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RESEARCH ARTICLE

Evaluation of cashew apple RTS beverages blend with mango and papaya for its physicochemical properties and storage life

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Abstract

For every tonne of cashew nuts, 10 to 15 tonnes of cashew apples are spoiled in orchards, representing a significant economic loss in India. Cashew apple juice is astringent because of the presence of anacardic acid and tannins when eaten as such. Ready-to-serve (RTS) beverages prepared from cashew apple juice blended with mango and papaya in varying proportions were evaluated for physicochemical properties, organoleptic scores, and microbial counts at 0, 30, 60 and 90 days of storage during 2022-2023 using Completely Randomized Design with two replications and six treatments. RTS blend of 50% cashew apple and 50% mango juice (T2) exhibited a gradual reduction in pH and ascorbic acid content and an increase in density, total soluble solids (TSS), acidity, reducing sugar and TSS/acid ratio from 0 to 90 days of storage followed by T6, a blend of 25% cashew apple and 75% papaya juice RTS. The RTS blends T2 and T6 had low microbiological counts and excellent quality, color, taste and general acceptance based on organoleptic score. The highest net benefit for an RTS beverage was in T3 (Rs.32/-) followed by T2 (Rs.27.25/-) when compared to control (100% cashew apple juice at Rs.21/-). They also had affordable preparation costs, which added value to the cashew apple juice.

Keywords

cashew apple blend RTS beverages; economics; microbial count; organoleptic score; titrable acidity; total soluble solids

Introduction

The evergreen tropical cashew (*Anacardium occidentale* L.) tree was brought to India from Brazil because of its capacity to manage coastal erosion. Cashew is cultivated on 10.27 lakh hectares in India as a commercial crop, yielding 7.25 lakh metric tons of nuts with a 706 kg/hectare productivity. In Tamil Nadu, it is cultivated on 91,058 hectares with nut production (57,988 metric tonnes) and productivity of 640 kg/hectare (1). For every tonne of cashew nuts, around 10 to 15 tonnes of cashew apples are produced, rot and remain in orchards, resulting in considerable economic loss in terms of nutrients and national value. Even though these fruits are high in nutrients, they are not eaten like other fruits because of their astringency, which is brought on by polyphenols, tannins (0.35%) and unidentified oily compounds (3%), which are found in the waxy layer of skin and bind to salivary glycoproteins to produce an astringent taste. One important polyphenolic

compound, leucodelphinidin, is oxidized to quinines during preservation by polyphenol oxidase. Quinines and other phenolic acids such as gallic acid, protocatechuic acid and conjugated cinnamic acid are present in cashew apple juice. Quinines undergo non-enzymatic reactions with carbohydrates and proteins to produce brown melanins or browning, which is harmful to nutritional quality and alters sensory attributes (2). The elevated tannin concentration in cashew apple juice is diminished with the application of a fining agent, thereafter combined with other fruit juices to create Ready-to-serve (RTS) beverages (3). When ripe, cashew apples have a delicate exterior, are juicy and are granulated with sugar and salt. Fruit with high quantities of reducing sugars (50-60% dry basis) is perishable and spoils quickly because of microbial activity. Thus, the current study aims to standardize RTS beverages blended with mango and papaya and estimate the quality of resulting blends at different storage periods.

Materials and Methods

The experiment was performed in the Home Science Laboratory of Krishi Vigyan Kendra, Vridhachalam, Cuddalore district, during 2022-2023 using a Completely Randomized Design with two replications and six treatments. Harvested cashew apple fruits were collected from the field, stored under refrigerated conditions in the laboratory, washed with clean water, then analyzed for physicochemical properties and utilized for preparing cashew apple juice blends. Clarification of Cashew apple juice for RTS beverages is given in Fig. 1 as per the standardized procedure (3). Mango and papaya were purchased from a local market and utilized. Treatments were set up by blending several juices in different proportions (3) (Fig. 2).

