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Physico-chemical characteristics of noni fruit juice blended squashes during storage

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Abstract

Noni fruit (*Morinda Citrifolia* Linn.), which have highest value of the medicinal purpose but it has strong pungent flavour, acrid taste and turbid nature. Based on these characteristic nature, the present study was aimed to develop noni fruit juice blended squash with sensory acceptability and shelf stability. The extracted noni juice was utilized for the preparation fruit juice blended squashes with 0 to 25 percent of amla, sathukudi and grape juice distinctly and the best combination was found. The standardized noni fruit juice blended with amla squash (80:20) was prepared, packed in PET bottles and stored at room and refrigerated condition. The stored squashes were analyzed to find out the changes in physico-chemical characteristics during storage of six months. Results showed that an increasing trend in acidity, reducing sugar and non-enzymatic browning whereas a decreasing trend in pH, total sugar, ascorbic acid, tannin, total antioxidant activity and colour values, which were predominantly low in refrigeration condition during storage. Squashes retained maximum level of ascorbic acid total antioxidant activity in room and refrigerated conditions at the end of storage.

Keywords: Noni, blended squash, physico-chemical characteristics, shelf life

Introduction

Noni known as “Indian mulberry” (*Morinda citrifolia* Linn.) is an evergreen shrub or small tree that grows 10 to 20 feet height and it belongs to family, Rubiaceae [1]. In India noni was totally produced by 342 cultivators in the area of 653 acre. The area of the production of noni fruits in Andaman and Nicobar Islands was high (192 acre) followed by Maharashtra (166 acre) and Tamil Nadu were the lowest producers of noni fruits (5 acre) with one cultivator [2]. According to traditional treatment and recent researches reported, the noni plant has a broad range of therapeutic effects, including antibacterial, antiviral, antifungal, antitumour, anthelmintic, analgesic, hypotensive, anti-inflammatory and immune enhancing effect [3].

The noni fruit is a multiple fruit that has a pungent odour when ripening, and hence also known as cheese fruit or even vomit fruit. Despite its strong smell and bitter taste, the fruit is nevertheless eaten as a famine food [4]. It is due to the presence of high concentration of major volatile compounds octanoic, hexanic acid and 3-methyl-3buten-1-ol [5]. Hence, it is a challenging task to prepare food products from noni juice with sensory acceptability. Due to these reasons, blending of two or more fruit juices and their beverages with the addition of noni juice are thought to be a convenient alternative for its utilization in order to have value added fruit drinks which are of high quality in respect of both sensory and nutritional aspects. In the present study squash was prepared with blending of noni juice with other fruit juices to reduce the unpleasant flavour and further improve the nutritional characteristics of the developed blended product were also evaluated.

Methodology

Raw materials

Fully mature, noni fruit (*Morinda citrifolia* L.) was purchased from Horticultural College and Research Institute, Periyakulam, Tamil Nadu, India and brought to the working spot in a well cushioned container. Fully mature ripe grape (*Vitis vinefera*), amla (*Embllica officinalis*) and sathukudi (*Citrus limetta*) were purchased from the local market in Madurai city, Tamil Nadu, India and were used on the same day.

Extraction of juice from fruits

The noni juice was extracted from noni fruits kept for 24 hours at frozen condition followed by

thawing, crushing manually and filtering the juice through nylon net. The washed amla fruit was cut into small pieces and the seed was removed. Then it was crushed in the mixer and the pulp was filtered through a sterilized nylon net. The sathukudi fruits were washed under running tap water and surface dried. The fruit was cut into two halves with a knife and the juice was pressed out from the halves by means of small stainless steel squeezer. The squeezed juice was filtered through the sterilized nylon net. The individual grape berry was separated from bunches, washed in running tap water and surface dried, crushed by making use of mixer and filtered through a sterilized nylon net.

