International Research Journal of Pure & Applied Chemistry

21(12): 34-44, 2020; Article no.IRJPAC.59757
ISSN: 2231-3443, NLM ID: 101647669

Standardization of Recipe for the Preparation of Wild Jamun Squash: Effect of Packaging Materials and Temperature Conditions on Nutritional Quality during Storage

Kanchan Bhatt[1*], N. S. Thakur[1], Abhimanyu Thakur[1], Hamid[1] and Chetna Sharma[1]

[1]*Department of Food Science and Technology, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, 173230, India.*

Authors' contributions

This work was carried out by author KB during M.Sc. in Food Technology under the guidance of author NST. All authors have helped in preparation of manuscript and approved the final manuscript.

Article Information

DOI: 10.9734/IRJPAC/2020/v21i1230232
Editor(s):
(1) Dr. Wolfgang Linert, Vienna University of Technology Getreidemarkt, Austria.
Reviewers:
(1) Giulian César Da Silva Sá, Universidade Federal do Rio Grande do Norte, Brazil.
(2) Aumreetam Dinabandhu, National Institute for Plant Biotechnology, India.
Complete Peer review History: http://www.sdiarticle4.com/review-history/59757

Original Research Article

Received 02 June 2020
Accepted 08 August 2020
Published 19 August 2020

ABSTRACT

Jamun (*Syzygium cumini* L.) an evergreen wild fruit of utmost importance belongs to Myrtaceae family and grows throughout the Asian subcontinent, Eastern Africa, South America, Madagascar to USA. It is an edible antidiabetic fruit rich in anthocyanins native to India and West Indies. Thus, an attempt was made to develop squash from its fruit and determine quality changes during storage. Various combinations of enzyme assisted extracted juice and sugar syrup were tried and analyzed on the basis of sensory quality attributes to standardize proper combination for squash. The recipe with 35 per cent juice and 40˚B TSS was rated best on the basis of sensory and some physico-chemical characteristics packed in glass and PET bottles and stored for six months under ambient (20-25˚C) and refrigerated temperature conditions (4-7˚C). Squash could be safely stored for a period of six months under both the ambient and refrigerated conditions with mild change in various quality characteristics. Although, the changes in the quality characteristics of the squash were slower in refrigerated storage conditions

**Corresponding author: E-mail: kanchanbhatt14@gmail.com;*

as compared to ambient conditions. However, both packaging materials viz PET and glass bottles were found suitable with comparably less changes occurring in glass bottle under refrigerated conditions.

Keywords: Antidiabetic; anthocyanins; PET; squash; wild jamun.

1. INTRODUCTION

Jamun (botanically known as *Syzygium cumini* L.) is an evergreen wild fruit of family Myrtaceae originated from India, West Indies and found growing throughout the Asian subcontinent, Eastern Africa, South America and Madagascar to USA [1]. However, in India, it is found growing throughout the country up to an altitude of 1800 m. The production of cultivated jamun is widely distributed to Maharashtra, Uttar Pradesh, Tamil Nadu, Gujrat, Assam and others [1], however, in Himachal Pradesh only wild jamun is found and that too is confined to the districts like Bilaspur, Hamirpur, Una, Kangra, Mandi and Sirmour [2]. India is topmost producer of jamun in the world and globally, total production of jamun is 13.5 million tones out of which India contributes about 15.40 % [3]. Phytochemicals including tannins, anthocyanins, terpenes, flavanols and aliphatic-acids are present in extracts of various parts of *S. cumini* [4]. All parts of *S. cumini* are rich in polyphenols [5] whereas, both fruit and flowers are rich in anthocyanins as cyanidin, delphinidin, peonidin, pelargonidin, petunidin, and malvidin [6]. Anthocyanins possess immune modulating activity, have anti-carcinogenic effects such as inhibition of tumor formation, induction of cell-cycle arrest and induction of apoptosis to cancer cells respectively [7,8]. Besides, being antagonistic to some bacteria, virus and fungi [9]. Anthocyanins are also important in reducing the oxidative stress. Not only this, the ellagic acid and glucoside jamboline are known as bioactive components of jamun containing antioxidant activity and hold the capacity to convert the starch into sugar thus, can be considered as an effective antidiabetic fruit [10]. In addition, Jamun is a supreme cure for diseases like diarrhea, obesity, vaginal discharge, menstrual disorders, hemorrhage, chemotherapy etc., however, it is also used as effective antidote for ailments like anemia and pimples as well [11-13]. Jamun fruit juice has an appealing color and outstanding taste with certain medicinal properties that could be profitably utilized by beverage industry. Although, processed products made up of commercial jamun have conquered major section of market but keeping its availability, short shelf life and therapeutic values in mind the present studies have been carried out with the objective to develop squash from this underutilized wild fruit and assessing its quality during storage.

