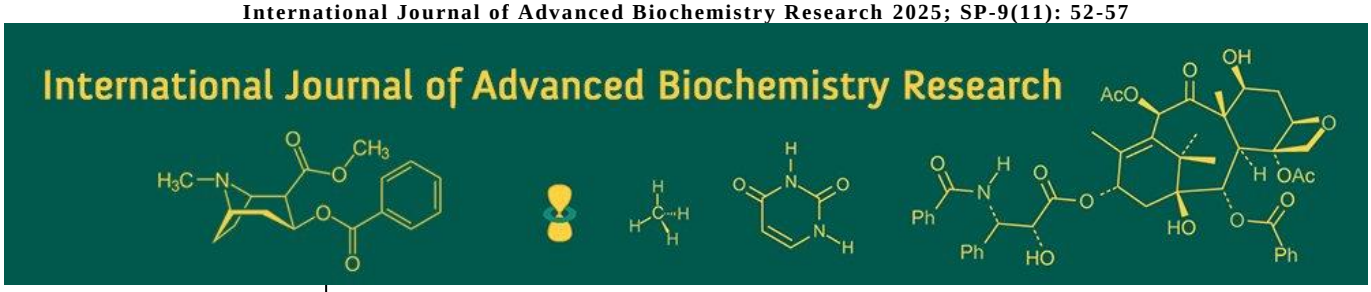

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Standardization of recipe for preparation of Carambola (*Averrhoa carambola* L.) nectar

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Abstract
The research study is entitled "Standardization of recipe for preparation of Carambola (*Averrhoa carambola* L.) nectar" was carried out during the year 2023-24 under M.Sc. degree programme at Fruit Science Laboratory Pt. K.L.S College of Horticulture and Research Station, Rajnandgaon (C.G.). The experiment was laid out in Completely Randomized Design (CRD) with 06 treatments and 03 replications. The six nectar recipes varied in juice percentage, while TSS concentration and acidity percentage remained constant. The nectar prepared with recipe T_3 (20% juice, 20°Brix TSS, and 0.3% acidity) received the highest organoleptic score in terms of appearance, colour, flavour & aroma, and overall acceptability, and found to be best recipe for carambola nectar. Among various treatments, T_6 (Juice 35%, TSS 20°Brix, acidity 0.3%) was found maximum in TSS, acidity, total sugar, reducing sugar, non-reducing sugar and ascorbic acid. The chemical composition in carambola nectar prepared from T_6 recipe (35% juice, 20°Brix TSS, and 0.3% acidity) retained the maximum TSS, acidity, total sugar, and reducing sugar, which showed an increasing trend during storage. However, the T_6 recipe (35% juice, 20°Brix TSS, and 0.3% acidity) also recorded the highest ascorbic acid and non-reducing sugar content, which exhibited a decreasing trend over the storage period.

Keywords: Carambola (*Averrhoa carambola* L.), nectar preparation, chemical analysis, sensory evaluation

