



Development and Quality Evaluation of Ready to Serve (RTS) Beverage from Banana Pseudo Stem

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Vegetable beverage was part of a balanced diet that make sure the vigor and healthy body. Vegetable juices were rich in fiber content which was quickly inducing the feeling of satiety and also improve digestion. The objective of this study was to formulate and prepare ready to serve (RTS) banana pseudo stem beverage. Two banana varieties were selected viz., ottu vazhai (syn Mupaddai) (V₁), vayal vazhai (V₂). Banana pseudo stem beverage was developed from banana tender core, natural flavorings (lemon, mint)extracts, 2% citric acid as a anti-browning agent, KMS (70ppm) as preservative and CMC (0.1%) as a stabilizer. The proximate composition, physico-chemical analysis, sensory evaluation and microbial study of the pseudo stem beverage was evaluated using standard procedures. The beverages were evaluated at 15 days interval period. During storage conditions the quality of juice with minimum significant changes in chemical properties was observed with the addition of KMS. Based on the sensory evaluation, lemon juice flavored pseudo stem beverage was highly accepted by consumer than mint flavored beverage.

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Storage study for the pseudo stem beverage was also carried out and significant difference was noticed in beverage. Compare to vayal vazhai (V_2), the yield of juice (87.0%) content was higher in ottu vazhai (syn Mupaddai) (V_1). The maximum desirable results were obtained from (V_1) lemon flavored beverage stored at refrigeration condition. The results were showed that pH (3.28 to 4.75), TSS (12 to 14.0° brix), Acidity (0.35 to 0.26) and vitamin C (0.77 to 0.59). From the storage studies, the lemon flavored pseudo stem beverage (Mupaddai variety V_1) was found to be the best in nutrient retention and sensory evaluation than mint flavour beverage and it was accepted up to 45 days.

Keywords: *Banana pseudo stem; browning reaction; pasteurization; blanching; antioxidant.*

ABBREVIATIONS

RTS-Ready to serve, KMS - Potassium metabisulphite, CA- Citric acid, CMC - Carboxymethyl cellulose, TSS-Total soluble solids, DNA - Deoxyribonucleic acid, ROS - Reactive oxygen species, TPC-Total plate count, YMC- yeast and mould count.

1. INTRODUCTION

Banana was one of the major fruit crop grown in India and area and production wise it stands second position. The banana stem otherwise known as pseudo stem. The pseudo stem juice contains rich fiber. Pseudo stem (vegetable) used as common foods in some regions of India (CFTRI, Mysore). Banana pseudostem which one considered as waste material and create environmental problem, now it greatly used for nutritious food [1].

After harvesting of the banana, disposing of the pseudo stem in the field was one of the problem. An average, 60 to 80 tones/hecter of the pseudo stem wasted alone. The banana tender core mainly contains 90% moisture content and it cannot be maintain long period of time [2]. The banana pseudo stem is highly perishable, because it comprises more moisture content and had a short shelf life [3]. The banana tender core rich in fiber content and it helps in weight control. The high fiber content relieves the constipation. It also rich in potassium and vitamin B6, it helps to detoxify the body being a diuretic. So, the tender core juice best remedy for kidney stones [4].

Fruit extracts that was rich in antioxidants such as lemon juice were used as an effective agent in decreasing intracellular ROS concentration and protecting lipid, DNA and mitochondrial functionality from the damage induced by free radicals. Lemons are an excellent source of vitamin C and flavonoids, which are antioxidants. Lemon juice has several important chemical components with therapeutic features such as

citric acid (Vitamin C, 2-hydroxy-1,2,3-propanetricarboxylic acid) [5]. Citrus fruits are also known to contain bioactive compounds such as phenolics, flavonoids, vitamins, and essential oils which are believed to be responsible for a range of protective health benefits including anti-oxidative, anti-inflammatory, antitumor, and antimicrobial activities. Citrus juices are consumed majorly because of their nutritional value and special flavor [6].

