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RESEARCH PAPER

Development of Jelly from Mulberry (*Morus alba* L.) and its Quality Evaluation during Storage

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ABSTRACT

Mulberry (*Morus alba* L.) is one of the underutilized fruit which is a rich source of antioxidants like phenols, besides its appealing taste and strong aroma. Investigations were conducted to develop jelly and its quality evaluation during storage is reported here. Different combinations of juice (40, 45, 50 and 55 %) and sugar (45 and 50 %) were tried to standardize proper combination for jelly. The jelly prepared by following the best selected recipe was packed in glass and PET jars and stored for six months under ambient and refrigerated temperature conditions. Jelly could be safely stored for a period of six months under both the conditions without much change in various quality characteristics. Different quality characteristics like TSS (°B), reducing sugars (%), total sugars (%) and pH of jelly increased from 66.00 to 66.56, 48.21 to 51.42, 63.08 to 63.46, 3.56 to 3.62 while other chemical characteristics like titratable acidity (%), ascorbic acid (mg/100 g), anthocyanins (mg/100 g), total phenols (mg/100 g), pectin (%) decreased from 0.75 to 0.67, 5.83 to 4.11, 9.00 to 6.71, 72.18 to 69.13, 1.06 to 0.88 and sensory characteristics scores of colour, texture, taste, aroma, overall acceptability score from 7.50 to 7.02, 7.83 to 7.27, 8.19 to 7.92, 8.00 to 7.55, 7.90 to 7.40, respectively during refrigerated storage. However the changes in the quality characteristics of jelly were slower in refrigerated storage conditions as compared to ambient conditions during six months of storage period the quality of the product was retained better in glass jars than PET jars under refrigerated storage condition.

Keywords: Mulberry, *Morus alba*, jelly, polyethylene terephthalate, storage, quality

Mulberry belongs to genera *Morus* in family moraceae. This genus is widely distributed in Asia, Africa, Europe, South and North America and also widely found in hilly areas of Himalayas upto 3300 m elevation (Zafar *et al*., 2013). Among various *Morus* species, *Morus alba* L. has been cultivated widely in Asia especially in China, Japan and India for rearing silkworms besides table fruit purpose. In India, *Morus alba* is widely distributed in Jammu and Kashmir, UP, Karnataka, Tamilnadu, West Bengal, Kerala and to a lesser extent in Himachal Pradesh. Mulberry (*Morus alba* L.) - a wild fruit is known as *shahtut*, *chinni* and *tut* in Himachal Pradesh (HP). Fruits of this species are long, ovoid or cylindrical, which are variable in colour like white, pink or purple to black. The fruit of *Morus alba* is a rich source of anti-oxidants (Butkhup *et al.,* 2013). Besides it has high nutritional value as well as for traditional medicine. Its fruits contain vitamins, polyphenols, carbohydrates, fibre, minerals, riboflavin, ascorbic acid, nicotinic acid and essential fatty acids (Zafar *et al*., 2013; Kumar and Chauhan, 2011). Mulberry juice is full of antiaging properties and enriches the blood, protecting liver from damage, calms the nerves, balances internal secretions and enhances immunity (Yadav *et al*., 2014). Scattered information is available on the processing of this fruit. So, being a rich source of antioxidants especially phenols, the present studies were undertaken with the objective to develop jelly from this underutilized fruit and to study the quality changes during storage.

MATERIALS AND METHODS

Fruit and juice extraction: The mature fruits of *Morus alba* were procured from Bela area of Hamirpur district of Himachal Pradesh (India) in the month of April. The juice from the mulberry fruits was extracted by using hydraulic press machine.

Preparation of jelly: Jelly was prepared by mixing and cooking known quantity of mulberry juice with sugar powder of different combinations (as per standard procedure mentioned by Islam *et al*., 2012) as given in Table 1. Constant quantity of pectin (1 %) and citric acid (0.75 %) were added to this mixture during cooking. The mixture was cooked with constant stirring to a desirable consistency until the TSS of product reached near 65 ^{o}B. The synthetic colour carmosine at the rate of 0.0020 per cent was added in the all treatment combinations during preparation and sodium benzoate (200 ppm) was also added to all the treatments near the end point of product preparation. The jelly prepared by following the best selected recipe was packed in pre-sterilised glass and PET jars (200 g capacity). All the jars were properly labelled and stored under ambient (20-25 ^{o}C) and low temperature (4-7 ^{o}C) conditions in a refrigerator for six months. The physico-chemical and sensory characteristics of jelly was estimated at zero, three and six months of storage.