2. MATERIALS AND METHODS

2.1 Raw Material and Extraction of Juice

Present study is based on collection of mature fruits of wild jamun from Bilaspur and Solan district of Himachal Pradesh (India) in the month of July, 2018. The fruit identification and authentication was carried out by Department of FST, YSPUHF, Solan, India. Numerous physico-chemical analyses were conducted by using fresh fruits while rest of the ripe fruits were washed and stored in deep freezer at -18 ˚C which were later used for juice extraction. Juice extraction from wild fruits of Jamun was done by heating whole fruit for 15 min under low flame and then passing the heated material through pulper. Further, the pulp was treated with Pectinase enzyme (0.08%) at 45˚ C for 90 min followed by extraction of juice through hydraulic press.

2.2 Development of Fruit Squash

As per the specifications of FSSAI (TSS and fruit part) different concentrations of wild jamun squash was prepared by mixing its juice and sugar syrup. In order to achieve the desired acid concentration (1.20%) in squash, addition of citric acid was done in all the treatment at the end. Out of eight treatment combinations first four treatments ($T_{1-}T_4$) were prepared with 25, 30, 35 and 40 % juice and 40°B TSS while rest four treatments (T_5-T_8) were prepared with 25, 30, 35 and 40 % juice and 45°B TSS.

2.3 Packaging and Storage

The squash prepared by following best combination of recipe on the basis of organoleptic evaluation was packed in pre-sterilized glass and PET bottles (700 ml capacity). For the period of six months all the packed products were properly labelled and stored in ambient (18-22°C) and low temperature (4-7°C) conditions. The various quality characteristics were analyzed at zero, three and six months of storage intervals.

2.4 Physico-chemical Analysis and Sensory Evaluation

The colour of squash in terms of Lab values was observed with Lovibond Colour Tintometer Model PFX-1 spectrophotometer in which RYBN colour units were obtained along with CIE readings i.e. 'L' (lightness), 'a'(red-green), and 'b'(yellow-blue) values. TSS, reducing sugars, total sugars, titratable acidity, ascorbic acid and anthocyanins content of prepared products were estimated according to method described by Ranganna [14] and AOAC [15]. Total phenols content of wild jamun squash was calculated by Folin Ciocalteu procedure given by Singleton and Rossi [16]. Antioxidant activity was measured as per the method of Brand-Williams et al. [17]. The pH of the samples was determined by using a digital pH meter (CRISON Instrument, Ltd, Spain). A panel of 10 judges was selected and nine points hedonic rating test was followed for conducting the sensory evaluation of the product for various characteristics like colour, body, taste, aroma and overall acceptability.

2.5 Statistical Analysis

Completely Randomized Design (CRD) was used to calculate the data on physico-chemical characteristics of squash before storage with one way analysis of variance and during storage with three way analysis of variance (ANOVA). However, data related to the sensory evaluation was analyzed by using Randomized Block Design (RBD). The experiments on recipe standardization and for storage studies were replicated three times.

