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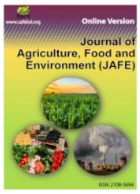

Research Article

Effect of packaging and storage of RTS beverage from *Garcinia cambogia*

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ABSTRACT

The present investigation was envisioned to develop RTS from the fruits of *Garcinia cambogia*. *Garcinia* is a popular perennial tree categorized under spice and condiment, distributed in the world's tropics. Currently, *Garcinia* is gaining attention and is considered a functional food because of its antioxidant, anti-inflammatory, anti-obesity, and antimicrobial properties. The RTS was pale yellow with a natural fruit flavour and acceptable in taste. Among the treatments T1 (Fresh *Garcinia* and Jaggery) scores maximum in organoleptic and nutrient evaluation. The developed RTS was stored for 3 months and the changes in physico-chemical parameters were observed. The initial titrable acidity was 0.32 percent. While storing acidity was found to be increased at both ambient and refrigerated temperatures with the decrease in pH. The initial TSS of the prepared RTS was 15^0 Brix. The minimum loss of ascorbic acid was observed in refrigeration storage during the storage period. The sample stored at refrigeration temperature and packed in PET bottles had a lesser percentage of nutrient loss than glass bottles. The total antioxidant activity was around 44.81 percent. An increase in reducing sugar was observed during the storage. The non-enzymatic browning and clarity of the beverage were also influenced by the storage days. A notable reduction in the tannin content of RTS was observed throughout the storage period. There was a slight increase in microbial load during storage. The mean scores of sensorial evaluations of stored *Garcinia* RTS drinks decreased gradually during the storage period.

Introduction

The world is endued with a huge array of medicinal plants. As India has a prosperous plant-based alternative medicine in the world, medicinal plants form a crucial "Natural resource". Plants have been used for centuries as remedies for human diseases because they contain many bioactive compounds that can be of interest in therapeutic value. *Garcinia cambogia* is a cultivar of the family Clusiaceae, and endemic to Western Ghats, South India. The plant in Tamil Nadu is known as "Kudampuli" where the plant leaves and fruits are used for culinary purposes. *Garcinia cambogia* fruits are edible, but too acidic to eat fresh. In Sri Lanka and India, it is commonly used as a condiment to spice curries instead of tamarind or lime and is valued economically as sun-dried smoked rind.

Indian spices and condiments have been continuously produced, consumed, and exported worldwide. More than 70% of the produced spices are consumed domestically, yet India is still the world's top exporter of spices in all their forms—raw, ground, processed, and as isolates of active ingredients.

In tropical regions, *Garcinia* is one of the naturally occurring, underutilized tree species. More than 200 species of Garcinia were distributed in Asia (Gupta *et al*., 2019). In India, particularly four species of *Garcinia* were economically important but only three varieties have been cultivated. *Garcinia indica* commonly known as Kokum grown in the Konkan region (Swami *et al*., 2014). *Garcinia cambogia* (L.) locally known as "Kudampuli or Kodapuli" is found in Kerala and used for culinary purposes. *Garcinia mangostana* is cultivated in the lower Nilgiris, Courtallam, and other parts of South India for its appetizing fruits. Gamboge used in medicines is primarily derived from the wild variety of *Garcinia morella*.

Although *Garcinia* is enriched with medicinal and nutritive properties, it is not produced commercially like mango, cashew nuts, etc. yet commonly found in the backyard as well as along the roadside plants. To gain greater commercial significance, product development, diversification, and value addition require a greater thrust and innovation. *Garcinia* is currently regarded as a functional food because of its antioxidant, antimicrobial, anti-inflammatory, and insecticidal properties. The higher bioactive components present in *Garcinia* are used to cure many lifestyle diseases. *Garcinia* with its eminent health benefits has the scope in the food industries. To acquire the benefits of Garcinia, the value addition of raw or ripe fruits through advanced processing technology is essential. Such technology minimizes fruit loss after harvest and also creates rural employment with high profit to the farmers.