Mint leaves were well known herb and considered stimulant, carminative and antispasmodic. It leaves was good source of β -carotene, calcium, Iron, and vitamin C. It had antibacterial effect [7]. Mint was also a rich source of polyphenolic compounds and hence it had strong anti-oxidant properties [8]. It was used in the food industry as an additive in beverages or food products. Intensely fragrant mint essential oil contained primarily in the leaves of this plant [9]. The present study was focused with an objective to formulate and analyze the acceptability of the naturally flavored pseudo stem RTS beverage and to evaluate the quality attributes of the formulated RTS beverage, such as the sensorial, microbiological and physicochemical changes of the developed RTS beverage, during storage under different storage conditions.

2. MATERIALS AND METHODS

The variety of banana pseudo stem such as Ottu vazhai (syn Mupaddai), vayal vazhai was procured from Kovilpappakudi & Thathakkoundampatti, Madurai district, Tamil Nadu, India. Natural flavorants such as lemon, mint was purchased from local market, Madurai, India.

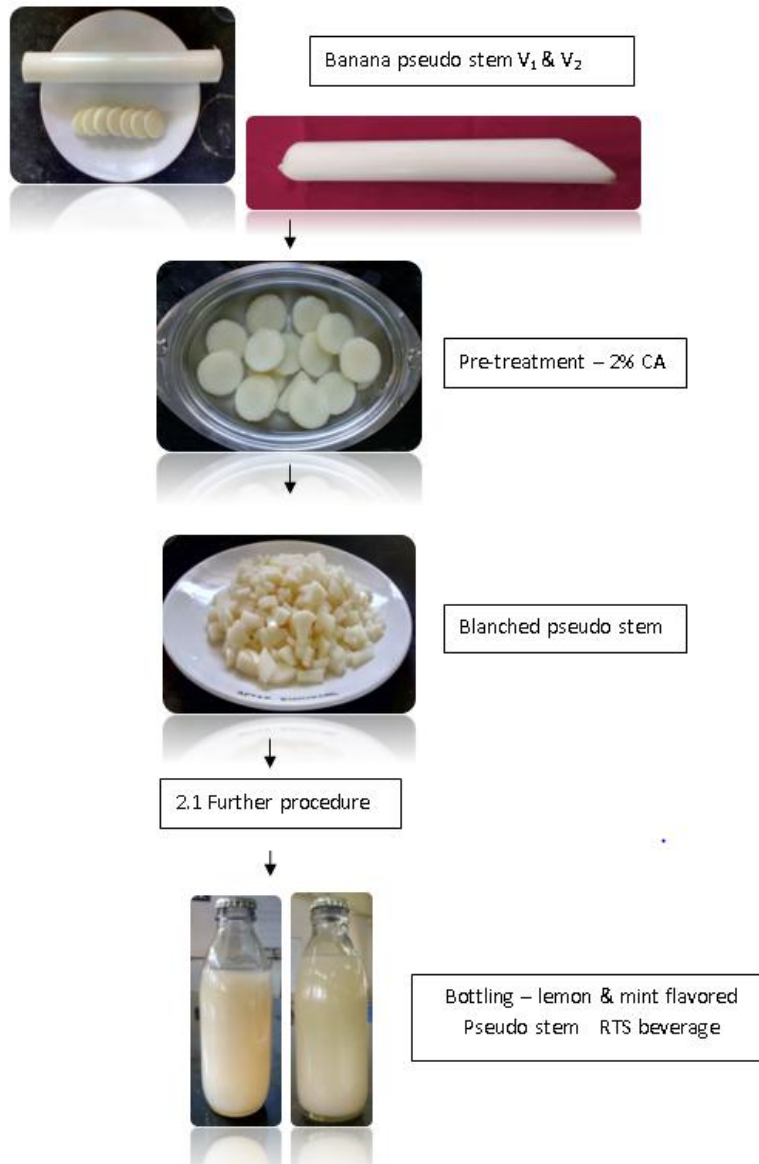
2.1 Preparation of Banana Pseudo Stem Juice

Banana pseudo stem (1 kg) was weighed and washed thoroughly. Pseudo stem center core

was cut into slices and fiber was removed. The pseudo stem were chopped into cube shape and it was soaked in citric acid (2%) solution for 10 mins, to prevent the browning reaction. The banana pseudo stem were steam blanched at 65°C for 3 mins, the pseudo stem was crushed using the mechanical crusher. The juice extracted was filtered through muslin cloth, juice and water was mixed in the ratio of 3:1. The beverage was prepared using sugar solution. The natural flavours of lemon juice and mint (20 ml extract /lit) was added separately. The prepared banana pseudo stem juice was

pasteurized at 72–80°C temperature. It was cooled and then preservative (70ppm KMS), stabilizer (0.1%CMC) were added. Beverage was filled in sterilized glass bottle (150 ml), leaving the head space of 1 cm. The bottles were crown corked air tightly. The crown corked bottles were heated up to 72–80°C for 20 mins and then stored at ambient and refrigerated condition. Control pseudostem RTS beverage also prepared as per following procedure by using local variety pseudo stem. Without addition of natural flavorings control was developed.