3. RESULTS AND DISCUSSION

3.1 Standardization of Recipe for the Preparation of Wild Jamun Squash

Data related to physico-chemical and sensory characteristics of wild jamun squash prepared by following different recipes was given in Table 1 and Fig. 1. Data pertaining to Table 1 reveals the colour components in terms of 'L' (lightness), 'a' (red-green) and 'b' (yellow-blue) values of different recipes ranged between13.74 to 14.35, 26.15 to 26.64 and 1.42 to 1.64, respectively. The maximum 'L' (lightness) value was recorded in T_1 and lowest in T_8. The highest 'a' (red) value was recorded in T_8 and lowest in T_1. Whereas, highest 'b' (yellow) value was recorded in T_1which was at par with T_2 and lowest in T_8 which was at par with $T_{7.}$ The ascorbic acid content of wild jamun squash in various treatment combinations ranged between 4.72 to 7.77 mg/100 mL and highest was recorded in T_8 and the lowest in T_1 which was statistically at par with T_5. The anthocyanins content of different recipes of this beverage ranged between 41.35 to 69.12 mg/100 ml. The highest value of anthocyanins was recorded in T_8 and lowest in T_1 which was statistically at par with $T_{5.}$ The total phenols content of different recipes of wild jamun squash varied from 78.89 to 116.42 mg/100 ml, highest was found in T_8 which was statistically at par with T_4 and lowest in T_1 which was at par with $T_{5.}$ However, the antioxidant activity of all recipes ranged between 20.01 to 29.13 %, the highest antioxidant activity was recorded in T_8 which was at par with T_4 and lowest in T_1 which was statistically at par with T_5. Table 1 highlights that increase in juice content of different recipes produces a significant effect on physico-chemical characteristics of wild jamun squash recipe. Data depict that recipe T_4 as well as T_8 recorded higher values of total sugars, reducing sugars, anthocyanins, total phenols, ascorbic acid and antioxidant activity which were because of the use of higher amount of juice as compared to other recipes like T_1 and $T_{5.}$ The changes in juice content had also affected the colour values of different recipes of the squash. Data on sensory characteristics scores of different recipes of wild jamun squash given in Fig. 1 indicate that the colour score was recorded highest (7.86) in T_8 and the lowest (7.22) in $T_{1.}$ The recipe T_3 obtained maximum (7.97) body score and minimum in T_5 (6.56) which was statistically at par with T_1. The same recipe (T_3) obtained the maximum taste score (8.19) and T_8 scored the minimum (5.42). The highest score (7.82) of overall acceptability was awarded to recipe T_3 and lowest (6.15) in T_8 closely followed by $T_{7,}$ T_5 and T_1. Data appended in Fig. 2 highlights the significant effect of juice-acid-syrup blend on sensory scores of different recipes of wild jamun squash. The higher colour scores of recipe T_8 and T_4 might be due to maximum juice content as compared to other recipes. The recipe T_3 obtained highest taste and body scores which were due to the higher juice content as well as better combination of juice-syrup and sugar-acid-juice blend in this recipe. The higher overall acceptability scores of recipe T_3 might be due to the better combination of juice-acid-syrup blend coupled with attractive colour and body of the product. From the above results it was concluded that the recipe with 35 per cent juice, 40^{o} B TSS (T_3) and 1.20 per cent acidity was found to be best on the basis of sensory and some physico-chemical characteristics. Nearly similar results have been observed by Thakur and Thakur [18] in box myrtle squash and Thakur and Hamid [19] in mulberry squash.

3.2 Storage of Wild Jamun Squash

3.2.1 Physico-chemical characteristics

3.2.1.1 Colour

Significant increase was noticed in 'L' (lightness) value with decrease in 'a' (red) and 'b' (yellow) value of wild jamun squash during storage (Fig. 2a, 2b and 2c). More increase in 'L' and decrease in 'a' and 'b' colour value of syrup was recorded under ambient storage conditions as compared to refrigerated. Increase in lightness and decrease in other colour values during storage might be due to degradation of anthocyanins pigment, however, more degradation of anthocyanins occurred due to the light and high temperature in ambient storage conditions as compared to refrigerated [2]. As far as the packaging material is concerned, more retention of red and yellow colour values of squash packed in glass bottle were due to the slower reaction rate in it which was a result of slow conduction of heat to the product as compared to PET bottle. Our results for the colour attributes are in confirmation with the findings of Bhatt et al. [2] in wild jamun beverage.

Table 1. Physico-chemical characteristics of wild jamun squash

Treatments	Colour			Ascorbic acid (mg/100 mL)	Anthocyanins (mg/100 mL)	Total phenols (mg/100 mL)	Antioxidants activity (%)
	L^*	a^*	b^*				
T_1	14.35	26.15	1.64	4.72	41.35	78.89	20.01
T_2	14.16	26.28	1.60	5.68	50.23	85.15	22.82
T_3	13.91	26.48	1.53	6.65	60.61	102.71	25.70
T_4	13.84	26.57	1.49	7.75	69.11	116.40	29.11
T_5	14.30	26.17	1.60	4.75	41.36	78.91	20.02
T_6	14.11	26.29	1.56	5.71	50.25	85.17	22.84
T_7	13.81	26.50	1.46	6.68	60.63	102.75	25.72
T_8	13.74	26.64	1.42	7.77	69.12	116.42	29.13
$CD_{0.05}$	0.02	0.01	0.04	0.17	0.26	0.20	0.16