Introduction
Carambola (*Averrhoa carambola* L.) belongs to the family Oxalidaceae, popularly known as star fruit, coromandal gooseberry, kamaranga, kamrakh or five fingers. The genus Averrhoa contains two species: Bilimbi (*Averrhoa bilimbi* L.) and Carambola (*Averrhoa carambola* L.) among which carambola is considered as most important. Tree of carambola is medium sized, attractive and evergreen attaining a height of 6.5-10 m and bark shows dark grey colour with horizontal folds. Leaves of carambola tree are compound spirally arranged and alternate, 15-30 cm long, with 5-11 nearly opposite, ovate-oblong leaflets that are 1.5-9 cm long and 1-4.5 cm wide (Campbell *et al.*, 1985) [3]. Leaves are medium green, and smooth on the upper surface, and slightly pubescent and whitish on the lower surface (Crane, 1994) [6]. The green leaflets are sensitive to light and fold inward at night. Carambola flowers are bisexual, 5-11 mm long, 5 mm in diameter, with pink to lavender petals and a dark-red heart and born in clusters in axils of leaves on young branches or on older branches without leaves. Most flowering and fruit production occur at the middle canopy level (Crane *et al.*, 1991) [8]. The Fruit of carambola are fleshy five lobbed, ovate to ellipsoid, 5-15 cm long and 3-10 cm in diameter is attractive and pleasantly aromatic. When sliced in cross section a perfect star is formed. The skin is thin, yellow to dark yellow and smooth with a waxy cuticle. Immature fruits are green, turning yellow or orange when ripe. The flesh is light yellow to yellow translucent, crisp, very juicy and is not fibrous. The acidic nature of the pulp is due to its oxalic acid content (Chadha, 2001) [4]. Star fruit seeds are small, 0.6 to 1.3 cm long, thin, brown, edible and there are usually 10-12 seeds per fruit (Morton, 1987) [15]. The seeds are ovoid, compressed, funicle of seed dilated into a fleshy bilabiate irregularly cut aril's. They consist of tough outer skin and a tangy white inside. Carambola trees are heterostylous (Morton, 1987) [15]. Carambola can either be mildly sweet or extremely sour depending upon the cultivar type and amount of oxalic acid concentration.

The fruit has a distinctive ridges running down its sides; the fruit when cut in horizontally gives a star shape hence, the fruit is called as star-fruit. Carambola is believed to be originated from Malaysia or Indonesia (Zewen and De Wet, 1982) [23] but distributed around the world especially in South East Asian countries including China, Malaysia, Thailand, Pakistan, Indonesia and India (Ghosh and Dhua, 1990) [11] It is commercially grown in the U.S. in South Florida and Hawaii. In India, it is one of the underutilized, unexploited fruit crops with no systematic plantation. It is distributed in Uttar Pradesh, Assam, West Bengal, Madhya Pradesh, Chhattisgarh, Bihar and foot hills of Tamil Nadu. However, Pijpers *et al.* (1986) [18] indicated the centre of origin of Carambola as Sri Lanka or India. Carambola prefers warm moist climate and can be grown on the hills up to 1200 m (Chadha, 2001) [4]. A well distributed rainfall encourages normal growth and cropping. It can grow on any type of soil with good drainage, but deep rich soil supports better plant growth. It prefers acidic soils but can also be grown in alkaline soils. In tropical areas, carambola tree has potential to flower year round (Crane *et al.*, 1998) [7] but, two main flushes, one in October-November and another in April-May are observed. The peak yields are obtained during January-February and September-October. The fruit have high water content and rich source of dietary fiber, Vitamin-C, antioxidant phyto-nutrients such as polyphenols, flavonoids, B-complex vitamins (B_9, B_2 and B_6), low in sugar, sodium and acid. It also contain small amount of minerals like potassium, phosphorus, zinc and iron (Shui and Leong, 2004; Muthu *et al.*, 2016) [21, 16]. Carambola is good source of vital nutrients. It is very good source of vital natural antioxidants like L-ascorbic acid, epicatechin and gallic acid in gallotannin forms. Consuming 100 g of this fruit can provide, 35.7 g calories, 0.38 g proteins, 9.38 g carbohydrates, 0.80 g-0.90 g dietary fibre, 0.8 g fat, 4.4-6.0 mg calcium, 0.32-1.65 mg iron, 15.5-21.0 mg phosphorous, 2.35 mg potassium, 0.003-0.552 mg of carotene, 4.37 mg tartaric acid, 9.6 mg oxalic acid, 2.2 mg α-ketoglutaric acid, 1.32 mg citric acid. Moreover, various amino acids like 0.03-0.038 mg of thiamine, 0.019-0.03 mg of riboflavin, 0.294-0.38 mg of niacin, 3 mg of tryptophan, 2 mg of methionine and 26 mg of lysine are also present in 100 g of the fruit. Starfruit has been shown to possess medicinal qualities such as anti-inflammatory, analgesic, hypoglycemic, anti-bacterial, hepatoprotective, and anti-ulcer activity in tests conducted by (Dasgupta *et al.*, 2013) [9]. Hence the plant and its's fruit can be utilized as powerful medicine. It is highly perishable fruit at maturity and ripened stage. Due to lack of storage facility and knowledge of processing, preservation and value addition, a huge amount of fruits go wasted every year. Carambola fruit have limited marketability because of high perishability and high moisture content which lead to the extensive postharvest losses. It is required that fruits have to be preserved fresh or processed to reduce the post-harvest losses & wastage. Drying and value addition in the form of squash, nectar, RTS, jam, pickle, candy and salted dry preserve could extend the shelf life up and make it available throughout the year. Carambola fruit are not being cultivated commercially in Chhattisgarh, but in some parts of Rajnandgaon, Chhuria, Mohla-Manpur-Ambagarh-Chouki, Jagdalpur it is found in scattered form in badi of the farmers and bears profuse flowers and fruiting. As per the observations recorded on physico-chemical properties of some carambola germplasm. The germplasm Carambola-1 having fruit weight 59.2 g, fruit length 6.6 cm, fruit width 2.8 cm, and Ascorbic acid content 37 mg/100 g, total sugar content 12.76%, reducing sugar 6.30%, non-reducing sugar 6.46%, acidity 0.20%, and TSS 15 °Brix was found suitable for preparation of RTS, Nectar and other value added products, considering which the fruit of carambola-1 was used for processing purpose in this research.

