altitude of 1800 m in Assam, Meghalaya, Arunachal Pradesh, Western ghats, Nilgiris, Palani Hills, Tamil Nadu, Kerala, Maharashtra, Orissa etc [4]. The genus *Syzygium* consists of about 1100 species and besides, *Syzygium cumini, S. aqueum, S. samarangense, S. jambos* and *S. densiflorum* are also edible species. The cultivated jamun is being produced in Maharashtra, Uttar Pradesh, Tamil Nadu, Gujrat, Assam and others [2] but in HP (Himachal Pradesh) only wild jamun is widely distributed in certain pockets of various districts like Bilaspur, Hamirpur, Una, Kangra, Mandi and Sirmour. This fruit is abundant source of sugars, vitamins, amino acids, minerals and other phytochemicals [5] including ascorbic acid (Vit C), tocopherols and tocotrienols (Vit E), carotenoids (pro-Vit A), phenols and flavonoids (flavons, isoflavones, flavones, chatechins and anthocyanins) [6]. Jamun is a ultimate cure for diseases like diarrhoea, obesity, vaginal discharge, menstrual disorders, haemorrhage, chemotherapy etc, however, it can also be considered best remedy for ailments like anemia and pimples as well [7-10]. It plays an important role in bringing down sugars levels in urine and blood as it carries no sucrose. In addition to this, it is effective against diabetes because of its effects on pancreas, however, this fruit is also reported to increase insulin activity and sensitivity as its seeds contain various bioactives glucoside, jamboline and ellagic acid which are reported to have the capacity to check the conversion of starch into sugar in case of excess production of glucose [11, 12]. The small purple fruit can be consumed raw but has very short shelf life owing to which it can be processed into various products. However, there are many products in the market which are made up of cultivated jamun, but no work has been done on wild jamun especially in HP. Therefore considering its availability in the forest and wastelands present studies have been carried out with the objective to develop syrup from this underutilized fruit and assessing its quality during storage.

2. MATERIALS AND METHOD

2.1 Raw material and extraction of juice

In the present study mature fruits of wild jamun were collected from Sepu village of Bilaspur district and Subathu area of district Solan of Himachal Pradesh (India) in July month, 2018. Various physico-chemical analyses were done by using fresh fruits and rest of the ripe fruits were washed and stored in deep freezer at -18 ˚C which were later used for extraction of juice. Juice from these wild fruits of Jamun was extracted by heating of whole fruit for 15 min under low flame and passing the heated material through pulper followed by the enzymatic treatment of pulp with Pectinase enzyme (0.08%) at 45˚ C for 90 min. After enzymatic treatment of pulp extraction of juice was done through hydraulic press.

2.2 Development of fruit Syrup

Wild jamun syrup was prepared by intermixing its juice with sugar syrup in different concentrations as specified in Table 1. Different treatment combinations of Citric acid was added in order to achieve the desired acid concentration (1.50%) in syrup. In all the treatment combinations, Sodium benzoate (600 ppm) was added as preservative for the preparation of syrup at the end.

2.3 Packaging and storage

The syrup prepared by following best combination of recipe on the basis of sensory analysis was packed in pre-sterilized glass and PET (Polyethylene terephthalate) bottles (700 ml capacity). All the packed products were properly labeled and stored in ambient temperature (18–22 °C) and low temperature (4–7 °C) conditions for the duration of six months. Evaluation of physico-chemical and sensory characteristics of the prepared beverage was done at zero, three and six months of storage intervals.

Table 1: Treatment detail of syrup.