Preparation of noni fruit juice blended squashes

The noni juice squash (NO) and other noni fruit juice blended squashes were prepared by using in the combination of noni juice, amla juice, sathukudi juice and grape juice (0 to 25% respectively) is given in Table 1.

Each fruit blended noni squash was prepared by adding the selected fruit juices with noni juice at different levels and the squash was prepared as per FSSAI (2006) specification *viz.*, juice content-25.0 per cent, TSS-45°brix, acidity- 1.0 per cent

and preservative-350ppm of SO₂ for noni juice with amla (NA) and noni juice with sathukudi (NS) whereas 600ppm of benzoic acid for noni juice with grape fruit (NG).

Sugar syrup was prepared by heating the required amount of sugar, water and citric acid. It was filtered and allowed to cool at room temperature. Then the required amount of blended fruit juice was added to the syrup and mixed thoroughly. Salt was added at the level of 0.1 per cent to the prepared squash to reduce the astringent taste and to increase the flavour of the squash. The required amount of preservative was mixed in a small quantity of fruit juice and added to the prepared squash and mixed well. A control noni juice squash was prepared by following the above steps without the addition of any fruit juice. The prepared squash was poured in a sterilized PET (polyethylene terephthalate) bottles (capacity 680 ml), capped leaving a headspace of 1", labeled and kept for further analysis. The organoleptically rated best blended squash was chosen for further storage studies and kept under room (32±2°C) and refrigeration conditions (4±1°C) for a period of six months to evaluate its shelf stability. A control (NO) noni juice squash was prepared by following the above steps without the addition of any fruit juice.

Table 1: Proportion of fruit juices used for the preparation of noni fruit juice blended squash

Squashes	Fruit juice	Combinations (ml)					
		I	II	III	IV	V	VI
Control (NO)	Noni juice	100	-	-	-	-	-
Noni fruit juice blended with amla juice (NA)	Noni juice	100	95	90	85	80	75
	Amla juice	-	5	10	15	20	25
Noni fruit juice blended with sathukudi juice (NS)	Noni juice(ml)	100	95	90	85	80	75
	Sathukudi juice (ml)	-	5	10	15	20	25
Noni fruit juice blended with grape juice (NG)	Noni juice (ml)	100	95	90	85	80	75
	Grape juice (ml)	-	5	10	15	20	25

Physico-chemical analysis

The proximate compositions of noni fruit juice blended squashes were done for different parameters. Hand refractometer (Erma, Tokyo, Japan) ranged from 0 to 45° brix was used to measure the total soluble solids. Total acidity was determined as per the method described by [6]. The pH of the sample was estimated by the method described by [7]. Shaffer Somogyi micro method was followed for the estimation of reducing sugar and total sugar content [8]. The 2, 6-dichlorophenol-indophenol titration method was used for the estimation of ascorbic acid content [6]. The tannin content was determined using on ultra violet-visible recording spectrophotometer at 700nm (Systronics - Model 2201, India) as per the standard method described by [9]. The non enzymatic browning was measured as per the standard procedure described by [6], spectrophotometrically at 440nm. The total antioxidant activity was estimated by the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) assay, spectrophotometrically according to method described by [10]. The colour L* value of the samples were estimated by using a Hunter Laboratory chromometer (Model - Lovibond RT 100) with the Lovibond RT Colour software (Version 3.0). The colour value results was expressed as recommended by the International Commission on Illumination in 1976.

Organoleptic evaluation

Organoleptic evaluation of the prepared squashes was done by a panel of twenty untrained judges using a score card with a

nine point hedonic scale. The product was diluted with water at the ratio of 1:3 and converted into ready-to-serve form before conducting evaluation. The judges were asked to evaluate for colour and appearance, flavour, body, taste and overall acceptability. The acceptability of beverages was assessed at initial day and final day of six months [11].

Statistical analysis

All the experiments were conducted in triplicate and the mean and standard deviation (±SD) were calculated using MS Excel software. Differences are estimated by the ANOVA and it were considered to be significant at $p < 0.05$.