Following sterilization, the blended juices were poured into 250 ml capacity bottles, corked with a crown, heated to 65°C for thirty minutes in boiling water, cooled and stored/preserved (4, 5). Before making an RTS beverage from each blend, initial physicochemical characteristics of blended juices for pH, density, total soluble solids (TSS) and acidity were recorded (Table 1). The RTS made from Treatment 1 comprises 100 ml of RTS beverage, which is made up of 10 ml of blended cashew apple and mango juices, 10g of sugar and 80ml of water. In the same way, 100 ml of RTS beverages for Treatments 2 - 6 were prepared.

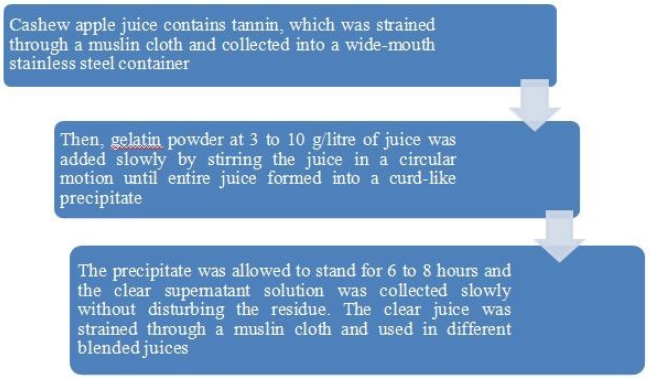

Fig. 1. Clarification of Cashew apple juice for RTS beverages as per standardized procedure (3).

Table 1. Physico-chemical parameters of cashew apple blended juice before RTS preparation of the different treatments

Treatments	pH	Density (kgm^{-3})	Total Soluble Solids (Brix°)	Titrable acidity (%)
T0	3.40	0.90	10.00	0.30
T1	3.50	0.80	11.00	0.25
T2	3.55	0.85	12.50	0.30
T3	3.45	0.80	13.00	0.35
T4	3.50	0.90	11.00	0.27
T5	3.55	0.80	12.50	0.30
T6	3.65	0.90	13.00	0.35
SE (m)	0.06	0.02	0.31	0.03
CD at 1%	0.17	0.05	0.92	0.10

SE - Standard Error; CD - Coefficient of Deviation

A panel of ten judges were assigned to assess the qualities of colour, taste and general acceptance; assign a score on the basis of a 9-point hedonic scale (6,7). Following processing, bottles of blended cashew apple RTS beverage were kept at room temperature (27-29°C), with observations made every 30 days for up to 90 days in order to examine cashew apple RTS beverage's microbiological stability and sensory assessment (8). Serial dilution and plate count methods were used with nutritional agar medium (3g beef extract, 5g peptone, 20g agar-agar & 1000ml distilled water) to assess bacterial growth. The same method was used with potato dextrose agar medium (200g potato, 20g dextrose, 20g agar-agar and 1000 ml of distilled water) to estimate fungal growth (8). The average number of colonies per cm^2 was determined by recording five random observations on each plate. From there, the number of colonies per plate was computed as suggested by (8). Standard Error (SE) and Coefficient of Deviation (CD) at 1% were statistically analysed.

Results and Discussion

Physical and Chemical analysis

Cashew apples were physically measured for their weight (50-120g), length (4.0-6.5 cm) and girth (3.5-4.0 cm). The Chemical composition is attributed mainly to the type of soil, climatic conditions and maturation stage (Table 2).

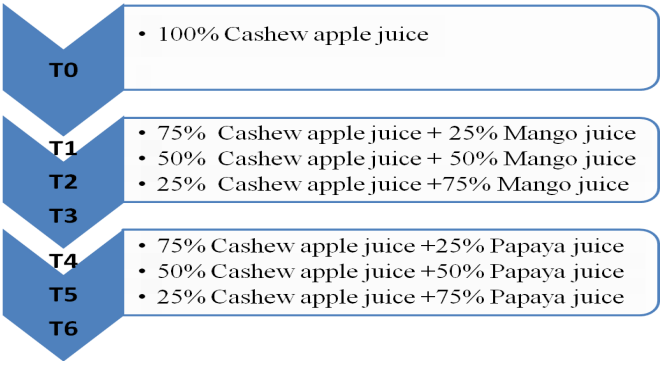

Fig.2. Details of treatment combinations of cashew apple juice with mango and Papaya as per standardized procedure (3).