Treatment	**T_1**	**T_2**	**T_3**	**T_4**	**T_5**	**T_6**	**T_7**	**T_8**
Juice (%)	25	30	35	40	25	30	35	40
TSS (°B)	65	65	65	65	70	70	70	70

2.4 Physico-chemical analysis and sensory evaluation

The colour of syrup in terms of Lab values was observed with Lovibond Colour Tintometer Model PFX-1 spectrophotometer in which RYBN colour units were obtained alongwith CIE readings i.e. 'L', 'a', and 'b' values. Ostwald viscometer was used to assess the apparent viscosity of the syrup and was expressed in time (flow rate in minutes). TSS, reducing sugars, total sugars, titratable acidity and ascorbic acid of prepared products were arbitrated as per the method reported by Ranganna and AOAC [13, 14]. Determination of total phenols content was done by Folin Ciocalteu procedure given by Singleton and Rossi [15]. Anthocyanins content present in samples was determined by spectrophotometric method given in Ranganna [13]. Antioxidant activity (Free radical scavenging activity) was measured as per the method of Brand-Williams *et al*. [16]. Digital pH meter (CRISON Instrument, Ltd, Spain) was used for measuring pH of the samples. For sensory evaluation of wild jamun syrup nine points hedonic rating test was followed [17]. The commitee of ten judges was selected for organoleptic evaluation of the product.

2.5 Statistical analysis

Completely Randomized Design (CRD) was used for the evaluation of the data on physico-chemical attributes of syrup before storage with one way analysis of variance and during storage with three way analysis of variance (ANOVA) was applied. Whereas, data of organoleptic characteristics was analyzed using Randomized Block Design. All the experiments were replicated three times.

3. RESULTS AND DISCUSSION

3.1 Optimization of recipe for the preparation of wild jamun syrup

Data pertaining to physico-chemical and sensory characteristics of wild jamun syrup prepared by following different recipes was given in Table 2 and 3. Data highlighted in Table 2 depicts that colour values of different recipes ranged between 10.68 to 11.25, 27.12 to 27.65 and

1.70 to 1.87 respectively. The highest (11.25) ‘L’ value (lightness) was reported in T_1 which was statistically at par with T_2, T_5 and T_6 and lowest (10.68) in T_8 which was at par with recipe T_4 and T_7. The maximun (27.65) ‘a’ value (red-green) was observed in T_8 and minimum (27.12) in recipe T_1, whereas, the highest (1.87) ‘b’ value (yellow-blue) was recorded in T_1 which was at par with T_2, T_5 and T_6 and lowest (1.70) in recipe T_8 which was statistically at par with T_3 and T_7. The ascorbic acid content present in wild jamun syrup varied from 4.85 to 7.86 mg/100 mL and highest (7.86 mg/100 mL) was recorded in T_8 which was at par with T_4 and lowest (4.85 mg/100 mL) in T_1. The anthocyanins content of different recipes of syrup ranged from 41.50 to 69.24. The highest anthocyanins (69.24 mg/100 mL) were recorded in T_8 and lowest (41.50 mg/100 mL) in T_1 which was at par with T_5. Phenolic content of different recipes of syrup ranged between 79.32 to 117.25 mg/100 mL and highest (117.25 mg/100 mL) was recorded in recipe T_8 which was at par with T_4 and lowest (79.32 mg/100 mL) in T_1 which was at par with P_5. The antioxidant activity of all recipes was recorded in the range between 20.45 to 29.32 per cent, highest (29.32) was found in T_8 and T_4 and lowest (20.45) in T_1. Data given in Table 2 depicts that recipe T_4 and T_8 had higher content of anthocyanins, total phenols, ascorbic acid and antioxidant activity which might be due to the use of high juice percentage as compared to other recipes like T_1 and T_5. The colour units of different recipes of syrup have also been affected by changes in juice content.

Table 2: Physico-chemical attributes of different recipes of wild jamun syrup

Treatments	Colour			Ascorbic acid (mg/100mL)	Anthocyanins (mg/100mL)	Total phenols (mg/100mL)	Antioxidants activity (%)
	L*	a*	b*				
T_1	11.25	27.12	1.87	4.85	41.50	79.32	20.45
T_2	11.20	27.34	1.83	5.76	50.37	86.05	22.97
T_3	**10.76**	**27.57**	**1.72**	**6.81**	**60.70**	**103.42**	**25.90**
T_4	10.70	27.63	1.71	7.85	69.21	117.24	29.30
T_5	11.22	27.14	1.86	4.86	41.52	79.33	20.46
T_6	11.19	27.36	1.82	5.77	50.39	86.06	22.98
T_7	10.73	27.59	1.71	6.82	60.72	103.44	25.94
T_8	10.68	27.65	1.70	7.86	69.24	117.25	29.32
$CD_{0.05}$	**0.06**	**0.01**	**0.08**	**0.14**	**0.25**	**0.22**	**0.21**