Results and discussion

Sensory evaluation of noni fruit juice blended squashes

The sensory score of the freshly prepared noni fruit juice blended squashes are given in Table 2. The optimum proportion of the fruit juices in preparing blended squashes from the mean score of the organoleptic assessment showed that noni fruit juice blended with amla squash made from 80% noni juice + 20% amla juice, noni fruit juice blended with sathukudi squash made from 80% noni juice + 20% sathukudi juice and noni fruit juice blended with grape squash made from 85% noni juice + 15% grape juice had the highest organoleptic values. Among all the squashes prepared noni juice blended with amla juice (80% noni juice + 20% amla juice) was selected for storage studies since it has maximum score compared to sathukudi and grape fruits.

Table 2: Sensory scores of different noni fruit juice blended squashes

Squashes	Combination	Sensory characteristics					
		Colour	Flavour	Body	Taste	Overall acceptability	CD at 5%
Control	100%N	7.6±0.17	7.0±0.10	7.0±0.12	6.4±0.19	7.0±0.09	0.0824**
Noni fruit juice blended with amla juice	95%N+5%A	8.1±0.04	8.1±0.02	7.4±0.01	7.1±0.11	7.7±0.15	0.0217**
	90%N+10%A	8.4±0.14	8.1±0.09	7.6±0.09	7.9±0.26	8.0±0.20	0.0154**
	85%N+15%A	8.5±0.14	8.2±0.20	7.8±0.26	7.7±0.13	8.0±0.26	0.0109*
	80%N+20%A	8.6±0.01	8.7±0.17	8.3±0.04	8.3±0.05	8.5±0.05	0.0116**
	75%N+25%A	7.8±0.12	7.3±0.16	6.7±0.13	6.2±0.16	7.0±0.10	0.0164*
Noni fruit juice blended with sathukudi juice	95%N+5%S	8.2±0.10	6.6±0.06	6.6±0.17	6.0±0.10	6.9±0.22	0.0308 ^{NS}
	90%N+10%S	8.3±0.14	6.9±0.06	6.7±0.19	6.3±0.05	7.0±0.02	0.0217 ^{NS}
	85%N+15%S	8.3±0.23	6.5±0.07	7.2±0.03	6.8±0.20	7.2±0.12	0.1109**
	80%N+20%S	8.5±0.02	7.4±0.24	7.6±0.16	7.3±0.16	7.7±0.24	0.0554**
	75%N+25%S	8.4±0.22	6.8±0.18	6.9±0.14	6.5±0.11	7.1±0.03	0.0781**
Noni fruit juice blended with grape juice	95%N+5%G	8.4±0.12	8.4±0.02	7.7±0.00	7.3±0.21	7.9±0.05	0.0419*
	90%N+10%G	8.4±0.02	8.3±0.04	8.1±0.06	7.7±0.05	8.1±0.21	0.0392*
	85%N+15%G	8.4±0.18	8.4±0.21	7.9±0.13	8.0±0.17	8.2±0.26	0.0209**
	80%N+20%G	7.8±0.04	7.6±0.12	7.3±0.18	7.9±0.19	7.7±0.03	0.0296**
	75%N+25%G	7.1±0.26	7.3±0.15	7.2±0.04	7.4±0.00	7.2±0.20	0.2965**

N – Noni juice, A – Amla juice, S – Sathukudi juice, G – Grape juice

NS – non significant, * - significant, ** - highly significant

Physico-chemical characteristics of the standardized noni fruit juice blended squashes

Table - 3 illustrated the physico-chemical analysis of the freshly prepared noni fruit juice blended squashes. The TSS content of the prepared squashes ranged between 45.0 (NO) and 45.8°brix (NG). The acidity content of all the prepared squashes was found to be more or less similar and ranged between 1.00 and 1.02 per cent. The pH varied from 2.70 to 2.76. Among the squashes noni juice blended with grape juice recorded higher reducing sugar content (5.28g/100ml) whereas control had least (4.88g/100ml). The total sugar content of NO, NA, NS and NG were 32.56, 33.46, 33.52 and