Table 2. Chemical constituents (per 100 g of fresh Cashew apple fruits)

S.No.	Nutrient content	Average values
1	Moisture (%)	85.00
2	Total Soluble Solids (Brix°)	10.00
3	pH	4.15
4	Tannins (mg)	155
5	Ascorbic Acid (mg)	165
6	Crude Fibre (%)	1.50
7	Ash (%)	0.40
8	Titrable acidity (%)	0.30
9	Iron (mg)	1.33
10	Carbohydrate (%)	12.20

Quality Parameters of RTS

Table 3 shows how the length of storage (more than 0, 30, 60 and 90 days) affects RTS made from blended cashew apple juice in terms of colour, density, pH, as well as total soluble solids.

Color : The color of the RTS beverage altered, with cashew apple and mango blends demonstrating the most favorable hue at 0 days. The combination of cashew apple juice and mango juice (T2 and T3) exhibited a gradual alteration in colour due to product oxidation, which triggered the Maillard process (9).

pH : From 0 to 90 days of storage, the pH of RTS from various mixes showed a trend toward decrease. Since acidity and pH have an inverse relationship, the pH of T2 dropped from 3.50 at the beginning of storage to 3.03 after 90 days, and in T6, it declined from 3.45 to 3.10. This could be the result of an increase in titrable acidity (10, 11).

Density : The densities of cashew apple and papaya RTS treatments range from 0.90 to 0.98 kg/m^3, whereas cashew apple and mango RTS treatments showed the lowest density range, from 0.92 to 0.94 kg/m^3, after 0 days of storage. At 30, 60 and 90 days of storage, other treatments displayed an increasing trend, with a minimum of 1.00 -1.25 kg/m^3.

Total Soluble Sugars (TSS) : In treatments of cashew apple and papaya RTS beverages ranged from 14.50 - 15.50 ºBrix, with the lowest range of 15.00 - 15.50 ºBrix observed in cashew apple and mango RTS at 0 days of storage. Other treatments trend increased from a minimum of 14.60 ºBrix (T4) to a maximum of 16.50 ºBrix (T6) overall storage days. However, a higher TSS range of 15.55 to 15.70 ºBrix was observed in T2 and 15.8 to 16.50 ºBrix in T6 at 30, 60 and 90 days of storage, respectively. Higher TSS may be attributed to hydrolysis of sugars and decreased acidity levels (11, 12). The effect of the storage period on acidity, reducing sugars, Ascorbic acid and TSS/ acid ratio of RTS prepared from Cashew apple blended juices are depicted in Table 4.

Titrable acidity : The range of titrable acidity for cashew apple and papaya RTS beverage treatments was 0.45 to 0.55. Cashew apple and mango RTS beverage treatments showed the lowest range, 0.42 to 0.50, after 0 days of storage. The titrable acidity of the other treatments trended between 0.43 and 0.65 after 30, 60 and 90 days of storage. The acidity of RTS beverages varies as acid is released due to hydrolysis, oxidation, or breakdown, which alters the quantity of hydrogen ions. Comparable results were noted by (13).

Reducing sugars : The range of reducing sugars in cashew apple and papaya RTS treatments was 3.03 to 5.10, with cashew apple and mango RTS exhibiting the lowest range (2.10 - 3.72) after 0 days of storage. At 30, 60 and 90 “days of storage, all treatments showed an increasing trend in reducing sugars, ranging from 2.40 to 5.75. The treatments T2 and T6 showed higher values among mango and papaya blend RTS, respectively, throughout all storage times. This may be attributed to the addition of sugars and the conversion of polysaccharides into reducing sugars in the presence of citric acid (11, 14).