L=lightness, a*= red-green, b*= yellow-blue; CD: Critical Difference*
(T_1-T_4: 25, 30, 35 and 40% juice with 40°B TSS; T_5-T_8: 25, 30, 35 and 40% juice with 45°B TSS)

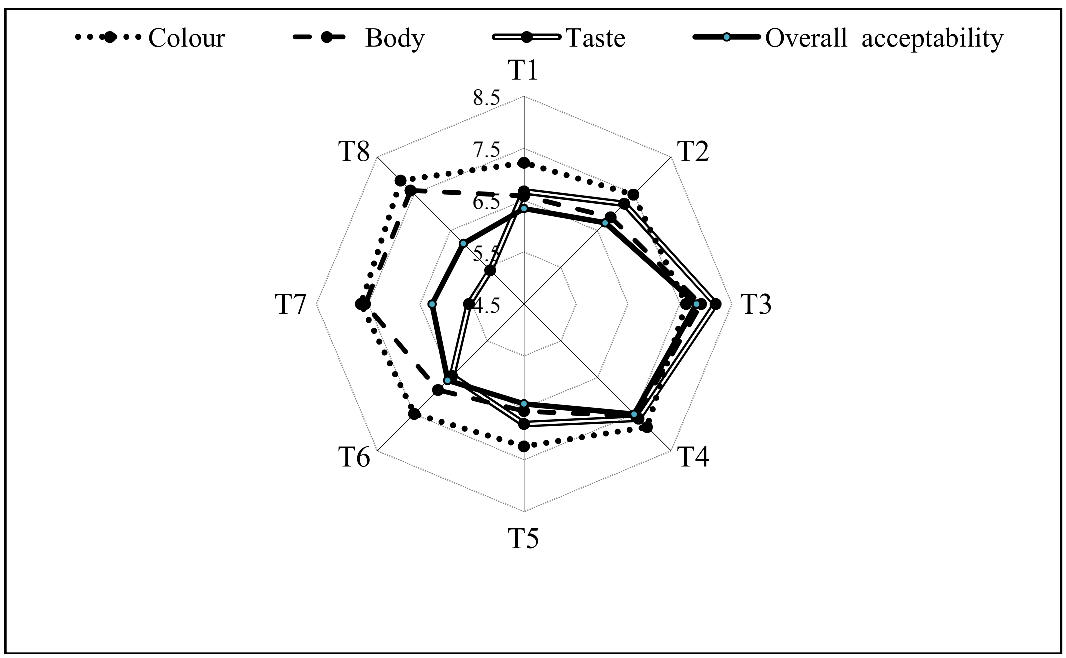


Fig. 1. Sensory characteristics (scores) of different recipes of wild jamun squash (T_1-T_4: 25, 30, 35 and 40% juice with 40°B TSS and T_5-T_8: 25, 30, 35 and 40% juice with 45°B TSS)

3.2.1.2 TSS and sugars

Moderate increment in the TSS content of squash was seen during storage (Fig. 2d) and this increase might be due to hydrolysis of polysaccharides into monosaccharides and soluble disaccharides. Our results are in agreement with the results reported by Kayshar et al. [20] in mixed fruit squash, and Sharma et al. [21] in *Aloe vera*-aonla blended functional squash. However, reducing and total sugars of squash showed a significant increase during storage (Fig. 2e and 2f) which was comparatively less in refrigerated storage conditions than in ambient. Increase in reducing and total sugars during storage might be attributed to the hydrolysis of starch into sugars and higher increase in sugars might be due to the faster rate of reactions because of high temperature in ambient conditions. More increase in sugars recorded in squash packed in PET bottle as compared to glass bottle might also be due to faster rate of chemical reactions in the product packed in PET bottle as an outcome of difference in their thermal conductance properties [22]. Our findings are similar to the findings of Ali et al. [23] in sea buckthorn squash and Relekar et al. [24] in sapota squash.