Physico-chemical analysis: The colour of jelly was observed visually by comparing with the colour cards of Royal Horticulture Society, London and the card numbers have been mentioned along with the colour. Total soluble solids (TSS), reducing sugars, titratable acidity, pectin and anthocyanins of jelly were determined according to Ranganna (1997) and AOAC (1984). Total phenols content was estimated by Folin-Ciocalteu procedure given by Singleton and Rossi (1965).

Fruit

↓

Washing

↓

Extraction of juice

↓

Mixing of sugar + juice and then heating followed by addition of pectin

(Different combinations 40, 45, 50 and 55 % juice + 45 and 50 % sugar)

↓

+Sodium benzoate (200 ppm) Boiling with continuous stirring till end point reached

↓

Filling in jars

↓

Capping

↓

Labelling

↓

Storage

Fig. 1: Unit operations for the preparation of mulberry jelly

Table 1: Treatment detail of jelly

Treatment	J_1	J_2	J_3	J_4	J_5	J_6	J_7	J_8
Juice (%)	40	45	50	55	40	45	50	55
Sugar (%)	45	45	45	45	50	50	50	50

Sensory evaluation: Nine point hedonic rating test (Amerine *et al*., 1965) was followed for conducting the sensory evaluation of mulberry jelly. The panel of ten judges were selected to evaluate the product for sensory parameters such as colour, texture, taste, aroma and overall acceptability. Coded samples were given to the judges along with performa. They rinsed their mouth with water in between the sample evaluation. Efforts were made to keep the same panel for sensory evaluation throughout the entire period of study.

Statistical analysis: Data on physico-chemical characteristics of jelly were analysed by Completely Randomized Design (CRD) before and during storage, whereas, data pertaining to the sensory the evaluation were analyzed by using Randomized Block Design (RBD) as described by Mahony (1985). The experiments on recipe standardization and for storage studies were replicated three times.

RESULTS AND DISCUSSION

Standardization of recipe for the preparation of mulberry jelly

Physico-chemical and Sensory characteristics: Data pertaining to physico-chemical characteristics of different recipes of mulberry jelly presented in Table 2 indicate that the visual colour of all the recipes was Red group 53 (A) and TSS of all the products was 66 ^{o}B in all the recipes. Increase in juice content in different recipes led to a significant effect on physico-chemical characteristics of mulberry jelly recipes. Data in Table 2 show that recipe J_1 (40 % juice + 45 % sugar) and J_5 (40 % juice + 50 % sugar) had lower amount of anthocyanins, total phenols and ascorbic acid, which might be due to lower amount of juice used as compared to other recipes like J_4 (55 % juice + 45 % sugar) and J_8 (55 % juice + 50 % sugar), where higher content of anthocyanins, total phenols and ascorbic acid were observed, because of higher amount of juice used in these recipes.

Data on sensory characteristics of different recipes of mulberry jelly given in Table 3, indicate that the mean colour, texture, taste, aroma and overall acceptability scores were awarded the highest to the product J_3 compared to other treatments. It was concluded that the recipe with 50 per cent juice and 45 per cent sugar (J_3) was the best on the basis of sensory characteristics and some physico-chemical characteristics of jelly. The results clearly show that there was a significant effect of juice-acid-sugar-pectin blend on sensory scores of different recipes of mulberry jelly.

Storage of mulberry jelly

Physico-chemical characteristics

The colour of mulberry jelly as per Royal Horticultural Society Cards was retained as such [Red group 53 (A)] during six months of storage under refrigerated and ambient storage conditions. The TSS of jelly increased slightly during storage (Fig. 2a) and the increase in TSS during storage might be due to hydrolysis of polysaccharides into monosaccharide and soluble disaccharides. No much changes in TSS