Ascorbic acid : The range of ascorbic acid level in cashew apple and papaya RTS was 11.52 - 20.54 mg/100g, whereas cashew apple and mango RTS had the lowest range at 12.52 -13.32 mg/100g after 0 days of storage. At 30, 60 & 90 days of storage, all treatments exhibited a declining trend, with levels falling within the range of 22.12 - 20.94 mg/100g.

Table 3. Effect of storage period on color, pH, density and total soluble solids of the RTS prepared from blended Cashew apple juice

Treatments	Colour				pH				Density (kg m^{-3})				Total Soluble Solids (Brix°)			
	Storage periods (in days)															
	0	30	60	90	0	30	60	90	0	30	60	90	0	30	60	90
T0	Creamy white	Dusky white	Dusky white	Dusky white	3.65	3.30	3.15	3.10	0.90	1.07	1.01	1.10	14.50	15.50	16.15	16.50
T1	Light yellow	Light yellow	Light yellow	Light yellow	3.58	3.26	3.02	3.01	0.92	1.10	1.03	1.08	15.00	15.30	15.45	15.50
T2	yellow	yellow	Light yellow	Light yellow	3.50	3.65	3.05	3.03	0.94	1.08	1.10	1.15	15.50	15.55	15.60	15.70
T3	yellow	yellow	Light yellow	Light yellow	3.43	3.26	3.06	3.04	0.92	1.09	1.03	1.05	15.00	15.00	15.10	15.50
T4	Light red	Light red	Light red	Light red	4.30	3.50	3.20	3.10	0.94	1.00	1.05	1.12	14.50	14.60	15.50	15.90
T5	Light red	Light red	Light red	Light red	3.60	3.46	2.90	2.80	0.90	1.10	1.15	1.20	15.00	15.70	15.60	15.90
T6	Light red	Light red	Light red	Light red	3.45	3.24	3.12	3.10	0.98	1.15	1.20	1.25	15.50	15.80	15.70	16.50
SE(M)	-	-	-	-	0.10	0.06	0.06	0.07	0.02	0.04	0.03	0.03	0.31	0.19	0.31	0.32
CD at 1 %	-	-	-	-	0.29	0.18	0.18	0.21	0.05	0.11	0.09	0.09	0.92	0.57	0.93	0.97

SE - Standard Error; CD - Coefficient of Deviation

Table 4. Effect of storage period on acidity, reducing sugars, ascorbic acid and TSS/ acid ratio of RTS from blended Cashew apple juice

Treatments	Acidity (%)				Reducing sugars (%)				Ascorbic acid (mg/100g)				TSS/Acid Ratio			
	Storage periods (in days)															
	0	30	60	90	0	30	60	90	0	30	60	90	0	30	60	90
T0	0.40	0.50	0.60	0.70	3.10	3.55	4.10	4.15	39.50	36.20	35.50	35.30	37.50	31.00	26.91	23.14
T1	0.45	0.50	0.55	0.60	2.10	2.40	2.50	2.60	13.32	13.10	12.80	12.50	33.55	30.60	28.03	25.83
T2	0.42	0.43	0.45	0.50	3.72	3.85	4.10	4.15	13.10	12.70	12.40	12.30	32.15	35.73	33.55	30.40
T3	0.50	0.55	0.60	0.65	2.20	2.60	2.70	2.90	12.52	11.60	11.60	11.40	29.40	25.77	25.16	23.30
T4	0.45	0.50	0.55	0.60	3.03	3.10	3.20	3.50	11.52	10.50	10.40	10.30	34.00	31.10	28.90	26.66
T5	0.50	0.55	0.60	0.65	5.00	5.20	5.40	5.60	13.60	15.10	14.50	14.20	31.20	29.27	27.50	25.69
T6	0.55	0.50	0.60	0.70	5.10	5.12	5.60	5.75	20.54	22.12	20.94	20.50	29.63	27.33	26.46	25.00
SE(M)	0.13	0.09	0.12	0.09	0.13	0.13	0.12	0.12	0.17	0.48	0.35	0.38	0.05	0.61	0.57	0.25
CD at 1 %	0.39	0.29	0.36	0.26	0.38	0.39	0.37	0.36	0.49	1.42	1.05	1.13	1.63	1.81	1.70	3.73

SE - Standard Error; CD - Coefficient of Deviation

However, at different storage conditions, the least amount of ascorbic acid was seen in T3, which was followed by T4 and T5. This is because ascorbic acid is easily oxidized in the existence of oxygen by both enzymatic and non-enzymatic catalysts and is sensitive to light, heat and oxygen. Similar findings are also reported in earlier studies (15-19).