Materials and Methods

The present experiment entitled "Standardization of recipe for preparation of Carambola (*Averrhoa carambola* L.) nectar" was carried out during the year 2023-24 under M.Sc. degree programme at Fruit Science Laboratory Pt. K.L.S College of Horticulture and Research Station, Rajnandgaon, Mahatma Gandhi Udyanikee Evam Vanikee Vishwavidyalaya, Durg. (C.G.). The experiment was laid out in Completely Randomized Design (CRD) with 06 treatments and 03 replications. The treatment includes T_1 (Juice 10%, TSS 20°Brix, acidity 0.3%), T_2 (Juice 15%, TSS 20°Brix, acidity 0.3%), T_3 (Juice 20%, TSS 20°Brix, acidity 0.3%), T_4 (Juice 25%, TSS 20°Brix, acidity 0.3%), T_5 (Juice 30%, TSS 20°Brix, acidity 0.3%), T_6 (Juice 35%, TSS 20°Brix, acidity 0.3%). The observation were recorded for at every 15 days interval till 60 days of storage period.

Result and Discussion

Table 1: Chemical properties of Carambola fruit

S.N	Parameters	Composition
1.	Total soluble solid (TSS °Brix)	15 °Brix
2.	Acidity%	0.20%
3.	Ascorbic acid (mg/100 g)	37 mg/100 g
4.	Total sugar%	12.76%
5.	Reducing sugar%	6.30%
6.	Non-reducing sugar%	5.46%

Chemical properties of carambola nectar

Total soluble solids (°Brix)

The different recipe treatments data on total soluble solid of carambola nectar at refrigerator preservation is shown in Table 2, TSS level of carambola nectar rise significantly from 15 to 60 days of storage period, At its initial preparation of time non-significant difference was observed in TSS of carambola nectar with all the treatment having TSS of 20 percent. The maximum TSS content (20.06, 20.09, 20.32, 20.48, 20.58) was recorded in treatment 6 with (Juice 35%, TSS 20°Brix, acidity 0.3%) At 0, 15, 30, 45 and 60 days of storage period, followed by T_5 (20.04, 20.08, 20.27, 20.39, 20.42) and T_4 (20.03, 20.04, 20.23, 20.28, 20.34). while treatment T_1 (20.00, 20.00, 20.09, 20.16 and 20.20) had the lowest TSS content. The increase in Total Soluble Solids (TSS) in the carambola nectar is likely due to increase in soluble solids content and total soluble sugars caused by hydrolysis of polysaccharides like starch, cellulose and pectin substances into simpler substances. This finding aligns with previous research, such as Shinde (2014) [20] in carambola nectar, Lad *et al.* (2013) [13] in lime squash, Sherzad *et al.* (2017) [19] in strawberry based blended nectar and Mahar *et al.* (2021) [14] in dragon fruit RTS.