Table 2: Physico-chemical characteristics of different recipes of mulberry jelly

Treatments	Chemical characteristics		
	Anthocyanins (mg/100 g)	Total phenols (mg/100 g)	Ascorbic acid (mg/100 g)
J_1	8.29	58.96	4.95
J_2	8.75	66.20	5.35
J_3	9.00	72.18	5.83
J_4	9.32	76.53	6.08
J_5	8.30	58.92	4.97
J_6	8.75	66.20	5.32
J_7	9.08	72.18	5.80
J_8	9.34	76.58	6.10
$CD_{0.05}$	0.03	0.09	0.07

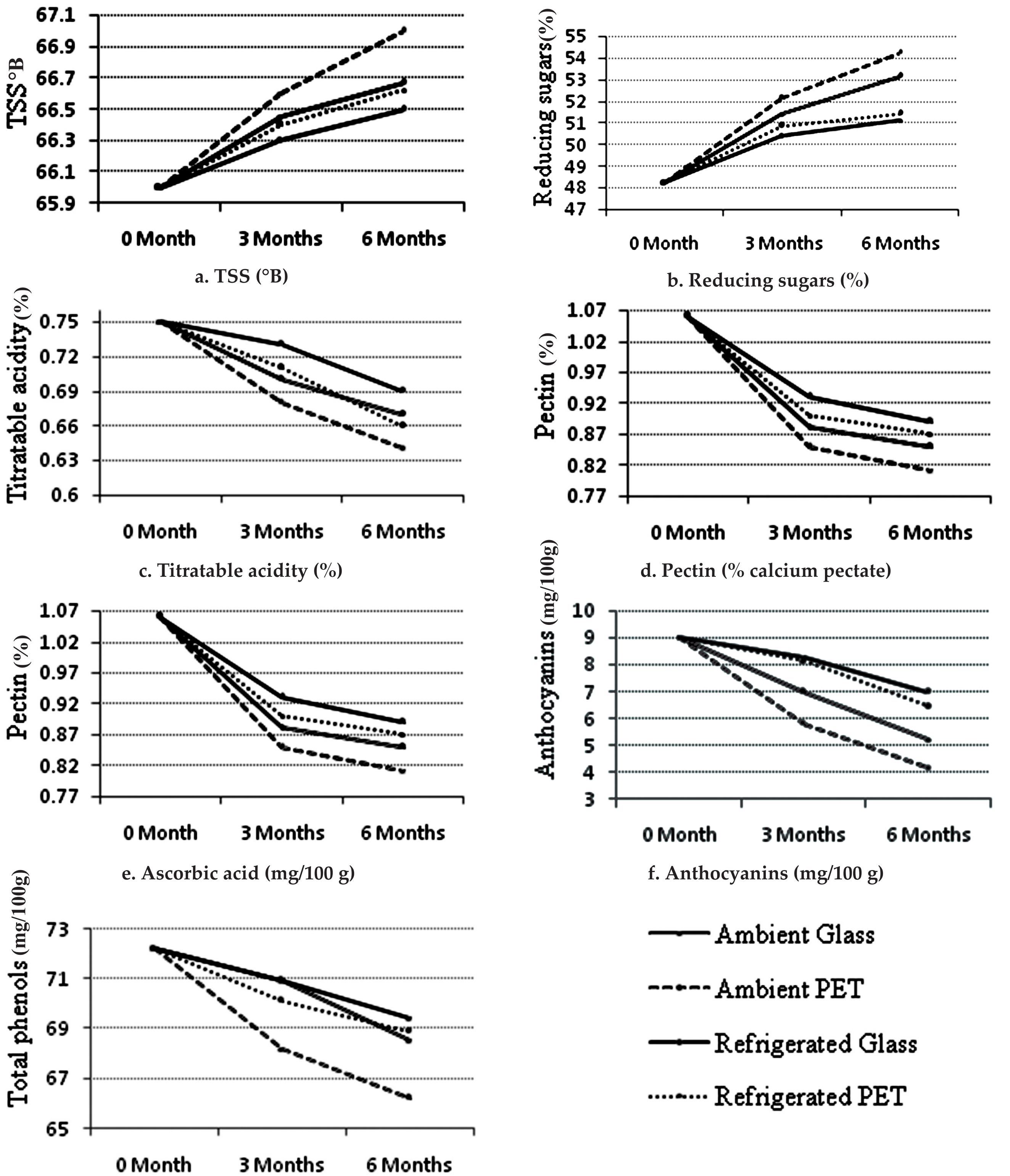
Table 3: Sensory characteristics (score) of different recipes of mulberry jelly