2.1.1 Preparation process



2.2 Chemical Analysis

The control and flavored banana pseudo stem beverage physico-chemical properties were analysed such as total soluble solids, pH, titrable acidity and vitamin C. The stored samples were analysed at 15 days interval periods during storage condition. The total soluble solids content was recorded by using the hand refractometer. Then, the digital pH meter was used to recorded pH of the pseudo stem beverage. Titrable acidity, total sugar, reducing sugar, starch, phenols was determined as given by Sadasivam and Manickam (2008) [10]. Total acidity (% citric acid), vitamin C, and microbial study were estimated as given by Ranganna (2000) [11].

2.3 Sensory Analysis

The prepared sample of the flavored pseudo stem RTS beverage was evaluated for sensory characteristics on the basis of colour & appearance, flavour, consistency, taste and overall acceptability on a 9 point hedonic scale (9 and 1 point showing like extremely and dislike). The panel of 20 members was used for sensory evaluation throughout the storage period.

2.4 Microbial Analysis

The quality of developed pseudo stem RTS beverage was based on the number and kind of microorganisms present, which was determined by Total plate count method. Commonly used media for enumeration of bacteria and fungi was plate count agar and potato dextrose agar. The total plate count was determined by observing the colonies formed especially bacteria and fungi.

2.5 Statistical Analysis

The results of the chemical analysis was analysed statistically by ANOVA using computer aided AGRES statistical analysis package to evaluate the significance at $P < 0.05$. All the obtained data from test was triplicate and it was subjected to the single factorial completely randomized design AGRES software.

3. RESULTS AND DISCUSSION

3.1 Proximate Composition

Table 1 showed that proximate composition of the developed pseudo stem beverage. Pseudo

stem Juice yield (%) from the two varieties also differs. Comparing the two varieties of banana pseudo stem, variety1 provides high yield (87%) of juice content. Dawn et al., (2016) reported that the banana tender core mainly contains 90 % moisture content [2]. The control sample V_0 had TSS (12° brix), pH (5.7), acidity (0.17%), vitamin C (0.61 mg) and protein content (3 g), total sugar, reducing sugar and starch was nearly (8.61, 6.34 and 20.78) g respectively. The V_0 sample had (51.92) mg phenols and (11.03) mg flavonoids. The lemon flavored pseudo stem RTS beverage from V_1 & V_2 had TSS content (12° brix), pH (3.28, 3.23), acidity (0.35%, 0.38%), vitamin C (0.77,0.73) mg and protein content (3.20,3.11)g. Total sugar, reducing sugar and starch content of lemon flavored beverage from V_1 & V_2 was (16.2, 15.40) g, (9.01, 8.57) g and (22.73, 21.34) g respectively. The lemon flavored RTS had nearly V_1 (53.11) mg, V_2 (52.42) mg of phenol content and V_1 (14.02) mg, V_2 (13.38) mg of flavonoids. The mint flavored pseudo stem RTS from V_1 & V_2 had TSS content nearly (12° brix), pH (3.41, 3.52), acidity (0.33%, 0.35%), vitamin C (0.76,0.71) mg and protein content (3.18,3.25) g. Total sugar, reducing sugar and starch content of ginger flavored beverage from V_1 & V_2 was (15, 14.50) g, (8.04, 8.72) g and (23.14, 22.40) g respectively. The mint flavored RTS had nearly V_1 (53.21) mg, V_2 (52.07) mg of phenol content and V_1 (13.73) mg, V_2 (13.07) mg of flavonoids. Bhaskar et al. (2011) researched that proximate composition of banana pseudo stem, had 2.5% protein, 1.7% fat, 27.3% starch, 3.4% free sugar, 1.4% soluble dietary fiber, 27.4% insoluble dietary fiber, 0.3% ash, 15.1% moisture respectively [12]. Aziz et al. (2011) researched the proximate composition of banana pseudostem. The banana pseudo stem had the 8.8% moisture, 3.5% protein, 1.2% fat, 10.1% ash, 19.5% crude fiber, 56.9% total carbohydrate respectively [13].