3.2.1.3 Titratable acidity and pH

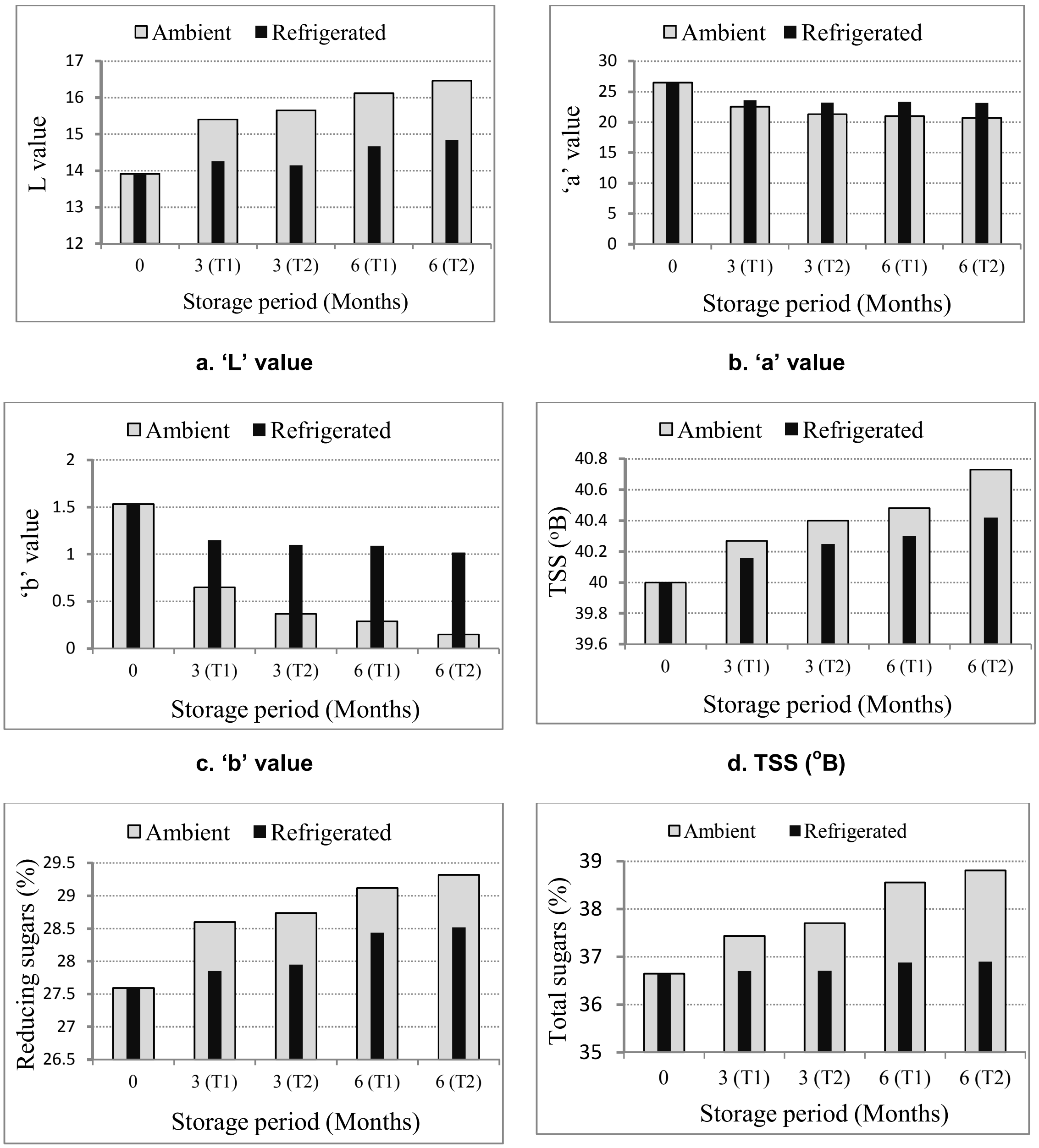
The wild jamun squash showed a slight decrease in titratable acidity during storage which could be attributed to the chemical interactions of organic acids of syrup with sugars and amino acids and this was comparatively more under ambient storage conditions as compared to refrigerated (Fig. 2g). This might be due to the faster rate of reaction because of high temperature in ambient conditions. However, with respect to packaging material, this decrease was non-significant. Our results are in conformity with the findings of Syed et al. [25] in sweet orange squash and Thakur and Thakur [18] in box myrtle squash. Slight increase was observed in the pH of squash during storage (Fig. 2h) which was statistically non-significant with respect to storage conditions and packaging material. Noticeably, this increment in pH could be due to the degradation of acid in the product during storage. Similar results were also reported by Bhatt et al. [2] in wild jamun beverage.