34.16 per cent respectively. The ascorbic acid content of NA showed higher values (64.10 mg/100ml) followed by NS (56.08 mg/100ml), NG (44.15 mg/100ml) and NO (36.00 mg/100ml). The maximum tannin content was observed in NA on 0.650 per cent tannic acid and least in NO on 0.175 per cent tannic acid. The squash, NG contained slightly higher non enzymatic browning i.e. 0.190 absorbance followed by NA, NO and NS. The total antioxidant activity was higher in NA (161.80 mg TE/100ml) and low in NS (114.40 mg TE/100ml). The highest colour L^* value was observed in NS followed by NA, NO and NG.

Table 3: Physico-chemical characteristics of the standardized noni fruit juice blended squashes

Nutrients	Noni fruit juice blended squashes				CD at 5%
	NO	NA	NS	NG	
TSS (°brix)	45.0±0.29	45.0±0.95	45.4±1.42	45.8±0.93	0.2696 ^{NS}
Acidity (%)	1.00±0.01	1.02±0.01	1.01±0.03	1.01±0.01	0.0567 ^{NS}
pH	2.76±0.06	2.70±0.02	2.73±0.08	2.73±0.08	0.0813*
Reducing sugar (g)	4.88±0.07	5.03±0.06	5.12±0.03	5.28±0.16	0.1134**
Total sugar (g)	32.56±0.31	33.46±0.61	33.52±1.00	34.16±0.44	0.0657*
Ascorbic acid (mg)	36.00±0.19	64.10±1.57	56.08±0.65	44.15±1.14	0.0703**
Tannin (% Tannic acid)	0.175±0.00	0.650±0.01	0.325±0.01	0.475±0.01	0.1315**
Non enzymatic browning (absorbance)	0.175±0.06	0.177±0.08	0.168±0.14	0.190±0.18	0.0929**
Total antioxidant activity (mg TE)	123.50±1.67	161.80±1.10	114.40±0.86	120.70±0.16	0.1859**
Colour (L^* value)	62.47±0.48	63.40±0.17	67.11±0.09	56.71±1.20	0.2630*

NO - 100% Noni juice, NA - 80% Noni juice + 20% Amla juice,

NS - 80% Noni juice + 20% Sathukudi juice, NG - 85% Noni juice + 15% Grape juice

NS – non significant, * - significant, ** - highly significant

Among all the prepared squashes noni juice blended with amla juice squash (NA) contained higher levels of organoleptic characteristics and various nutrients with special reference to vitamin C and antioxidant activity.

Storage of the noni fruit juice blended with amla squash (80:20)

Total soluble solids

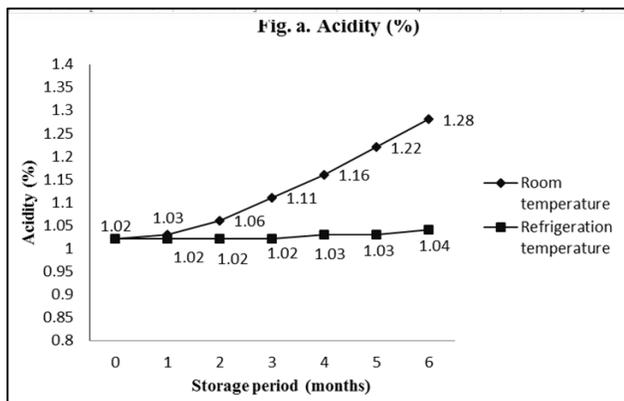
The initial TSS value of the noni fruit juice blended with amla squash on 45.0°brix did not show any significant changes during the storage period in both the temperature. Sudhagar (2001) [12] reported that the squash prepared from pear and pineapple blended squashes initially had 44.5 and 45.5 °brix

TSS respectively did not show any changes at room temperature throughout the study period of 6 months.