Treatment	Colour	Texture	Taste	Aroma	Overall acceptability
J_1	7.00	6.80	7.53	7.24	7.15
J_2	7.24	7.10	7.87	7.60	7.46
J_3	7.50	7.83	8.19	8.00	7.90
J_4	7.50	7.66	7.90	7.92	7.75
J_5	7.15	6.75	7.40	7.20	7.10
J_6	7.30	7.10	7.75	7.54	7.42
J_7	7.46	7.69	7.91	7.84	7.72
J_8	7.53	7.40	7.50	7.90	7.58
$CD_{0.05}$	0.26	0.20	0.25	0.23	0.30

have also been observed during storage earlier by Hossen *et al.* (2009) in guava jelly and Releker *et al*. (2011) in sapota jelly. The reducing sugars of jelly (Fig. 2b) showed a significant increase during storage which was comparatively slower in refrigerated storage conditions than in ambient and this slower increase might be due to the slower rate of reactions because of lower temperature in refrigerated conditions. This increase might be due to hydrolysis of starch into sugars as well as conversion of complex polysaccharides into simple sugars. The overall effect of packaging materials on reducing sugars indicates that less increase was found in reducing sugars of jelly in glass jars than PET jars during storage. Similar increase in reducing sugars during storage has been reported by Udin and Haque (1996) in papaya jelly, Sundaram *et al*. (2007) in seabuckthorn mixed fruit jelly and Releker *et al*. (2011) in sapota jelly.

The jelly showed a slight decrease in titratable acidity during storage (Fig. 2c) which was comparatively higher under ambient conditions as compared to the refrigerated conditions due to the faster rate of reactions as a result of high temperature in ambient conditions. The decrease in titratable acidity might be due to co-polymerization of organic acids with sugars and amino acids. Similar results were recorded by Singh *et al*. (1985) in guava jelly and Relekar *et al*. (2011) in sapota jelly. There was a decrease in pectin content of jelly during storage (Fig. 2d) and possible reason for slight decrease in pectin content of mulberry jelly may be hydrolysis of pectin into simple compounds. Both the storage conditions and packaging materials retained the pectin content at par as there was no significant difference among them. Our results are similar to the findings of Singh *et al*. (1985) in guava jelly and Assis *et al*. (2007) in cashew apple jelly. Ascorbic acid content of jelly decreased significantly during storage; however, the decrease was lower in refrigerated storage conditions than ambient conditions (Fig. 2e). Decrease in ascorbic acid content might be due to its degradation into dehydro-ascorbic acid or furfural during storage. Less decrease of ascorbic acid in refrigerated storage might be due to the slower rate of its degradation in low temperature as compared to ambient storage conditions because of its susceptibility to high temperature. The overall effect of storage conditions as well as packaging materials on ascorbic acid content of jelly was found to be significant.

Retention of higher ascorbic acid of jelly in glass jar may be due to the slower rate of reactions in glass jar as glass absorbs heat at slower rate as compared to PET jar during storage. The findings of the present studies are in agreement with the results reported by Singh *et al*. (1985) in guava jelly, Sundaram *et al*. (2007) in seabuckthorn mixed fruit jelly and Singh and Chandra (2012) in guava-carrot jelly. A significant decrease in anthocyanins content of jelly was recorded during the storage (Fig. 2f) and lower loss of anthocyanins was observed under refrigerated storage conditions than ambient. Loss of anthocyanins in jelly might be due to their high susceptibility to auto-oxidative degradation during storage. More retention of this attribute in the product in refrigerated conditions



a. TSS (°B)

b. Reducing sugars (%)

c. Titratable acidity (%)

d. Pectin (% calcium pectate)

e. Ascorbic acid (mg/100 g)

f. Anthocyanins (mg/100 g)

g. Total phenols (mg/100 g)

Fig. 2: Effect of storage on physico-chemical characteristics of mulberry jelly

as compared to ambient might be due to the slower rate of auto oxidation of anthocyanins in refrigerated conditions. The overall effect of storage conditions and storage period as well as packaging materials on ascorbic acid content of jelly found to be significant. Retention of higher anthocyanins in glass jar may be due to the slower rate of reactions in glass jar as glass absorbs heat at slower rate as compared to PET jar during storage. Similar findings were recorded by Maestre *et al.* (2000) in pomegranate jelly and Selvamuthukumaran *et al.* (2007) in seabuckthorn-grape jelly.