Materials and Methods

2.1. Preparation of *Garcinia* RTS

RTS was prepared with Fresh and dried fruits of *Garcinia cambogia* in consort with natural sugars like palm sugar and Jaggery. The fruits were soaked in hot water (200ml) at 80^{0}C for 10 minutes. Core and seed were removed and the fruit rind parts are grinded in to fine fruit pulp. The obtained fruit pulp filtered through the muslin cloth to obtain clear juice. The different treatments for RTS production is T_{0}- Tamarind and Jaggery (control), T_{1}- Fresh *Garcinia* juice and Jaggery, T_{2}- Fresh *Garcinia* juice and palm sugar, T_{3}- Dried *Garcinia* juice and Jaggery and T_{4}- Dried *Garcinia* juice and palm sugar. According to FSSAI guidelines RTS is a type of fruit drink containing 20 % of fruit juice, acidity - 0.3 % and TSS - 15^0 brix.

Table 1. Formulae for the production of *Garcinia cambogia* RTS.

Ingredients	T_0	T_1	T_2	T_3	T_4
Control: Tamarind juice (ml)	100	-	-	-	-
Fresh *Garcinia* juice (ml)	-	100	100	-	-
Dried *Garcinia* Juice (ml)	-	-	-	100	100
Jaggery (g)	75	68.5	-	68.5	-
Palm sugar (g)	-	-	69	-	69
Water (ml)	321	327.5	327	327	325

T_{0}- Tamarind and Jaggery; T_{1}- Fresh *Garcinia* and Jaggery; T_{2}- Fresh *Garcinia* and palm sugar;
T_{3}- Dried *Garcinia* and Jaggery; T_{4}- Dried *Garcinia* and palm sugar

2.2. Sensory evaluation

Ready to serve *Garcinia* drink was evaluated organoleptically for various sensory attributes such as colour, texture, flavour, taste and overall acceptability. A panel of ten untrained judges evaluated the RTS using 9-point hedonic scale as per the procedure given by Lawless and Heymann, (2010). The samples were coded prior to presentation and place in separate panel of judges in order to get unbiased results.

2.3. Analytical methods

The *Garcinia* RTS was evaluated for different physical and chemical characteristics. The pH and TSS of the prepared RTS drink were assessed by using instruments like pH meter and Refractometer (Kale *et al.*, 2018). The sodium hydroxide was titrated against the sample to determine its acidity. For determination of ascorbic acid, 2, 6- dichloro indophenol dye was used (Sadasivam and Manickam, 2008). The Shaffer Somogyi micro method determined the sugar content of the sample. The tannin content was determined as per the method described by Rebaya *et al.* (2015). The spectrophotometer measured the non-enzymatic browning at a wavelength of 440nm. The radical scavenging activity of the samples was determined through the DPPH radical scavenging assay. The clarity was determined by measuring the absorbance at 660 nm using UV-Visible Double Beam Spectrophotometer (Rebaya *et al.*, 2015). The microbial load of the stored juice sample was computed by serial dilution technique as described by Panghal *et al.* (2017).

2. 4. Storage studies

The two packaging materials like glass bottles and PET bottles, were used to study the storage stability of *Garcinia* RTS drink. It was then kept in ambient and refrigerated conditions for a period of 60 days to assess its shelf life. Observation was recorded at 15 days interval, the samples were withdrawn and analysed for pH, soluble solids, titratable acidity, vitamin C, total antioxidant activity, reducing and total sugar, non-enzymatic browning, clarity, total plate count and sensory characteristics.

Results and Discussion

3.1. Chemical composition of RTS

The chemical composition of RTS drink from *Garcinia* was given in table 2. The data recorded shows that the highest ascorbic acid content was noted in the treatment T_1 (Fresh *Garcinia* and Jaggery) in the range of 26mg/100g. According to FSSAI guidelines, the acidity was maintained as 0.30 percent. The reducing sugar and total sugar found to be in the range of 11 g and 16g/100ml. The tannin content was found to be in the range of 2 to 3 per cent. The nutrient parameters of RTS drink shows slight changes when developed from fresh and dried fruit rind.

Table 2. The Chemical composition of *Garcinia cambogia* RTS.