Acidity

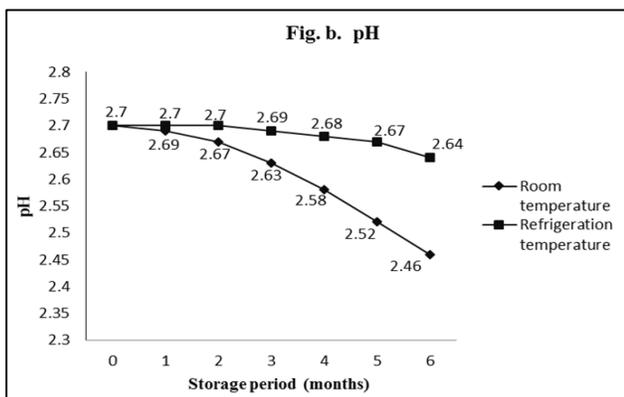
The noni fruit juice blended with amla squash showed an increased acidity from 1.02 to 1.28 and 1.04 per cent store at room and refrigeration temperature respectively at the end of the storage period (Fig. a). The significant increase in acidity could be due to release of methyl groups of pectins to liberate free – COOH groups of pectin, partial hydrolysis of soluble proteins into free amino acids (Kerby's cycle) which contributed to acidity and interaction of citric acid in the beverages [13]. The acidity increases were to conformity with

the findings of Shanmugam (2004) [14] in mixed fruit squashes during a period of 6 months storage under room temperature condition.



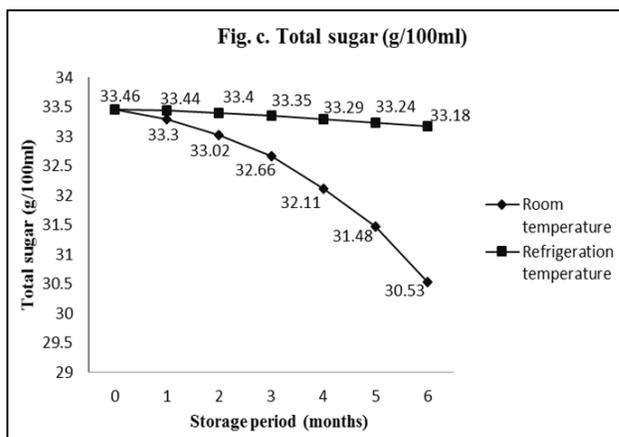
pH

The initial pH of noni fruit juice blended with amla squash was 2.70, whereas the final pH was noted as 2.46 and 2.64 after 6 month of storage at room and refrigeration temperature condition respectively (Fig.b). This might be due to the increasing percentage of acidity has influenced the pH content of the squashes. Yadav *et al.* (2014) [15] observed the gradual decrease in the pH content of the blended squash prepared from the pulp of guava-mango (20:80) during the storage period of three months in room condition.