TSS to acid ratio : In every treatment, the ratio of TSS to acid grew as TSS rose and acidity fell in tandem. At 0, 30, 60 and 90 days into storage, this ratio also increased. However, T2 had the greatest TSS/acid ratio (30.40) over the course of all storage durations. After ninety days of storage, T6's ratio was 25.00. Across all days of storage, a consistent increase in T2 was seen, followed by T6, which matched with an earlier investigation (20).

Organoleptic score : The cashew apple RTS's organoleptic score showed that T2 had the highest flavor in terms of color and taste, followed by T6 and T5 at 90 days of storage. T2 had the greatest overall acceptability score (7.30) at 90 days of storage, followed by T6 (8.00) as given in Table 5. As storage duration extended, organoleptic scores for colour, taste, as well as overall acceptability in various treatments dropped. RTS, on the other hand, produced at T2 and T6 showed stability and produced a blend with higher sensory scores. Comparable outcomes were documented (16, 21). RTS beverage made with cashew and mango juice scored the highest on organoleptic score when it came to quality characteristics that were studied.

Microbial studies in cashew apple RTS beverages during storage

Bacterial count : Regardless of treatments or storage settings, Table 6 shows that bacterial count in blended cashew apple RTS grew from 0 to 90 days of storage. The bacterial burden in blended cashew apple RTS was significantly impacted by the interplay of treatments and storage conditions. The interaction with the lowest observed bacterial growth, T2 S2 (1.10×10^{-3}) during 30 days of storage, outperformed the other two interactions, T6 S2 (1.20×10^{-3}) at 60 days and T6 S2 (1.30×10^{-3}) at 90 days of storage. Similar findings were reported in other investigations (16, 22-25).

Fungal count : Regardless of treatments or storage settings, Table 6 demonstrated that fungal counts in the blended cashew apple RTS beverage rose from 0 to 90 days of storage. The fungal load in blended cashew apple RTS beverage was considerably impacted by the interaction of treatments and storage conditions. The lowest fungal count was recorded in interaction T6 S2 (1.00×10^{-3}) at 30 days storage, T2 S2 (1.40×10^{-3}) at 60 days storage and T2 S2 (1.50×10^{-3}) at 90 days storage. The results matched with the findings of earlier investigations (26, 27).

Economics of ready-to-serve beverage prepared from cashew apple blend juices

The production cost of RTS beverage under various conditions is shown in Fig. 3. When compared to the control (100% cashew apple juice at Rs.21), the highest net advantage for an RTS beverage was in T3 (Rs.32), followed by T2 (Rs.27.25) and

Table 5. Effect of storage period on the organoleptic score of Cashew apple blend RTS for color, taste, and overall acceptability

Treatments	Colour				Taste				Overall Acceptability			
	Storage periods (in days)											
	0	30	60	90	0	30	60	90	0	30	60	90
T0	8.50	8.20	8.10	8.00	8.10	6.50	7.30	7.20	7.80	6.60	7.10	7.50
T1	5.00	6.00	6.50	6.30	8.80	6.80	6.70	6.50	6.50	7.80	6.40	6.30
T2	4.00	6.10	5.90	5.75	8.90	7.20	6.90	7.10	7.10	6.80	6.00	7.30
T3	5.20	5.10	5.10	5.05	8.70	6.50	6.50	6.30	6.80	7.60	5.50	6.50
T4	5.50	5.80	5.10	5.00	7.20	7.50	7.00	7.00	5.90	5.50	7.30	7.20
T5	5.70	5.60	6.20	6.10	7.40	6.50	7.25	7.10	6.80	6.20	7.50	6.50
T6	5.40	5.50	6.55	6.30	7.50	7.30	7.50	7.20	6.50	6.80	6.50	8.00
SE(M)	0.09	0.14	0.14	0.09	0.16	0.16	0.14	0.15	0.17	0.78	0.13	0.16
CD at 1 %	0.26	0.30	0.31	0.28	0.49	0.47	0.40	0.46	0.50	0.62	0.39	0.47