T_1: (25% Juice+65 °B TSS); T_2: (30% Juice+65 °B TSS); T_3: (35% Juice+65 °B TSS); T_4: (40% Juice+65 °B TSS); T_5: (25% Juice+70 °B TSS); T_6: (30% Juice+70 °B TSS); T_7: (35% Juice+70 °B TSS); T_8: (40% Juice+70 °B TSS). L*=lightness, a*= red-green, b*= yellow-blue; CD: Critical Difference.

3.2 Sensory characteristics

There was a significant effect of juice-acid-syrup blend on organoleptic scores of different recipes of wild jamun syrup as shown in Table 3. The higher colour and aroma scores for recipe T_8 and T_4 might be due to highest juice content in comparision to other recipes, whereas, the recipe T_3 obtained highest taste and body scores due to best combination of juice-syrup and sugar-acid-juice blend in this recipe. The higher overall acceptability score of recipe T_2 might be due to better blending of juice-acid-syrup coupled with attractive colour and body of the product.

It was concluded that the among different treatments, recipe with 35 percent Jamun juice, 65 ^{o}B TSS and 1.50 per cent acidity was best on the basis of organoleptic and physico-chemical characteristics of this beverage.

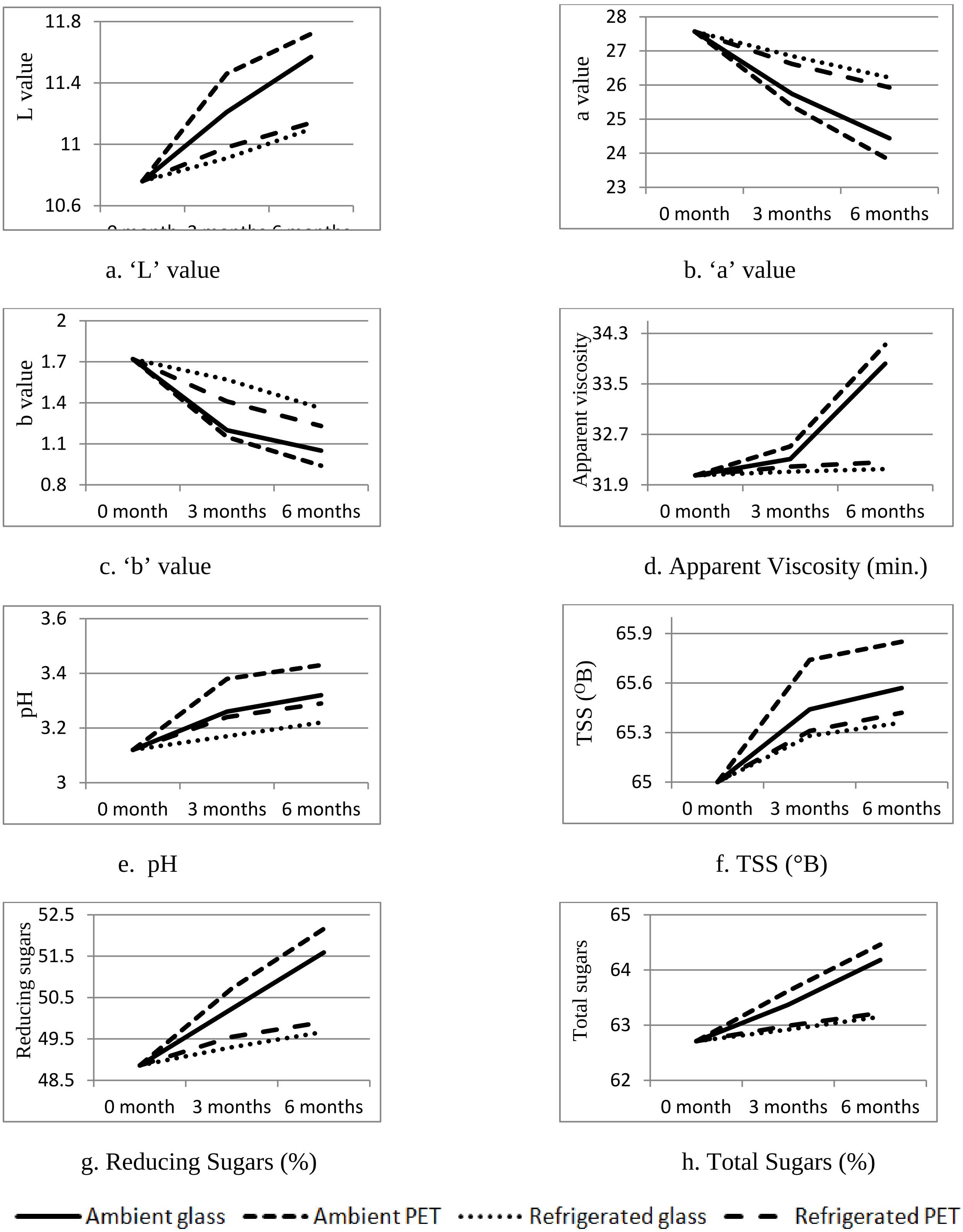
Table 3: Sensory scores of wild jamun syrup