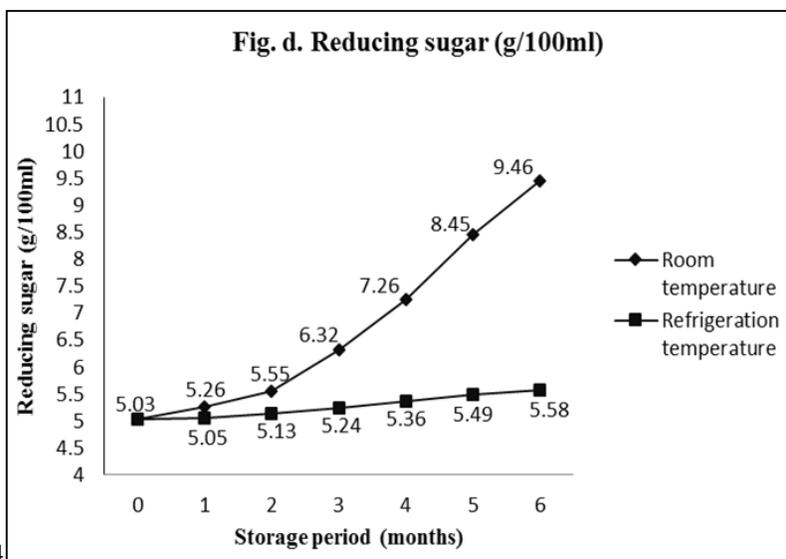
Total sugar

The initial total sugar content of the noni fruit juice blended with amla squash was 33.46g/100ml. The values at the end of 180 days of storage was 30.53 and 33.18 g/100ml stored at room and refrigeration temperature condition respectively (Fig. c). This might be due to the reaction of sugars with amino acids and co-polymerization of sugars in the presence of acids which might slightly decrease the total sugar content in the stored product [16]. Vennila *et al.*, (2015) [17] also reported that their papaya based mixed fruit squashes were stored for six months at room temperature showed a change in the total sugar content from 36.94 to 32.92 per cent in plastic container.



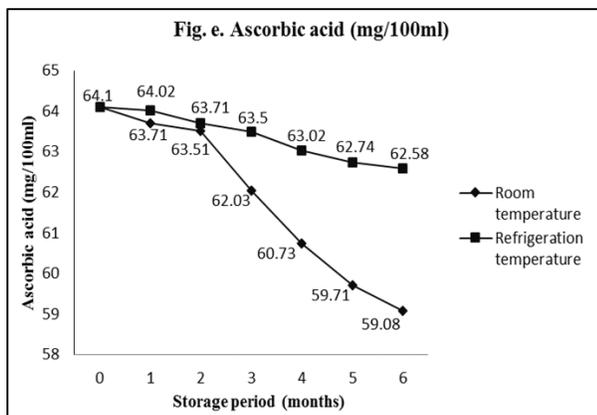
Reducing sugar

The initial reducing sugar content of the noni fruit juice blended with amla squash was 5.03 g/100ml and it increased to 9.46 and 5.58 g/100ml after 6 month of storage at room and refrigeration temperature condition respectively (Fig. d). Kiranmai *et al.* (2015) [18] reported that the tamarind pulp blended with mango pulp (80:20) squash stored at room temperature recorded a significant increase in reducing sugar content of the samples from 0 days (15.56 %) to 90 days (19.77 %) of storage period. They also reported that increase in reducing sugar content may be due to hydrolysis of total sugar by acid present in fruit, which might have resulted in degradation of disaccharides to monosaccharaides.



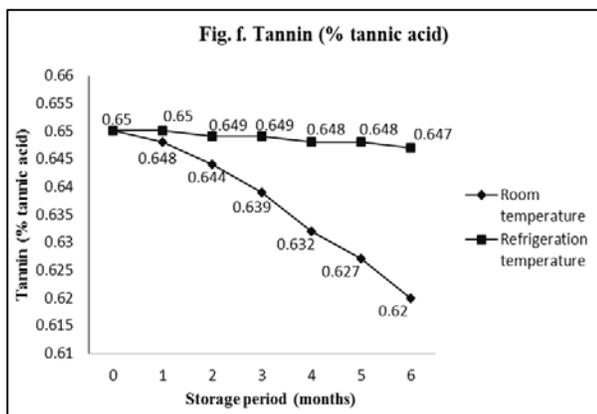
Ascorbic acid

The initial ascorbic acid content of the noni fruit juice blended with amla squash was 64.10 mg/100g, which significantly decreased ($p < 0.05$) to 59.08 and 62.58 mg/100gm, after 6 month of storage at room and refrigeration temperature condition respectively (Fig. e). The retention of ascorbic acid content was high in refrigerated condition stored sample on 97.62 per cent after 6 months of storage. Selvamuthukumaran *et al.* (2012) [19] observed that the initial vitamin C content of spiced squash was 6.72 mg/100ml, which significantly decreased to 3.15 and 2.23 mg/100 ml after six months of storage at ambient temperature and at 37°C respectively. They also reported that this could be due to oxidation or degradation of ascorbic acid into dehydroascorbic acid, furfural and hydroxyl furfurals at above temperature.