Acidity (%)

The experimental data shown in Table 3, Treatment 6 (Juice 35%, TSS 20°Brix, acidity 0.3%) recorded maximum

acidity percent (0.35, 0.39, 0.41, 0.44 and 0.49) at 0, 15, 30, 45, and 60 days of storage period respectively which was followed by treatment 5 (0.33, 0.38, 0.40, 0.43 and 0.47%) and treatment 4 (0.32, 0.36, 0.38, 0.41 and 0.45%) However, treatment 1(0.30, 0.31, 0.33, 0.37 and 0.40%) had the lowest acidity percent. The acidity of nectar witnessed an increasing trend during storage period and the rise in nectar acidity during storage may be due to the creation of organic acids through the breakdown of ascorbic acid, as well as pectin hydrolysis. It is also because production of acids from sugar. The results of this investigation corroborate by the findings of Jain and Singh (2007) [12] in aonla nectar, Byanna *et al.* (2012) [2] in orange-pomegranate blended RTS, Choudhary *et al.* (2012) [5] in aonla nectar, Divyashree *et al.* (2018) [10] in sweet orange based RTS blend, Panda *et al.* (2019) [17] in jamun RTS and Mahar *et al.* (2021) [14] in dragon fruit RTS.

Ascorbic Acid (mg/100 g pulp)

The information on the variations in the ascorbic acid content of carambola nectar is shown in Table 4, The information revealed that variations in the amount of ascorbic acid were significantly influenced by the storage duration and the treatments. Ascorbic acid of carambola nectar at 0, 15, 30, 45 and 60 days of storage (34.61, 34.47, 34.29, 33.80 mg/100 g) was recorded significantly highest in treatment T_6 with (Juice 35%, TSS 20°Brix, acidity 0.3%), which was at par with treatment T_5 (33.80, 33.60, 33.52, 33.46 and 33.01 mg/100 g) and the minimum ascorbic acid content (31.75, 31.67, 31.12, 31.08 and 31.01 mg/100 g) was recorded in treatment T_1 at 0, 15, 30, 45 and 60 days of storage period respectively. The ascorbic acid content of carambola nectar decreased significantly during 60 days of storage. The decline in the ascorbic acid content of nectar during storage could be due to oxidation of ascorbic acid to dehydro-ascorbic acid during storage may be the cause of a decrease in ascorbic acid levels. Similar findings on the decline of ascorbic acid during storage reported by Choudhary *et al.* (2012) [5] in aonla nectar, Bayana and Gowda (2012) in sweet orange nectar, Shinde (2014) [20] in carambola nectar and Sherzad *et al.* (2017) [19] in strawberry based blended nectar. Divyashree *et al.* (2018) [10] in sweet orange based RTS blend.

Total sugar (%)

Data revealed that the total sugar content in carambola nectar increased significantly during storage (0-60 days). Treatment T_6 (Juice 35%, TSS 20°Brix, acidity 0.3%) has superiority with maximum total sugar per cent (12.84, 13.45, 13.47, 13.52 and 13.57%) at 0, 15, 30, 45 and 60 days of storage period. Which was at par with treatment T_5 (12.37, 12.90, 12.92, 12.98 and 13.14%), While the lowest total sugar percent was measured (11.03, 11.26, 11.32, 11.41 and 11.58%) for the treatment T_1 (Juice 10%, TSS 20°Brix, acidity 0.3%). Significant rise in total sugar of carambola nectar was noted in refrigerated temperature, in storage period of 60 days. The reason of rise in total sugars content was due to advanced rate of solubilization of starch particles and rise in total soluble sugar by addition of sugars during preparation and by the conversion of acids in to sugars, thus reducing hydrolysis of polysaccharides and acids. The results of the current investigation are corroborated by findings of Verma and Gahlot (2006) [22] in bael beverages, Bhardwaj and Nandal (2014) [1] in kinnow mandrin juice blend, Sherzad *et al.* (2017) [19] in strawberry based blended nectar. Similar results were also reported by Panda *et al.* (2019) [17] in jamun RTS and Mahar *et al.* (2021) [14] in dragon fruit RTS.