A significant decrease in total phenols content of jelly was recorded during storage (Fig. 2g) and decrease was lower under refrigerated storage conditions than ambient. The decrease in total phenols in jelly during storage might be due to their involvement in the formation of polymeric compounds by complexing with protein and their subsequent precipitation as observed by Abers and Wrolstad (1979). As far as packaging material is concerned, more retention of phenols in jelly packed in glass jar than PET jar might be due to the difference in their thermal conductance properties which affected internal reactions. Similar trend of decrease in phenols has been reported by Sundaram *et al.* (2007) in seabuckthorn mixed fruit jelly, Selvamuthukumaran *et al.* (2007) in seabuckthorn-grape jelly and Assis *et al*. (2007) in cashew apple jelly.

Sensory characteristics of mulberry jelly during storage

The colour scores of jelly decreased significantly during storage (Fig. 3 & 4) and this decrease was more pronounced under ambient storage conditions than refrigerated. Decrease in colour scores of jelly during storage might be due to the degradation of anthocyanins pigment which affected the visual colour of the product. Non-enzymatic browning of the product might have also contributed towards the loss of intensity of colour indirectly. Retention of higher colour scores of jelly in refrigerated storage conditions might be due to the slower rate of degradation of anthocyanins as well as slower rate of non-enzymatic browning of the product as compared to ambient storage conditions. Both the packaging materials retained the colour score of jelly at par as there was no significant difference among them. Similar results have been reported by Selvamuthukumaran *et al.* (2007) in seabuckthorn-grape jelly, Relekar *et al*. (2011) in sapota jelly and Singh and Chandra (2012) in guava-carrot jelly. There was a decrease in texture scores of jelly with the advancement of storage period (Fig. 3 & 4). The possible reason for decrease in texture scores might be due to the degradation of original texture/shape as a result of hydrolysis of pectin during storage. However, decrease in texture scores was significantly lower under refrigerated storage conditions than ambient. The overall effect of packaging material on texture score of the product was found to be significant and shows that it was retained more in glass jar as compared to PET jar during storage, which might be due to difference in their thermal conductance properties which affected internal decomposition reactions. Our results of texture scores are in conformity with the findings of Yousuf and Alghamdi (1999) in date jelly, Sundaram *et al.* (2007) in seabuckthorn mixed fruit jelly and Relekar *et al*. (2011) in sapota jelly. Taste score of jelly decreased with advancement of storage (Fig. 3 & 4) and their decrease was found less in refrigerated conditions as compared to ambient conditions. The decrease in taste scores of product during storage might be due to loss of sugar-acid blend responsible for taste. Both the packaging materials retained the taste score of jelly at par as there was no significant difference among them. Our results are in conformity with the finding of Selvamuthukumaran *et al.* (2007) in seabuckthorn-grape jelly, Relekar *et al*. (2011) in sapota jelly, Singh and Chandra (2012) in guava-carrot jelly. Retention of higher taste scores in refrigerated conditions might be due to the better retention of original sugar-acid blend as a result of slower reaction rate at low temperature.

The aroma scores of jelly decreased during storage (Fig. 3 & 4). However, the jelly stored in refrigerated storage conditions was significantly better in aroma