Note : Hedonic rating scale : Dislike extremely-1, Dislike very much -2, Dislike moderately -3, Dislike slightly -4, Neither like nor dislike -5, Like slightly-6, Like moderately -7, Like very much -8, Like extremely -9

SE - Standard Error; CD - Coefficient of Deviation

Table 6. Changes in the bacterial count and fungal count (colony count×10^{-3}/ml) of cashew apple blend RTS under ambient temperature (27- 30°C) and

Treatments	Bacterial count / Storage periods (in days)								Fungal count /Storage periods (in days)							
	0		30		60		90		0		30		60		90	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T0	0.00	0.00	2.15	1.30	2.50	1.70	2.70	1.80	0.00	0.00	1.50	1.20	2.80	1.30	2.80	1.50
T1	0.00	0.00	1.98	1.20	2.20	1.60	2.50	1.70	0.00	0.00	1.75	1.10	2.30	1.50	2.90	1.60
T2	0.00	0.00	1.35	1.10	2.55	1.50	2.90	1.60	0.00	0.00	1.50	1.30	2.25	1.40	2.70	1.50
T3	0.00	0.00	2.60	1.50	2.60	1.80	2.80	1.90	0.00	0.00	1.60	1.40	2.10	1.60	2.60	1.60
T4	0.00	0.00	2.20	1.60	2.50	1.80	2.60	1.90	0.00	0.00	1.50	1.60	2.50	1.60	2.50	1.90
T5	0.00	0.00	2.50	1.50	2.10	1.40	2.00	1.50	0.00	0.00	1.75	1.25	2.10	1.50	2.80	1.70
T6	0.00	0.00	2.60	1.40	2.50	1.20	2.80	1.30	0.00	0.00	1.20	1.00	2.70	1.50	2.70	1.70
SE(M)	-	-	0.05	0.03	0.06	0.04	0.03	0.05	-	-	0.05	0.03	0.06	0.04	0.05	0.03
CD at 1 %	-	-	0.14	0.08	0.17	0.11	0.09	0.14	-	-	0.15	0.09	0.19	0.11	0.15	0.10

S1 - Ambient temperature S2 - Cold storage

SE - Standard Error; CD - Coefficient of Deviation

Rs.25 in T6. The net benefit for other RTS beverages was in the middle across treatment combinations. The cost of production of 1000 ml RTS incurred was Rs.22.75, 23.00 and 22.50, respectively, for treatments T3, T2 and T6. Similar outcomes were documented in another study (21). On the other hand, the best RTS beverage was made with a blend of mango and cashew apple juice, as determined by organoleptic score. The best beverage, in terms of cost economics, was determined to be a blend of papaya and cashew apple juice, according to the quality parameters examined in this study (Fig. 4).

Conclusion

Increased levels of total soluble solids, density, acidity, reducing sugar and TSS/Acid ratio were found in the ingredient composition of 50% cashew apple and 50 % mango juice blend (T2) and 25% cashew apple and 75% papaya juice blend (T6). Increased titrable acidity, decreased pH and ascorbic acid drop rate were noted in treatment T2 and T6, following closely behind. The value of cashew apple RTS evaluated at intervals of 0, 30, 60 and 90 days after storage was found to be enhanced by RTS beverages made from cashew apple and mango as well as cashew apple and papaya mixes. T2 had the highest organoleptic evaluations in terms of colour, taste, as well as general acceptability, followed by T6 and 25% cashew apple and 75 % mango juice blend (T3). Additionally, microbiological analysis of blended cashew apple RTS beverages (both bacterial and fungal) revealed that interactions in T2 and T6 were optimal for up to ninety days of storage. These combinations offer value to cashew apple juice and are cost-effective for using with mango and papaya in RTS beverage making.