Parameters	T_0	T_1	T_2	T_3	T_4
Acid (%)	0.35± 0.00^c	0.32±0.002^a	0.32±0.003^a	0.34±0.00^b	0.35±0.001^c
pH	2.24±0.03^a	3.51±0.02^b	3.51±0.05^b	3.49±0.05^b	3.48±0.05^b
TSS^0 brix	15.00±0.24^a	15.10±0.06^a	15.13±0.19^a	15.14±0.09^a	15.12±0.09^a
Reducing sugars (g)	11.68±0.11^b	12.18±0.12^c	11.98±0.08^b	10.78±0.09^a	10.99±0.07^a
Total sugars (g)	14.20±0.23^a	16.15±0.19^b	16.10±0.25^b	15.95±0.06^b	15.96±0.12^b
Ascorbic acid (mg)	2.32±0.02^a	26.00±0.01^d	25.96±0.00^d	19.86±0.19^c	19.23±0.07^b
Tannin (%)	6.04±0.09^c	2.113±0.02^a	2.111±0.02^a	3.09±0.01^b	3.10±0.01^b

^{a,b,c,}Means with the different letter within the column are significantly different (P< 0.05)
Values are Mean ± S.E (from 3 determination)

3.2. Sensory Qualities

The *Garcinia* RTS was pale yellow in colour with a natural fruit flavour and was acceptable in taste. The RTS drink developed from fresh *Garcinia* juice was good in sensory characteristics (flavour, colour, taste and consistency) than the drink from the dried fruit rinds. The dried one produce unpleasant smoky flavour and is too much acidic to consume. Based on the results of chemical composition and sensory studies, it was concluded that Treatment T_1 (Fresh *Garcinia* and Jaggery combination) was considered as best and taken for storage studies for 60 days in two packaging containers like glass and Polyethylene Terephthalate (PET) bottles at ambient and refrigerated environmental condition.

3.3. Changes in the chemical composition of the processed *Garcinia* RTS during storage.

3.3.1. Acidity and pH

Over the storage period, the acidity level of the developed RTS increased (as indicated in Table 3). The initial acid content was measured at 0.31%, and this accelerated to 0.47% in glass bottles and 0.39% in PET bottles stored at room temperature, whereas in refrigerated condition 0.38% in glass bottles and 0.36% in PET bottles was observed. As the acidity of the RTS drink increase, the pH levels decreased during storage. Initially, the pH was noted as 3.76; however, it diminished to 3.58 in glass bottles and 3.51 in PET bottles stored at room temperature. The least significant alterations in acidity and pH were observed in the RTS beverage packed in PET bottles and kept under refrigeration. Joshi *et al*. (2012) created a similar RTS beverage using Tamarind and noticed an increase in acidity during storage at both room temperature and refrigeration.

Table 3. Changes in the acid (%) and pH content of *Garcinia cambogia* RTS during storage.

Storage Days	T_1				T_2			
	P_1		P_2		P_1		P_2	
	Acidity	pH	Acidity	pH	Acidity	pH	Acidity	pH
0	0.31^a	3.76±0.04^b	0.31^a	3.76±0.05^b	0.31^a	3.76±0.05^a	0.31^a	3.76±0.03^a
15	0.35^b	3.74±0.01^b	0.33^b	3.75±0.04^b	0.32^b	3.76±0.00^a	0.32^b	3.76±0.00^a
30	0.39^c	3.72±0.05^b	0.34^b	3.70±0.01^b	0.34^c	3.74±0.03^a	0.33^c	3.75±0.00^a
45	0.44^d	3.63±0.03^a	0.36^c	3.63±0.05^a	0.37^d	3.70±0.01^a	0.34^d	3.72±0.05^a
60	0.47^e	3.58±0.05^a	0.39^d	3.51±0.00^a	0.38^e	3.67±0.00^a	0.36^e	3.70±0.06^a

For acidity, the standard error was 0.00 in all treatments

T_1- RTS stored at Ambient temperature; T_2- RTS stored at Refrigeration temperature
P_1- RTS packed in glass bottles; P_2- RTS packed in PET bottles

3.3.2. TSS

The increase in TSS content was observed during storage as given in Table 4. The minimum changes in TSS were noted in the RTS packed in PET bottles at refrigerated temperature (15.15^{0}brix). The increase in TSS was due to the hydrolysis of polysaccharides into monosaccharides and oligosaccharides. Similar increases in total soluble solids were reported in pineapple squash during storage (Akubor, 2017).