Reducing sugar (%)

The results indicate an increasing trend in reducing sugar levels over the 60 days storage period, with significant differences observed among treatments at the end of the storage period. The maximum reducing sugar percent of carambola nectar (5.42, 6.10, 6.17, 6.21 and 6.33%) was noticed under the superiority of treatment T_6 (Juice 35%, TSS 20°Brix, acidity 0.3%) which was at par with treatment T_5 (5.18, 5.78, 5.81, 5.89 and 6.08%) while the minimum reducing sugar percent observed in T_1 (4.91, 5.19, 5.28, 5.40 and 5.69%) at 0, 15, 30, 45 and 60 days of storage period respectively. The increase in reducing sugar as well as total sugar corresponded to the increase in TSS (total soluble soilds) and ultimate decrease in non reducing sugar in the beverage during storage period. The variation in different fractions of sugar might be due to hydrolysis of polysaccharides like starch pectin and inversion of non reducing sugar into reducing sugar, as increase in reducing sugar was co-related with the decrease in non reducing sugar. The increased level of total sugar was probably due to conversion of starch and pectin into simple sugars. The results are in conformity with the findings of Verma and Gehlot (2006) [22] in Bael beverages, Lad *et al.* (2013) [13] in lime squash, Shinde (2014) [20] in carambola nectar and Mahar *et al.* (2021) [14] in dragon fruit RTS.

Non reducing sugar (%)

The data recorded on effect of various recipe treatment on non reducing sugar percent of carambola nectar has been presented in Table 7 the maximum non reducing sugar percent was observed in T_6 (7.42, 7.35, 7.33, 7.31 and 7.23%) at 0, 15, 30, 45 and 60 days of storage period which was at par with T_5 (7.19, 7.12, 7.11, 7.09 and 7.06%), whereas, treatment T_1 recorded minimum non reducing sugar percent (6.12, 6.07, 6.04, 6.01 and 5.54%) respectively at similar days of storage. The variation in the various sugar fractions could be brought on by the hydrolysis of polysaccharides like pectin and starch as well as the inversion of non-reducing sugar into reducing sugar, since an increase in reducing sugar was linked to a decrease in non-reducing sugar. Similar findings were observed by Verma and Gehlot (2006) [22] in Bael beverages, Bayanna and Gowda (2012) [2] in sweet orange nectar, Panda *et al.* (2019) [17] in jamun RTS and Mahar *et al.* (2021) [14] in dragon fruit RTS.

Table 2: Effect of different recipe treatments on TSS (°Brix) of carambola nectar during storage under refrigerated condition.

Treatments	Storage period (in days)				
	0	15	30	45	60
T_1 Juice 10%, TSS 20°Brix, acidity 0.3%	20.00	20.00	20.09	20.16	20.20
T_2 Juice 15%, TSS 20°Brix, acidity 0.3%	20.01	20.01	20.12	20.18	20.22
T_3 Juice 20%, TSS 20°Brix, acidity 0.3%	20.00	20.01	20.18	20.24	20.30
T_4 Juice 25%, TSS 20°Brix, acidity 0.3%	20.03	20.04	20.23	20.28	20.34
T_5 Juice 30%, TSS 20°Brix, acidity 0.3%	20.04	20.08	20.27	20.39	20.42
T_6 Juice 35%, TSS 20°Brix, acidity 0.3%	20.06	20.09	20.32	20.48	20.58
S.Em. ±	0.015	0.021	0.051	0.069	0.080
C.D. at 5%	N/A	0.065	0.158	0.216	0.249
C.V	0.127	0.179	0.434	0.593	0.681

Table 3: Effect of different recipe treatments on acidity of carambola nectar during storage under refrigerated condition.