Treatment	Colour	Body	Taste	Aroma	Overall acceptability
T_1	7.54	7.22	7.02	7.08	7.20
T_2	7.60	7.45	7.28	7.14	7.67
T_3	**7.72**	**7.63**	**8.31**	**7.32**	**8.22**
T_4	7.84	7.50	8.22	7.47	7.59
T_5	7.58	7.29	7.05	7.16	7.13
T_6	7.63	7.40	7.30	7.22	7.54
T_7	7.78	6.95	8.21	7.40	7.78
T_8	7.90	6.90	8.19	7.52	7.35
$CD_{0.05}$	**0.06**	**0.09**	**0.14**	**0.20**	**0.23**

3.3 Storage of wild jamun syrup

3.3.1 Physico-chemical characteristics

3.3.1.1 Colour Significant increment in ‘L’ (lightness) value with decrease in ‘a’ (red) and ‘b’ (yellow) of wild jamun syrup during storage (Figure: 1a, 1b and 1c). More increase in ‘L’ and decrease in ‘a’ and ‘b’ colour value of syrup was observed under ambient storage conditions in comparison to refrigerated. Increase in lightness and decrease in other colour values during storage might be due to loss of anthocyanins pigment, whereas, more degradation of anthocyanins occurred due to the light and high temperature in ambient storage conditions in contrast to refrigerated. Nearly as much the packaging material is concerned, more retentivity of red and yellow colour values of syrup packed in glass bottle were because of the slower reaction rate in it as a result of slower conduction of heat to the product as compared to PET bottle. Similar trend was also observed in earlier reported studies [18].



a. 'L' value

b. 'a' value

c. 'b' value

d. Apparent Viscosity (min.)

e. pH

f. TSS (°B)

g. Reducing Sugars (%)