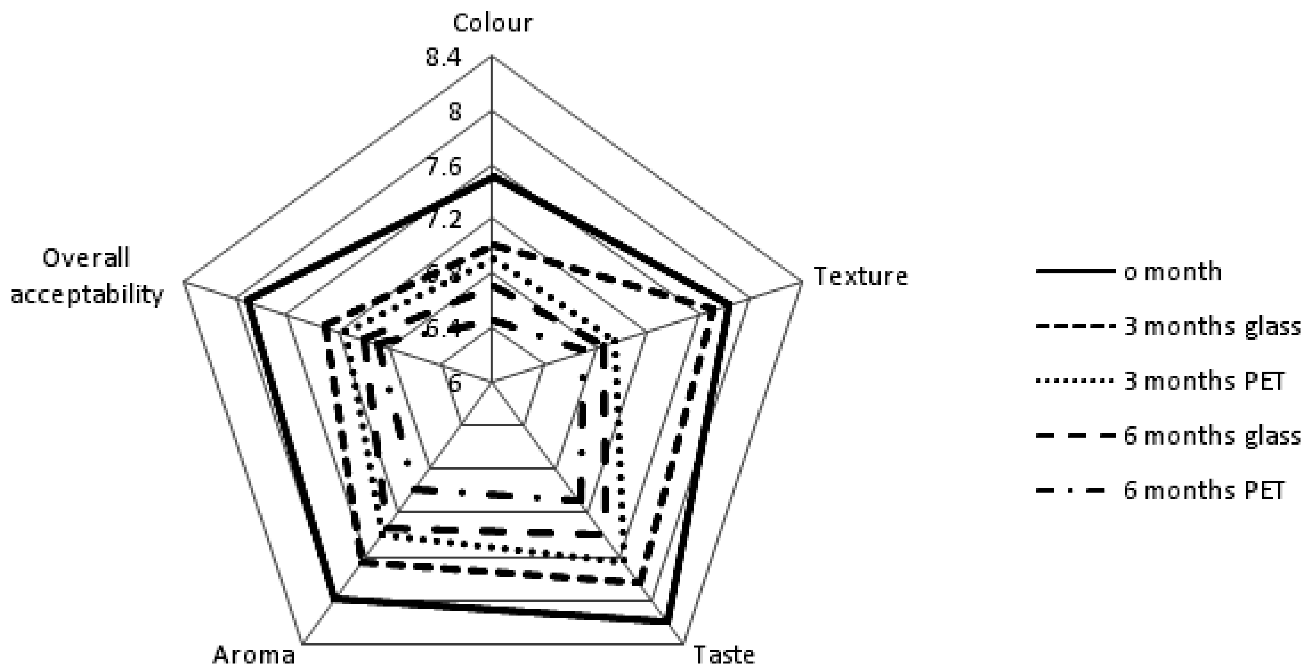


Fig. 3: Effect of storage and packaging on sensory characteristics of mulberry jelly stored under ambient conditions