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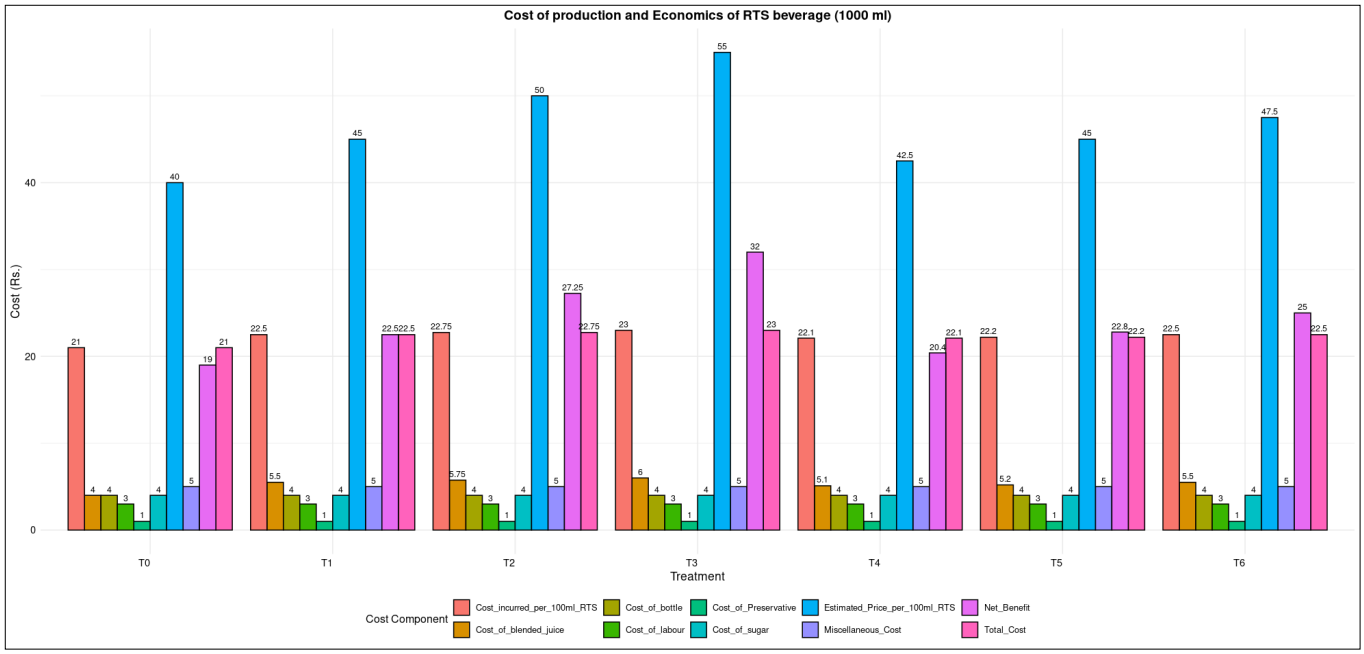

Fig.3. Cost of production and economics of Cashew apple blend RTS beverage (1000 ml) in different treatments

*Price was estimated based on the price prevailing in the local market of the respective RTS, as rated below One-litre mango RTS costs` 70/-; papaya RTScosts50/- and cashew apple RTS costs 40/-

Fig. 4. Photos showing the activities of Cashew apple RTS preparations and marketing.

Authors' contributions

SK conducted the primary study, was the methodologist in formulating RTS mixes, analyzed data and composed the original manuscript. NAKAH contributed to the analysis of research data, interpretation of results, discussion and the refining and rewriting of the text. AB participated as a writer of discussion through the horticultural inputs. NR performed the statistical analysis as graphs. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interest to declare.

Ethical issues: None

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