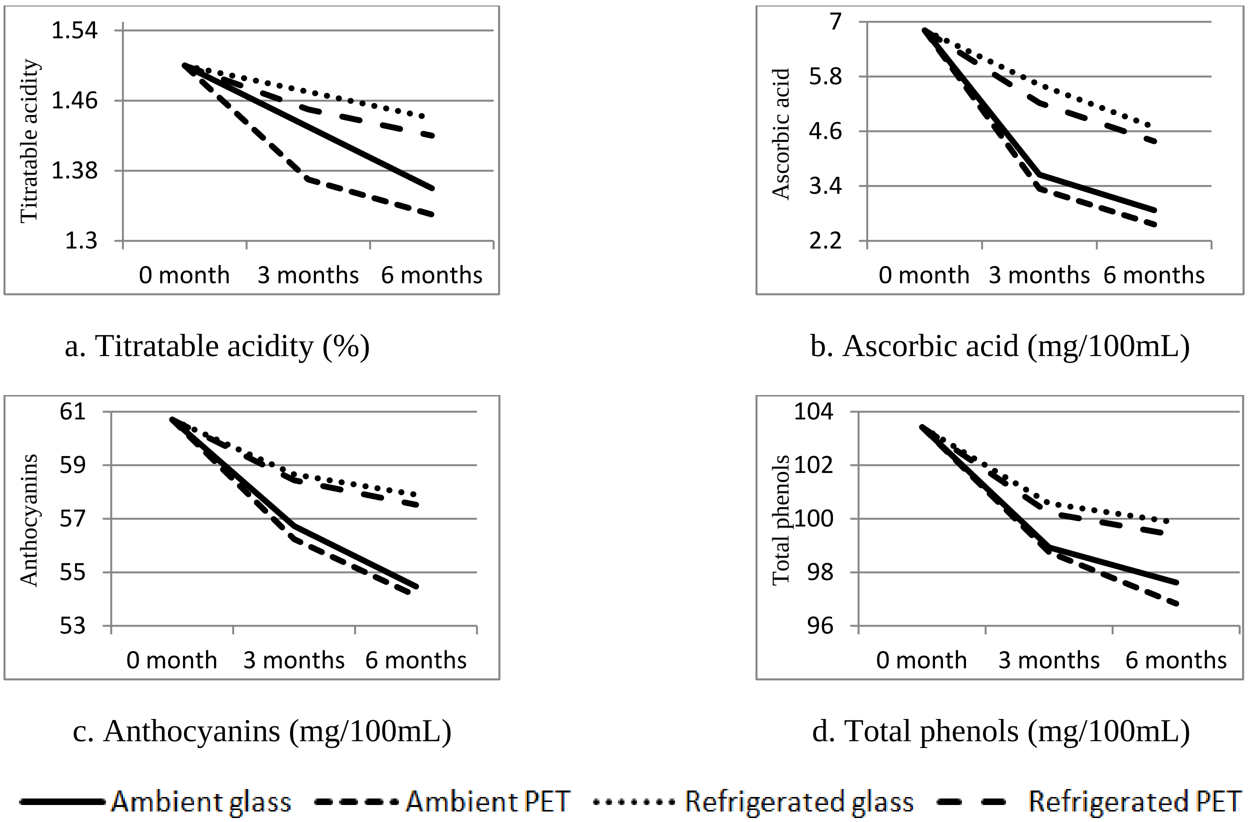
h. Total Sugars (%)

Fig. 1: Effect of storage on physico-chemical attributes of wild jamun syrup

3.3.1.2 TSS, Sugars and Apparent viscosity The TSS content of syrup increased slightly during storage (Figure 1f) owing to hydrolysis of polysaccharides into monosaccharides and soluble disaccharides [19]. Our results are in conformation with the findings of other studies [20, 21]. Significant increase during storage was found in reducing and total sugars of syrup (Figure 1g) which was however less in comparison to refrigerated storage conditions than in ambient. Increase in reducing and total sugars during storage might be accredit to the starch hydrolysis into sugars and higher increase in sugars might be because of the faster reactions due to high temperature in ambient conditions. The more increase recorded in sugars of jamun syrup packed in polyethylene terephthalate bottle over glass bottle might be due to varied rate of chemical reactions in the beverage due to difference in thermal conductance properties of packaging material. Similar trend of increase in reducing sugars has been reported in box myrtle syrup [22]. Apparent viscosity of wild jamun syrup also increased significantly (Figure 1d) during storage due to the increase in strain and shearing rate and decrease in the flow index of the beverage which in turn increases TSS and soluble sugars. Decrease in flow index helps to develope pseudo plasticity and increased apparent viscosity of the product. Other reason could be the precipitation of syrup caused due to the interaction of sugars with phenols and proteins. Similar trend or results have been reported in earlier study [23].