Tannin

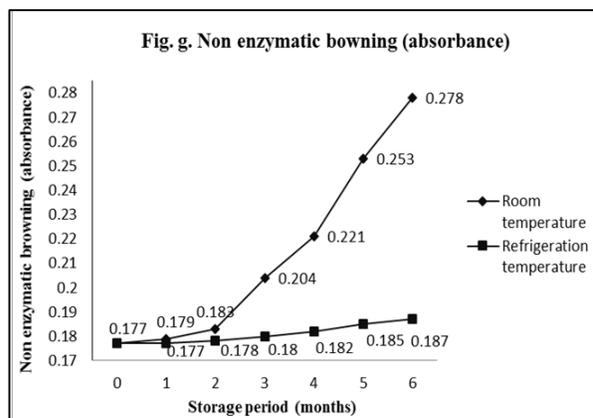
Tannin showed on decreases from 0.650 to 0.610 and 0.647 per cent tannic acid after 6 month of storage when noni fruit juice blended with amla squash was stored at room and refrigeration temperature condition respectively (Fig. f). Sudhagar (2001) [12] reported that the changes in tannin contents were as 0.123 to 0.096 in pear squash and 0.100 to 0.095 per cent in pear and pineapple juice blended squash during end of 180 days storage at room temperature.



Non enzymatic browning

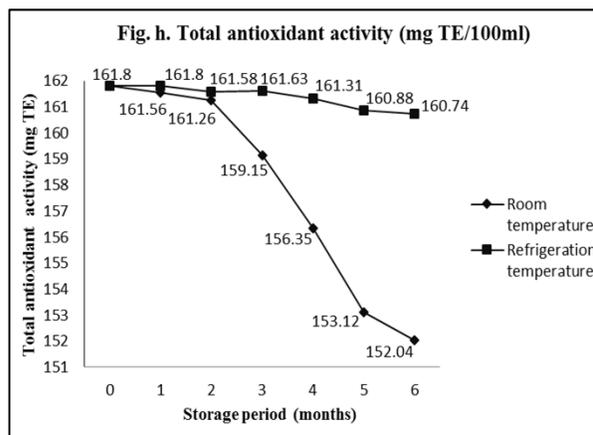
A gradual increase in the non enzymatic browning was observed in the noni fruit juice blended with amla squash from 0.177 to 0.278 and 0.187 absorbance at room and refrigeration temperature respectively at the end of 6 month of storage (Fig. g). Bhardwaj and Nandal (2014) [20] reported that kinnow juice (95%) blended with amla (5%) squash had initial non enzymatic browning of 0.088 and it was increased to 0.138 absorbance at ambient condition and 0.111

absorbance at refrigeration condition after six months of storage. They also reported that gradual browning of juice was observed with advancing storage period at both storage conditions which might be due to the enzymatic and non enzymatic reactions of the juice. An increase in the non enzymatic browning was noted among the squashes as reported by earlier scientists worked in this field.



Total antioxidant activity

Among the two types of storage condition, significantly higher antioxidant activity was reduced in noni fruit juice blended with amla squash at room condition from 161.80 to 152.04 mg TE/100ml and in refrigeration condition 160.74 mg TE/100ml (Fig. h). Byanna and Gowda (2012) [21] reported that the initial antioxidant activity of sweet orange and pomegranate (90:10) blended beverage was 12.91 which had decreased 12.04 mg/100ml after 180 days of storage at room condition on end of 6 month storage. That could be due to in addition to temperature and light, time was an important factor affecting loss of antioxidant activity during storage [22].