3.2.1.4 Ascorbic acid and anthocyanins

Decrease in ascorbic acid content during storage (Fig. 2i) might be due to its degradation into dehydro-ascorbic acid or furfural. Ascorbic acid has higher heat sensitivity; therefore, it is more degradable in ambient conditions. Less decrease in ascorbic acid content of squash packed in glass bottle observed during storage might be due to the slower rate of reactions in it as glass materials absorb slow heat as compared to PET material [22]. The findings of the present studies are in agreement with the results reported by Syed et al. [25] in sweet orange squash and Thakur and Hamid [19] in mulberry squash. Significant decrease in anthocyanins content of wild jamun squash was observed during (Fig. 2j) the storage and higher retention of anthocyanins was recorded under refrigerated storage conditions than ambient. During storage loss of anthocyanins in squash might be due to their susceptibility to auto-oxidative degradation. More retention attributed in this product stored in refrigerated conditions as compared to ambient might be due to slower rate of auto oxidation of anthocyanins in refrigerated conditions [26]. Less decrease of anthocyanins in glass bottle may be due to the slower rate of chemical reactions in the product in glass bottle as a result of difference in their thermal conductance properties during storage. Similar decrease in anthocyanins content was recorded in other studies conducted by Kannan and Thirumaran [27] in jamun squash and Thakur and Thakur [18] in box myrtle squash.

3.2.1.5 Total phenols and antioxidant activity

A gradual decrease in total phenols content of wild jamun squash was observed during storage (Fig. 2k) which was however, slower under refrigerated storage conditions than ambient. Significant decrease in total phenols content during storage might be due polymerization of phenolic compounds with protein followed by precipitation process. Slower rate of loss of total phenols might be due to slower reaction rate in refrigerated storage conditions as compared to ambient [28]. However, retention of more phenols of squash 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. Similar trend of decrease in phenols content have been reported by Thakur and Hamid [19] in mulberry squash, Thakur et al. [29] in wild prickly pear squash and Thakur et al. [30] in wild pomegranate squash. Antioxidant activity of wild jamun squash decreased gradually during storage (Fig. 2l) although this decrease was slower under refrigerated storage conditions than ambient conditions. This decrease during storage might be due to the degradation of anthocyanins and ascorbic acid during storage. Slower rate of loss of antioxidant activity in refrigerated storage might be due to slower reaction rate in refrigerated conditions as compared to ambient [26]. However, slower antioxidant activity of squash in glass bottle may also be because of slower reaction rates in glass bottle, as glass material absorb heat at slower rate as compared to PET. Nearly similar results for antioxidant activity were recorded by Kathiravan et al. [31] in beet root squash and Chauhan et al. [32] in spiced wild prickly pear squash.



a. 'L' value

b. 'a' value

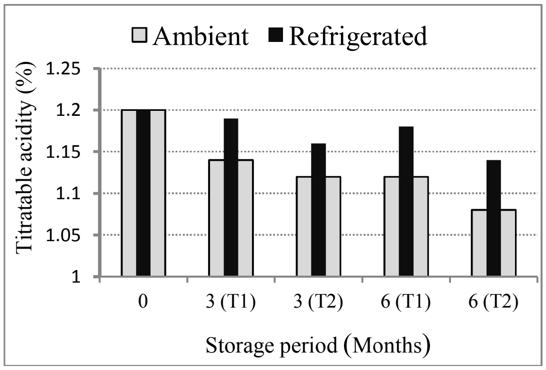
c. 'b' value

d. TSS (^{o}B)

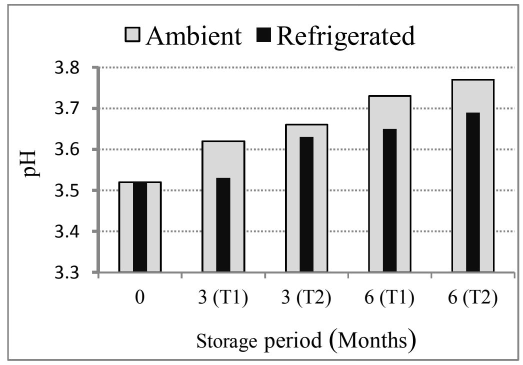
e. Reducing sugars (%)

f. Total sugars (%)

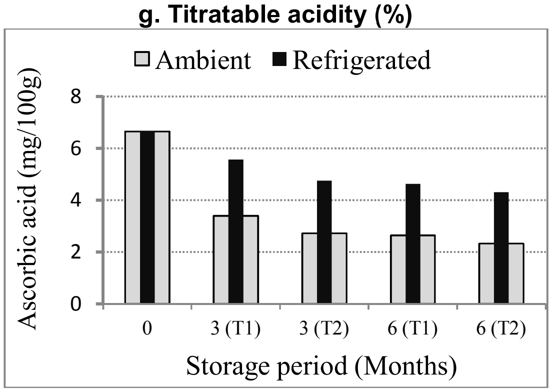
Fig. 2 (a-f). Effect of storage on physico-chemical characteristics of wild jamun squash (T_1: Glass bottles and T_2: PET bottles)