Table 4. Changes in TSS (^{0}brix) content of *Garcinia cambogia* RTS during storage.

Storage Days	T_1		T_2	
	P_1	P_2	P_1	P_2
0	15.00±0.21^a	15.00±0.01^a	15.00±0.07^a	15.00±0.17^a
15	15.16±0.11^a	15.11±0.20^a	15.00±0.060^a	15.00±0.22^a
30	15.78±0.02^b	15.43±0.02^b	15.05±0.11^a	15.02±0.02^a
45	16.03±0.21^b	15.66±0.05^b	15.12±0.18^a	15.10±0.24^a
60	16.89±0.10^c	16.00±0.03^c	15.18±0.08^a	15.15±0.10^a

[a,b,c]Means with the different letter within the column are significantly different (P< 0.05)
Values are Mean ± S.D (from 3 replication)
T_1- RTS stored at Ambient temperature; T_2- RTS stored at Refrigeration temperature
P_1- RTS packed in glass bottles; P_2- RTS packed in PET bottles

3.3.3. Ascorbic acid

Storage had an adverse impact on the ascorbic acid content of Garcinia RTS (table 5), leading to a reduction from the initial 26mg/100g to 22.05mg/100g in PET bottles stored at room temperature and 24.56mg/100g when stored in refrigerated conditions. Take and Mohit (2013) observed a declining pattern in the ascorbic acid content of blended RTS (a mixture of kokum juice, lime juice, and pineapple juice). The decline in ascorbic acid could be attributed to oxidation caused by factors like light exposure and storage temperature. Higher storage temperatures were found to particularly influence the reduction in ascorbic acid content.

Table 5. Changes in ascorbic acid (mg/100g) of *Garcinia cambogia* RTS during storage.

Storage days	T_1		T_2	
	P_1	P_2	P_1	P_2
0	26.00±0.06^c	26.00±0.07^c	26.00±0.15^c	26.00±0.13^c
15	25.75±0.34^c	25.55±0.34^c	25.00±0.26^b	25.59±0.10^b
30	24.71±0.21^b	24.45±0.34^b	24.75±0.00^b	24.85±0.21^a
45	23.02±0.36^a	23.65±0.37^b	23.44±0.29^a	24.58±0.10^a
60	22.25±0.35^a	22.05±0.22^a	23.05±0.07^a	24.56±0.02^a

[a,b,c]Means with the different letter within the column are significantly different (P< 0.05)
Values are Mean ± S.D (from 3 replication)
T1- RTS stored at Ambient temperature; T2- RTS stored at Refrigeration temperature
P1- RTS packed in glass bottles; P2- RTS packed in PET bottles

3.3.4. Total antioxidant activity

The decrease in overall antioxidant effectiveness during the storage period was shown in Table 6. At the end of storage, the decline in total antioxidant activity ranged between 44.81 to 42.08 for RTS stored in glass bottles at room temperature, and from 44.81 to 42.90 for RTS stored in PET bottles. The least decline in total antioxidant activity was observed in the RTS contained in PET bottles. Klimczak *et al.* (2007) observed a significant reduction in antioxidants after six months of storing orange juice.

Table 6. Changes in Total Antioxidant Activity (TAA) per cent of *Garcinia cambogia* RTS during storage.

Storage days	T_1		T_2	
	P_1	P_2	P_1	P_2
0	44.81±0.19 c	44.81±0.24 d	44.81±0.22 c	44.81±0.36 a
15	44.26±018 bc	44.71±0.15 cd	44.81±0.54 c	44.68±0.12 a
30	43.38±0.61 ab	43.96±0.08 bc	42.98±0.70 b	44.38±0.67 a
45	42.96±0.42 ab	43.28±0.33 ab	42.06±0.65ab	43.96±0.53 a
60	42.08±0.51a	42.90±0.37 a	41.06±0.15 a	43.28±0.64 a