Treatments	Storage period (in days)				
	0	15	30	45	60
T_1 Juice 10%, TSS 20°Brix, acidity 0.3%	0.30	0.31	0.33	0.37	0.40
T_2 Juice 15%, TSS 20°Brix, acidity 0.3%	0.31	0.33	0.35	0.38	0.43
T_3 Juice 20%, TSS 20°Brix, acidity 0.3%	0.31	0.35	0.37	0.40	0.44
T_4 Juice 25%, TSS 20°Brix, acidity 0.3%	0.32	0.36	0.38	0.41	0.45
T_5 Juice 30%, TSS 20°Brix, acidity 0.3%	0.33	0.38	0.40	0.43	0.47
T_6 Juice 35%, TSS 20°Brix, acidity 0.3%	0.35	0.39	0.41	0.44	0.49
S.Em. ±	0.004	0.005	0.005	0.005	0.006
C.D. at 5%	0.013	0.015	0.015	0.017	0.018
C.V	2.333	2.311	2.187	2.331	2.239

Table 4: Effect of different recipe treatments on ascorbic acid content of carambola nectar during storage under refrigerated condition.

Treatments	Storage period (in days)				
	0	15	30	45	60
T_1 Juice 10%, TSS 20°Brix, acidity 0.3%	31.75	31.67	31.12	31.08	31.01
T_2 Juice 15%, TSS 20°Brix, acidity 0.3%	32.45	32.37	31.57	31.44	31.10
T_3 Juice 20%, TSS 20°Brix, acidity 0.3%	32.93	32.86	32.28	31.56	31.36
T_4 Juice 25%, TSS 20°Brix, acidity 0.3%	32.95	32.88	32.76	32.55	32.15
T_5 Juice 30%, TSS 20°Brix, acidity 0.3%	33.80	33.60	33.52	33.46	33.01
T_6 Juice 35%, TSS 20°Brix, acidity 0.3%	34.61	34.47	34.34	34.29	33.80
S.Em. ±	0.448	0.437	0.558	0.419	0.425
C.D. at 5%	1.395	1.361	1.739	1.307	1.325
C.V	2.345	2.295	2.966	2.243	2.297

Table 5: Effect of different recipe treatments on total sugar content of carambola nectar during storage under refrigerated condition.

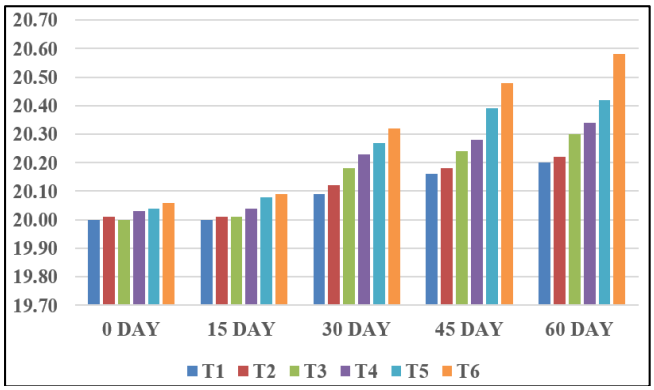
Treatments	Storage period (in days)				
	0	15	30	45	60
T_1 Juice 10%, TSS 20°Brix, acidity 0.3%	11.03	11.26	11.32	11.41	11.58
T_2 Juice 15%, TSS 20°Brix, acidity 0.3%	11.54	11.91	11.93	11.98	12.04
T_3 Juice 20%, TSS 20°Brix, acidity 0.3%	11.91	12.05	12.10	12.14	12.20
T_4 Juice 25%, TSS 20°Brix, acidity 0.3%	12.03	12.32	12.35	12.40	12.48
T_5 Juice 30%, TSS 20°Brix, acidity 0.3%	12.37	12.90	12.92	12.98	13.14
T_6 Juice 35%, TSS 20°Brix, acidity 0.3%	12.84	13.45	13.47	13.52	13.57
S.Em. ±	0.096	0.085	0.178	0.199	0.208
C.D. at 5%	0.30	0.265	0.555	0.619	0.649
C.V	1.397	1.195	2.500	2.774	2.884