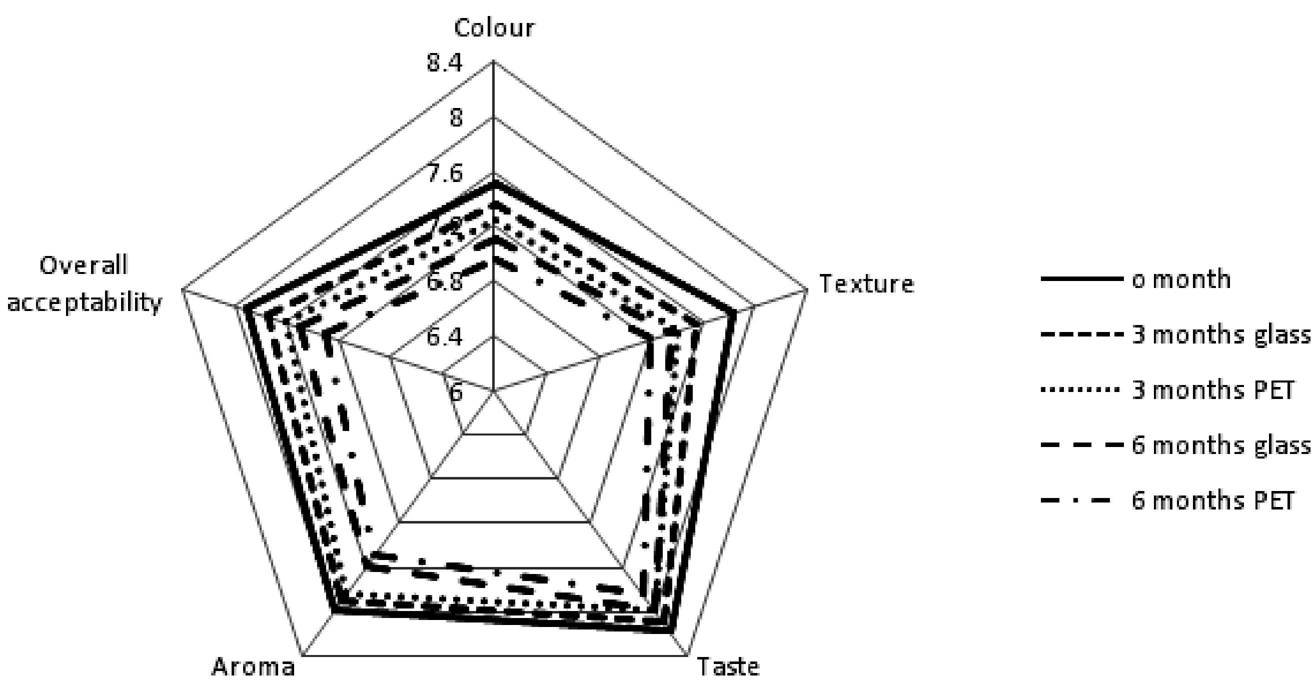


Fig. 4: Effect of storage and packaging on sensory characteristics of mulberry jelly stored under refrigerated conditions

scores than ambient conditions. The loss of aroma scores during storage might be due to the possible loss of volatile aromatic compounds which led the judges to award the lower scores. The aroma score of jelly packed in glass jar was retained better than PET jar during storage. Better aroma scores retained in glass jar as compared to PET might be due to the slower rate of loss of aromatic compounds of jelly in glass because it absorbs heat at slower rate than PET during storage. These results are in conformity with the findings of Selvamuthukumaran *et al.* (2007) in seabuckthorn-grape jelly.

The overall acceptability scores of jelly decreased during storage (Fig. 3 & 4) which were observed higher in ambient storage conditions than refrigerated conditions. Jelly packed in glass jar retained more overall acceptability scores than PET jar. Decrease in overall acceptability scores might be due to cumulative loss in appearance, texture and flavour of the product during storage. The findings of these studies are in agreement with the investigations reported by Selvamuthukumaran *et al.* (2007) in seabuckthorn-grape jelly, Relekar *et al*. (2011) in sapota jelly and Islam *et al.* (2012) in dragon fruit jelly. Retention of higher overall acceptability scores in refrigerated conditions might be the result of better retention of appearance, texture and flavour of the product as a result of slower reactions rates at low temperature. However, the retention of better overall acceptability scores of jelly in glass jar might be due to the better retention of above given factors as a result of slower reaction rate in glass jar as compared to PET jar.

So on the basis of above results it was found that per cent increase in various quality characteristics like TSS, reducing sugars and pH of jelly during ambient storage were 1.25 %, 11.36 %, 2.80 %, whereas in refrigerated storage conditions the increase in same parameters were observed as 0.84 %, 6.65 % and 1.68, respectively. However, per cent decrease in various other quality characteristics like titratable acidity, ascorbic acid, anthocyanins, total phenols, pectin were 13.33 %, 53.00 %, 48.00 %, 6.69 %, 21.69 % of jelly during ambient storage conditions took place, while in refrigerated storage conditions the decrease in same parameters were observed as 10.66 %, 29.50 %, 25.44 %, 4.22 % and 16.98 %, respectively. The per cent decrease in sensory characteristics scores of colour, texture, taste, aroma, overall acceptability score were 12.4 %, 13.53 %, 11.47 %, 10.37 %, 12.02% respectively, however in refrigerated storage conditions the decrease in same parameters were observed as 6.40 %, 7.15 %, 3.29%, 5.62 % and 6.32 %, respectively. In brief, the study clearly show that jelly could be stored safely for a period of six months under both ambient and refrigerated storage conditions and also in both packaging materials like PET and glass jars without much undesirable changes in physico-chemical and sensory characteristics. As changes in quality characteristics of jelly were slower in refrigerated storage conditions as compared to ambient conditions during six months of storage period, so best quality of jelly could be maintained in glass jars stored under refrigerated storage conditions as compared to PET jars.

CONCLUSION

On the basis of various quality parameters, jelly with 50 per cent juice and 45 per cent sugar (J_3) was found to be the best. The jelly could be stored safely for a period of six months under both the ambient and refrigerated storage conditions and also in both packaging materials like PET and glass jars. However, due to fewer changes in mulberry jelly packed in glass jars and PET jars and stored under refrigerated storage conditions, the quality of the jelly was maintained better than product packed in same packaging material under ambient storage conditions which should be preferred.

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