T1- RTS stored at Ambient temperature; T2- RTS stored at Refrigeration temperature
P1- RTS packed in glass bottles; P2- RTS packed in PET bottles

3.3.5. Reducing sugar and total sugars

RTS stored under room temperature showed the highest increase in reducing and total sugars (table 7), with levels increasing from 12.18 to 12.42 g in glass bottles and 12.18 to 12.41 g in PET bottles, in contrast to those stored in the refrigerated condition. The total sugar content of the RTS, initially stored at both room temperature and refrigeration, was found to have risen to 16.12g/100g by the end of the 60-day storage period. In both storage conditions, the samples kept in PET bottles seems to have better retention of the total sugar content compared to those in glass bottles. A similar trend of increasing total sugar content was observed in apple beverage stored for 270 days, as documented by Kumari *et al.* (2015).

Table 7. Changes in sugars (g/100g) content of *Garcinia cambogia* RTS during storage.

Storage days	T_1				T_2			
	P_1		P_2		P_1		P_2	
	Reducing sugar (g)	Total Sugar (g)	Reducing sugar (g)	Total Sugar (g)	Reducing sugar (g)	Total Sugar (g)	Reducing sugar (g)	Total Sugar (g)
0	12.18±0.09a	16.12±0.1 a	12.18±0.10 a	16.12±0.17 a	12.18±0.18 a	16.12±0.04 a	12.18±0.07 a	16.12±0.07 a
15	12.29±0.02 a	16.32±0.03 ab	12.29±0.08 a	16.30±0.15 ab	12.20±0.13 a	16.17±0.24 a	12.20±0.04 a	16.15±0.11 a
30	12.35±0.14 a	16.47±0.25 ab	12.32±0.03 a	16.37±0.11 ab	12.25±0.19 a	16.28±0.27 a	12.24±0.24 a	16.25±0.00 a
45	12.38±0.02 a	16.58±0.11 ab	12.30±0.10 a	16.50±0.07 ab	12.29±0.08 a	16.35±0.26 a	12.28±0.25 a	16.33±0.05 a
60	12.42±0.02 a	16.75±0.09 b	12.41±0.04 a	16.72±0.26 c	12.38±0.20 a	16.57±0.27 a	12.31±0.25 a	16.49±0.07 a

T_1- RTS stored at Ambient temperature; T_2- RTS stored at Refrigeration temperature
P_1- RTS packed in glass bottles; P_2- RTS packed in PET bottles

3.3.6. Non enzymatic browning and Clarity

During the storage period, the non-enzymatic browning in RTS underwent a gradual increase at room and refrigeration temperatures (Table 8). The non-enzymatic browning of freshly prepared *Garcinia cambogia* was recorded as 0.165abs. At the end of ambient room temperature storage, the non-enzymatic browning increased to 0.198abs (glass bottles) and 0.195abs (PET bottles), after refrigerated storage it increased to 0.188 abs (glass) and 0.179 abs (PET), respectively. The freshly prepared RTS had a clarity of 0.075. The clarity showed a decreasing trend during ambient storage 0.065 and 0.066, whereas 0.068 and 0.070 at Abs during refrigerated storage in glass and PET bottles respectively. The PET bottle packed *Garcinia cambogia* RTS exhibited minimal changes during refrigeration storage. Vishal *et al.*, (2015) studied the storage characteristic of papaya juice and claimed that it can be used 30 days by storing in low temperature. Vishal *et al.* (2015) studied the storage characteristics of papaya juice and claimed that it can be utilised for 30 days by storing it at a low temperature.

Table 8. Changes in Clarity (660 nm absorbance) and non-enzymatic browning (440 nm absorbance) of *Garcinia cambogia* RTS.