Table 6: Effect of different recipe treatments on reducing sugar content of carambola nectar during storage under refrigerated condition.

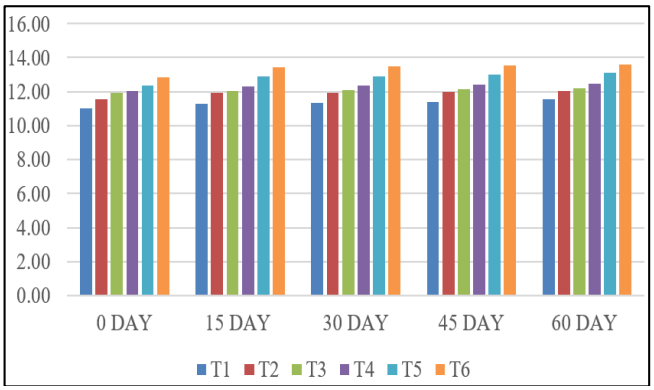
Treatments	Storage period (in days)				
	0	15	30	45	60
T_1 Juice 10%, TSS 20°Brix, acidity 0.3%	4.91	5.19	5.28	5.40	5.69
T_2 Juice 15%, TSS 20°Brix, acidity 0.3%	4.97	5.42	5.49	5.63	5.79
T_3 Juice 20%, TSS 20°Brix, acidity 0.3%	4.98	5.48	5.57	5.69	5.85
T_4 Juice 25%, TSS 20°Brix, acidity 0.3%	5.09	5.56	5.64	5.80	5.96
T_5 Juice 30%, TSS 20°Brix, acidity 0.3%	5.18	5.78	5.81	5.89	6.08
T_6 Juice 35%, TSS 20°Brix, acidity 0.3%	5.42	6.10	6.17	6.21	6.33
S.Em. ±	0.017	0.099	0.103	0.132	0.105
C.D. at 5%	0.053	0.31	0.321	0.412	0.329
C.V	0.581	3.078	3.155	3.969	3.07

Table 7: Effect of different recipe treatments on non-reducing sugar content of carambola nectar during storage under refrigerated condition.

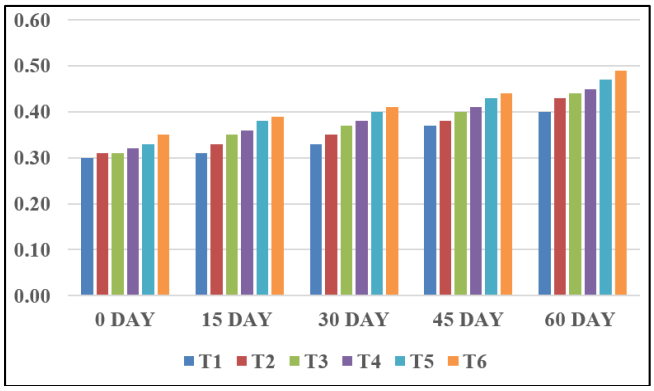
Treatments	Storage period (in days)				
	0	15	30	45	60
T_1 Juice 10%, TSS 20°Brix, acidity 0.3%	6.12	6.07	6.04	6.01	5.54
T_2 Juice 15%, TSS 20°Brix, acidity 0.3%	6.57	6.48	6.44	6.35	6.25
T_3 Juice 20%, TSS 20°Brix, acidity 0.3%	6.93	6.57	6.53	6.45	6.36
T_4 Juice 25%, TSS 20°Brix, acidity 0.3%	6.93	6.76	6.70	6.60	6.53
T_5 Juice 30%, TSS 20°Brix, acidity 0.3%	7.19	7.12	7.11	7.09	7.06
T_6 Juice 35%, TSS 20°Brix, acidity 0.3%	7.42	7.35	7.33	7.31	7.23
S.Em. ±	0.10	0.077	0.139	0.134	0.106
C.D. at 5%	0.311	0.238	0.432	0.418	0.331
C.V	2.521	1.971	3.593	3.499	2.836