3.3.1.3 pH and Titratable acidity Statistically non-significant increase in the pH of syrup was observed during storage (Figure 1e) with respect to storage conditions and packaging material. Marked increase in pH of syrup during storage might be due to the degradation of acid in the product. During storage slight decrease was found in the titratable acidity of syrup (Figure 2a) which could be due to the chemical interactions of organic acids of syrup with sugars and amino acids. Our results are supported by the findings of jamun syrup [24].

3.3.1.4 Ascorbic acid, Anthocyanins and Total phenols Decrease in ascorbic acid content during storage (Figure 2b) might be attributed its deterioration into dehydro-ascorbic acid or furfural. Ascorbic acid is highly heat sensitive which led to its more degradation in ambient conditions. During storage lower decrease in ascorbic acid content was found in syrup packed in glass bottle owing due to the slower rate of reactions in it as glass materials absorb heat slower than PET material. Present studies are in confirmation with the results reported in jamun syrup and in wild aonla syrup [23, 24]. Decreased anthocyanins content of wild jamun syrup was observed during (Figure 2c) the storage whereas higher retention of anthocyanins was recorded under refrigerated storage conditions than ambient. Loss of anthocyanins in syrup accredit to their vulnerability to auto-oxidative degradation during storage. Due to slower rate of auto oxidation of anthocyanins in refrigerated conditions, more retention of this pigment was found in in the Jamun syrup in low temperature storage conditions. As a result of variation in the thermal conductance properties which might be due to the slower rate of chemical reactions during storage higher retention of anthocyanins was observed in glass bottles as compared to PET bottles. Similar decrease in anthocyanins was recorded in another studies too [18, 25].



a. Titratable acidity (%)

b. Ascorbic acid (mg/100mL)

c. Anthocyanins (mg/100mL)

d. Total phenols (mg/100mL)

Fig. 2: Effect of storage on physico-chemical attributes of wild jamun syrup

Total phenolic content (Figure 2d) decrease significantly during storage due to their involvement in the formation of polymeric compounds by complexing with protein and their subsequent precipitations as reported by Abers and Wrolstad [26] in strawberry preserve. However, low rate of loss of total phenols might be due to slower reaction rate in refrigerated storage conditions as compared to ambient. As well as, retention of more phenols of syrup in glass bottle may also be due to the slower reaction rate in glass bottle, as glass material absorbs heat at slower rate as compared to PET. Same decreasing trend in phenols content have been reported in wild pomegranate syrup (with arils) and box myrtle syrup [27].