Colour (L^*) value

The freshly processed noni fruit juice blended with amla squash contained colour values (L^*) for 63.40, whereas the value showed reduction from initial value to 60.19 and 62.37 at the end of 6 month of storage respectively in room and refrigerated temperature (Fig. i). Sousa *et al.* (2010) [23] observed that a gradual decrease in the colour value (L^*) of the cashew apple, acerola, papaya, guava and passion fruit blended nectar initial L^* value was 39.5 ± 0.1 which changed into 38.8 ± 0.1 at room condition after 180 days of storage. According to Campos *et al.* (2002) [24] maillard reaction is a quick reaction and it is the major quality problem during

storage at room temperature. It is largely affected by pH and temperature changes. Besides the darkening, which is a sensory parameter, it reduces the protein digestibility and inhibits some digestible enzyme reactions.

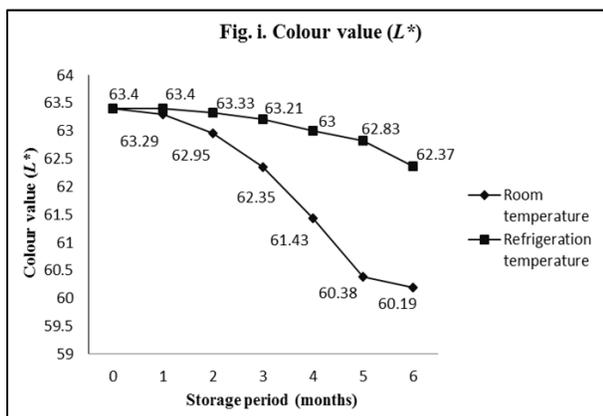


Table 4: Sensory scores of noni fruit juice blended with amla squash during storage

Storage period (Months)	Organoleptic characteristics									
	Colour and appearance		Body		Flavour		Taste		Overall acceptability	
	ROT	RET	ROT	RET	ROT	RET	ROT	RET	ROT	RET
0	8.9±0.20	8.9±0.20	8.9±0.05	8.9±0.07	9.0±0.19	9.0±0.27	8.7±0.10	8.7±0.18	8.8±0.29	8.8±0.07
6	8.5±0.09	8.8±0.14	8.5±0.13	8.8±0.20	8.5±0.25	8.9±0.08	8.4±0.20	8.6±0.25	8.5±0.21	8.7±0.16

ROT- Room temperature RET - Refrigeration temperature

Conclusion

The extracted juice from noni fruit could be successfully utilized in the processing of noni fruit juice blended squashes with suitable fruits viz., amla, sathukudi and grapes. It enhances the nutritional and sensory quality with reducing the pungent flavour and rancid taste of the noni fruit. The noni fruit juice blended with amla squashes packed in PET bottles showed significant changes in their physico-chemical and sensory characteristics and they had a shelf life of six months stored at room and refrigerated conditions. This simple technology is suitable for small scale as well as commercial level production of noni fruit juice blended with amla squashes.

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Organoleptic characteristics of stored noni fruit juice blended with amla squash

The organoleptic profile of the noni fruit juice blended squashes stored at room and refrigeration temperature in PET bottles are presented in Table 4. The noni fruit juice blended squashes stored at refrigeration temperature obtained a greater overall acceptability score value from 8.8 to 8.7 and in refrigeration condition it was reduced on 8.5, like very much was taken both the condition stored squashes. However, colour and appearance, body, flavour, taste and overall acceptability had highly changed at the end storage period in room conditioned stored squash. This decrease might be due to the copolymerization, interaction between phenolics and protein as well as the formation of cation complex with pectins [25], which might have decreased the aroma and taste score. In this certain persuaded biochemical changes decrease the overall acceptability in the product at room temperature. Similar reduction in organoleptic characteristics during storage has been reported in tamarind pulp blending with mango squash [18] and in papaya based mixed fruit squash [17].

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