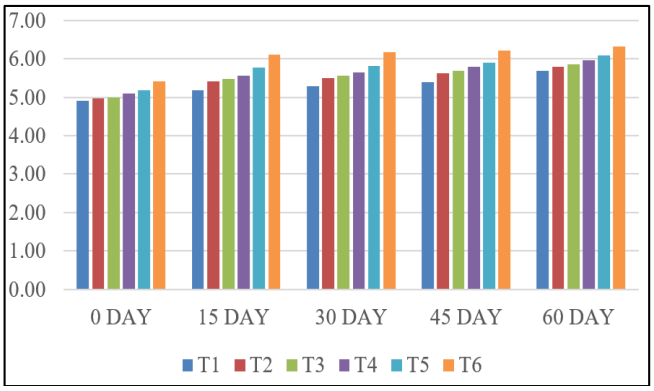
Total soluble solid (%)



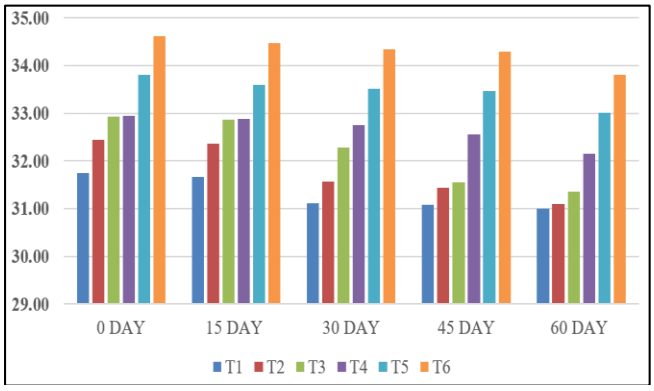
Total sugar (%)



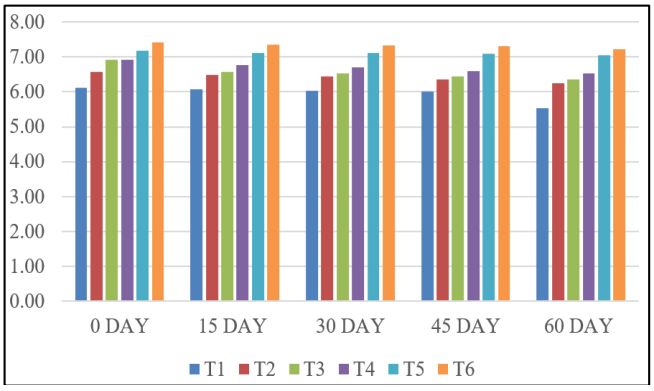
Acidity (%)



Reducing sugar (%)



Ascorbic acid mg/100 g



Non-reducing sugar (%)

Conclusion

On the basis of experimental findings, nectar prepared with the recipe of T_3 (Juice 20%, TSS 20°Brix, acidity 0.3%) was found to be best recipe with respect to organoleptic qualities. Hence, Treatment T_3 may be recommended for preparation of carambola nectar. On the other hand the nectar prepared with T_6 (Juice 35%,TSS 20°Brix, acidity 0.3%) showed a significant impact on the chemical properties (TSS, acidity, ascorbic acid, total sugar, reducing sugar and non-reducing sugar) of carambola nectar. During storage TSS, acidity, total sugar, reducing sugar increased. While ascorbic acid and non-reducing sugar decreased during storage period.

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