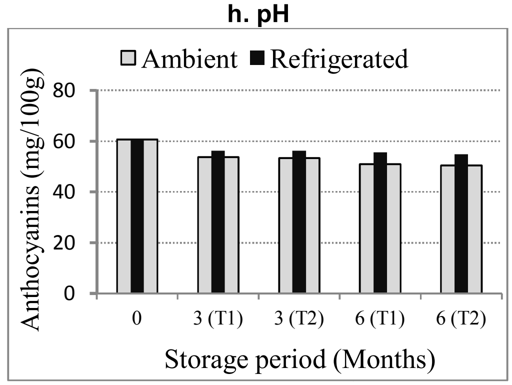
g. Titratable acidity (%)



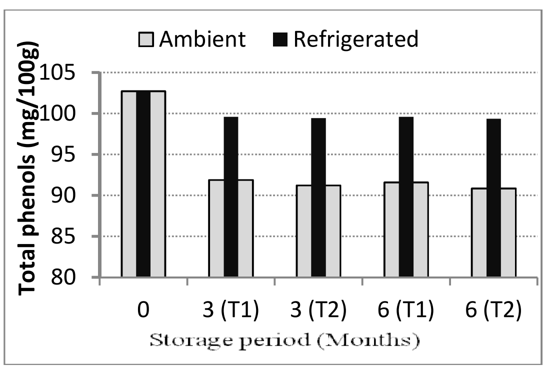
h. pH



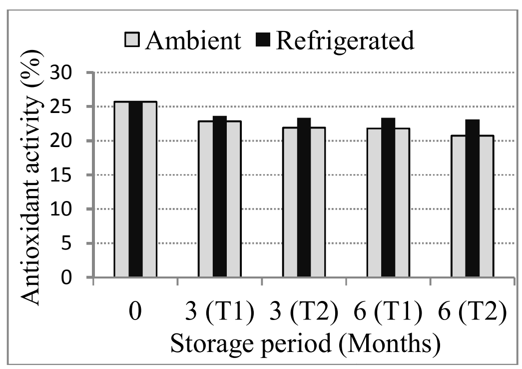
i. Ascorbic acid (mg/100g)



j. Anthocyanins (mg/100g)



k. Total phenols (mg/100g)



l. Antioxidant activity (%)

Fig. 2 (g-l). Effect of storage on physico-chemical characteristics of wild jamun squash (T_1: Glass bottles and T_2: PET bottles)

3.2.1.6 Sensory characteristics of wild jamun syrup during storage

During storage decrease in colour, body, taste and overall acceptability scores of squash were observed. However, decrease in score was more in ambient (Fig. 3) than refrigerated storage conditions (Fig. 4). The reason of decrease in colour scores during storage might be browning caused by copolymerization of organic acids of the product which have lead the judges to award the lower scores during storage. As far as packaging material is concerned, there was non-significant effect of packaging materials on the colour scores of squash. The formation of precipitates in the product as a result of interactions between phenols and proteins might be the reason of decrease in body scores of squash with advancement of storage period. Whereas, the possible reason of decrease 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. Judges did not find any difference in body of the product in both the packaging materials during storage so, they awarded the body scores in almost equal proportions. The overall acceptability score of squash decreased significantly during storage which might be due to the loss in appearance, flavor compounds and uniformity of the product during storage. Similar decreasing trends in sensory scores were reported by Ali et al. [22] in sea buckthorn squash, Syed et al. [25] in sweet orange squash, Relekar et al. [23] in sapota squash and Sharma et al. [21] in *Aloe vera*-aonla blended functional squash.