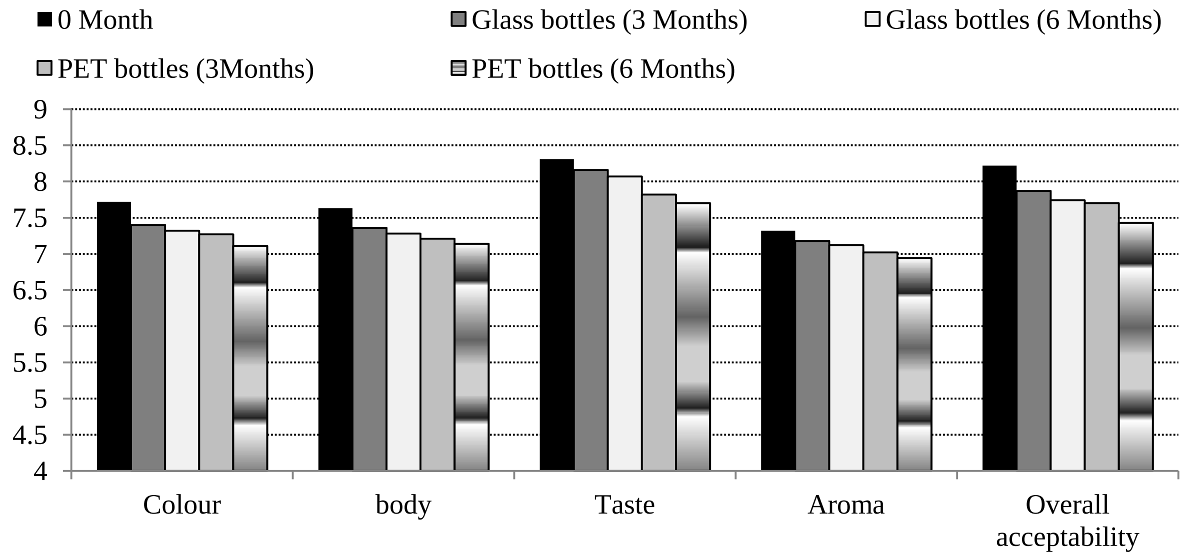


Fig. 3: Effect of storage and packaging on sensory characteristics of wild jamun syrup stored under ambient conditions

1`**3.3.2 Sensory characteristics of wild jamun syrup during storage** Decline in colour, body, taste, aroma and overall acceptability scores of syrup was observed during storage. However, less decrease in scores was found in refrigerated storage conditions (Fig 3) than ambient (Fig 4). Judges awarded lower colour scores to syrup during storage due to browning caused by copolymerization of organic acids of the product. The effect of different packaging materials on the colour scores of Jamun syrup was found non significant. The formation of precipitates in the product as a result of interactions between phenols and proteins lead to decrease in body scores of syrup with advancement of storage period. Whereas, the possible reason of decline in taste scores might be due to the loss of sugar-acid blend responsible for taste during storage. However, loss of volatile aromatic compounds during storage might be the reason behind higher loss of aroma scores. During storage the overall acceptability score of syrup substaintially decreased due to the loss in appearance, flavour compounds and uniformity of the product. Very close decreasing trend in sensory characteristics of Kokum products and in wild prickly pear syrup during storage has also been reported in earlier studies [22-29].

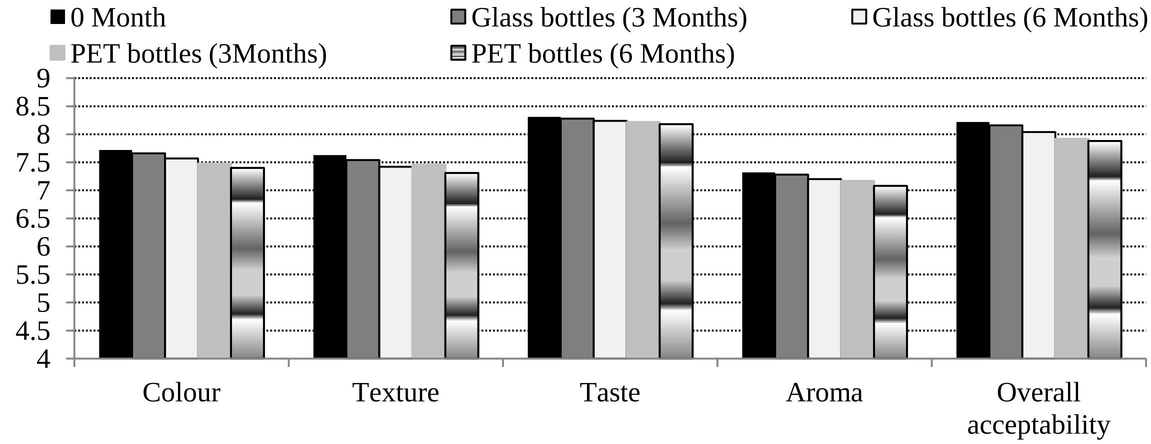


Fig. 4: Effect of storage and packaging on sensory characteristics of wild Jamun syrup stored under refrigerated conditions

4. CONCLUSION

Out of 8 different treatment combinations of wild jamun syrup recipe (T_3) containing 35% jamun juice, 65 °B TSS and 1.50% acid was observed best on the grounds of its physico-chemical characteristics and organoleptic parameters. For a period of 6 months the product could be stored safely under both storage conditions and in both packaging materials. The quality of this beverage could be maintained best in glass bottle stored under refrigerated storage conditions as compared to PET bottle.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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