Storage days	T_1				T_2			
	P_1		P_2		P_1		P_2	
	NEB	Clarity	NEB	Clarity	NEB	Clarity	NEB	Clarity
0	0.165a	0.075 d	0.165 a	0.075 d	0.165 a	0.075 d	0.165 a	0.075 c
15	0.168 ab	0.072 c	0.167 a	0.072 c	0.165 a	0.074 cd	0.165 a	0.074 bc
30	0.172 b	0.070 b	0.170 a	0.071 c	0.168 a	0.072 bc	0.166 a	0.073 bc
45	0.182 c	0.069 b	0.181 b	0.068 b	0.176 b	0.070 ab	0.169 a	0.072 ab
60	0.198 d	0.065 a	0.195 c	0.066 a	0.188 c	0.068 a	0.179 b	0.070 a

T_1- RTS stored at Ambient temperature; T_2- RTS stored at Refrigeration temperature
P_1- RTS packed in glass bottles; P_2- RTS packed in PET bottles

3.3.7. The Microbial load of *Garcinia cambogia* RTS during storage

The initial and stored microbial load of developed RTS was given in table 9. The increasing microbial population was found in RTS stored at ambient temperature. Comparing with glass bottles RTS packaged in PET bottles shows the minimum changes. Akubor *et al.* (2017) observed the increasing microbial load from initial (10 cfu/g) to final end of storage days (30 cfu/g). The microbial counts at the end of the storage period were insignificant in comparison to 2000 cfu/g, which is considered acceptable for foods. Therefore, no microbial hazard was associated to the storage of Garcinia RTS drink.

Table 9. Microbial changes in the *Garcinia cambogia* RTS during storage.

Microbes	Storage days	T_1		T_2	
		P_1	P_2	P_1	P_2
Bacteria	Initial (0 days)	1.0	1.0	1.0	1.0
(x10^{-6} cfu/ml)	Final (60 days)	5.0	4.0	3.0	2.0
Yeast	Initial (0 days)	1.0	1.0	1.0	1.0
(x10^{-5} cfu/ml)	Final (60 days)	4.0	3.0	2.0	2.0
Fungi	Initial (0 days)	1.0	1.0	1.0	1.0
(x10^{-4} cfu/ml)	Final (60 days)	4.0	3.0	2.0	1.0

T_1- RTS stored at Ambient temperature; T_2- RTS stored at Refrigeration temperature
P_1- RTS packed in glass bottles; P_2- RTS packed in PET bottles

3.3.8. Organoleptic characteristics of *Garcinia cambogia* RTS during storage

The quality attributes of the samples packed in glass and PET bottles showed a very slight difference during the ambient and refrigerated storage conditions. The beverages stored at refrigeration temperature obtained a higher value in all the quality attributes viz., colour and appearance, body, flavour, taste and overall acceptability than at ambient temperature. The initial overall acceptability score values were 8.5 and 8.6 in glass bottles and PET bottles whereas 8.5 and 8.7 at refrigerated condition. At the end of 60 days, scores ranged are 7.6,7.8,7.7 and 8.0. The *RTS* prepared from *Garcinia cambogia* had good organoleptic character up to 60 days of storage.

Table 10. Changes in the organoleptic characteristics of *Garcinia cambogia* RTS during storage.

Parameters		Colour and Appearance		Flavour		Body		Taste		Overall acceptability	
		P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
Initial	T_1	8.9	8.9	8.4	8.5	8.5	8.6	8.5	8.7	8.5	8.6
	T_2	8.8	8.9	8.5	8.6	8.3	8.5	8.5	8.8	8.5	8.7
Final (60 days)	T_1	7.9	8.0	8.3	8.3	7.0	7.2	7.3	7.8	7.6	7.8
	T_2	8.0	8.2	8.4	8.5	7.2	7.4	7.4	7.9	7.7	8.0

T_1- RTS stored at Ambient temperature;
T_2- RTS stored at Refrigeration temperature P_1- RTS packed in glass bottles; P_2- RTS packed in PET bottles

Conclusion

Results of study concluded that the *Garcinia* RTS drink with fresh juice and jaggery got the highest organoleptic score and were stored upto 60 days. During storage acidity, TSS, total sugar and reducing sugar were increased whereas TSS, pH, ascorbic acid, clarity and antioxidant activity were decreased. The RTS beverages stored at refrigeration temperature obtained a higher value in all the quality attributes viz., appearance and colour, taste, body, flavour, and overall acceptability than at room temperature. When comparing the two packaging materials PET bottles has good barrier properties for preserving the nutrients than the glass bottles.

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