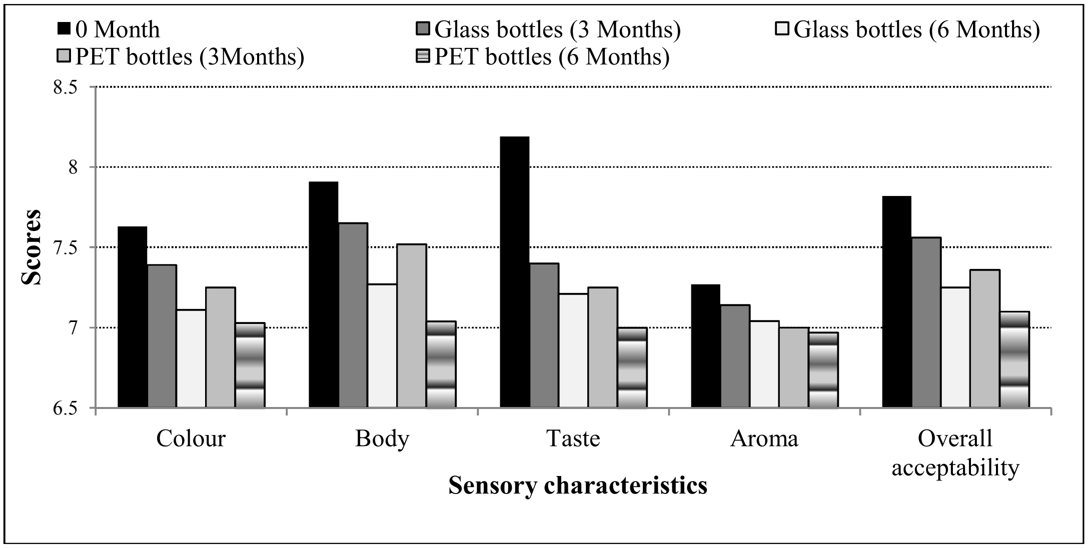


Fig. 3. Effect of storage and packaging on sensory characteristics of wild jamun syrup stored under ambient conditions

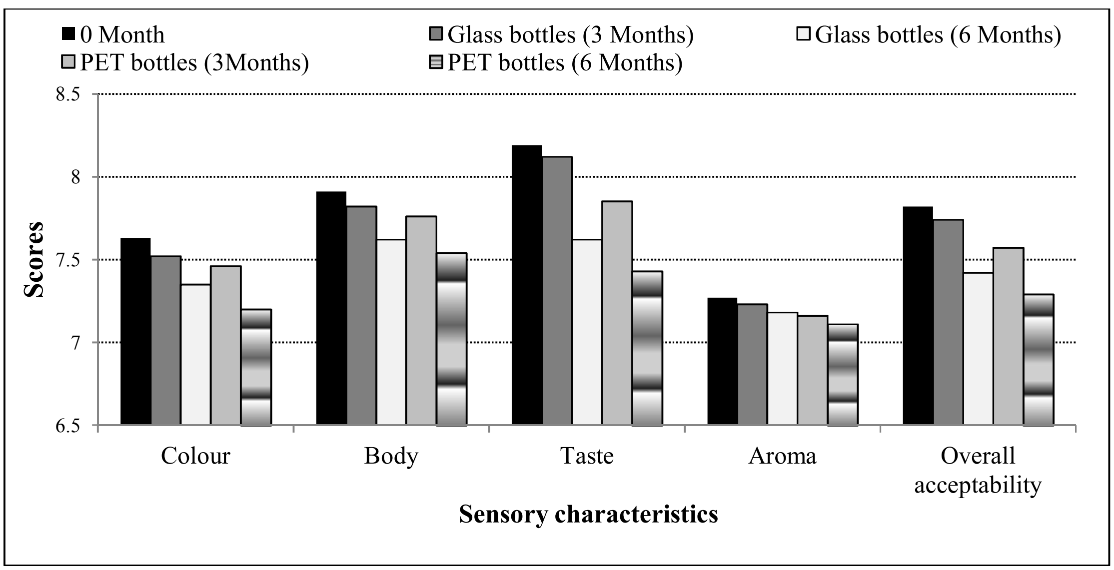


Fig. 4. Effect of storage and packaging on sensory characteristics of wild jamun syrup stored under refrigerated conditions

4. CONCLUSION

Out of 8 different treatment combinations of wild jamun squash recipe (T_3) containing 35% juice, 40 °B TSS and 1.20% acid was found to be best on the basis of its physico-chemical characteristics and sensory parameters. The product could be stored safely for a period of 6 months under both storage conditions and in both packaging materials. The best quality of this beverage could be maintained in glass bottle stored under refrigerated storage conditions as compared to PET bottle.

ACKNOWLEDGEMENTS

The authors are thankful to Dr. YS Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh 173230, for providing support for the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist

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Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/59757