3.2 Changes in Chemical Constituent of Pseudo Stem (RTS) Beverage

The storage studies for prepared pseudo stem RTS beverage were conducted. Table 2 showed that the results for pH, TSS, acidity, vitamin C of control as well as lemon juice flavored pseudo stem beverage. In refrigerated storage condition, significantly slight variation only occurs in pH, TSS acidity and vitamin C of the naturally flavored banana pseudo stem beverages.

Table 1. Proximate composition of ready to serve (RTS) non-flavored, lemon and mint flavored banana pseudo stem beverage

S.No	Parameters	Non flavored		Lemon flavored		Mint flavored	
		V ₀	V ₁	V ₂	V ₁	V ₂	
1.	pH	5.7±0.011	3.28±0.075	3.23±0.068	3.41±0.040	3.52±0.039	
2.	TSS °brix	12.0±0.081	12.0±0.084	12.0±0.028	12.0±0.056	12.0±0.197	
3.	Acidity %	0.17±0.001	0.35±0.009	0.38±0.010	0.33±0.004	0.35±0.002	
4.	Protein g	3.00±0.014	3.20±0.009	3.11±0.018	3.18 ±0.020	3.25±0.070	
5.	Total Sugar g	8.61±0.210	16.2±0.286	15.40±0.353	15.0 ±0.185	14.50±0.093	
6.	Reducing Sugar g	6.34±0.138	9.01±0.084	8.57±0.217	8.04 ±0.061	8.72±0.051	
7.	Starch g	20.78±0.636	22.73±0.107	21.34±0.427	23.14±0.131	22.40±0.198	
8.	Phenols mg	51.92±1.554	53.11±1.502	52.42±0.957	53.21±0.340	52.07±0.736	
9.	Flavonoids mg	11.03±0.142	14.02±0.074	13.38±0.078	13.73±0.258	13.07±0.069	
10.	Vitamin C mg	0.61±0.007	0.77±0.001	0.73±0.018	0.76±0.006	0.71±0.014	

V₀-control, V₁- Ottu vazhai (syn Muppada), V₂- Vayal vazhai. Values are Mean ± S.E from 3 determinations

3.2.1 Changes in pH

The results showed that no significance ($P<0.05$) difference was noticed in pH values during storage condition. The pH was slightly increased after 15th day of storage period and rapid increase in pH was observed on the 45th day of the ambient storage condition. So, pH was significantly ($P<0.05$) increased with gradual storage conditions. When compare to mint flavour, lemon flavored pseudo stem beverage from V₁ had minimum changes in pH content (4.75) at R₂ condition. Islam, M. A., et al., (2014) in his study revealed that there was a significant increase in pH (5.6) during storage period. This might be due to decrease in titrable acidity, as acidity and pH are inversely proportional to each other [14]. Hirdyani, H. (2015) reported that there was a significant decrease in pH during storage. This might be due to increase in titrable acidity [15].

3.2.2 Changes in TSS

At initial storage condition, there was no significant ($P<0.05$) difference noticed in TSS. The beverage TSS level was significantly ($P<0.05$) increased with gradual storage conditions. So, lemon flavored pseudo stem beverage from V₁ had minimum changes in TSS content (14.0° brix) at R₂ condition than mint flavored pseudo stem beverage. Hirdyani, H. (2015) reported that the TSS increased with gradual passage of storage time, which might be due to hydrolysis of polysaccharides into monosaccharide and oligosaccharides [15]. Jan and Masih (2012), Deka and Sethi (2001) in their studies revealed that in juice blends found an

increasing trend in total soluble solids during storage at ambient and low temperature in lime - aonla and mango pineapple spiced RTS beverages [16,17].

3.2.3 Changes in acidity

The significant difference ($P<0.05$) was present in the acidity of the sample during R₁ and R₂ storage condition. So, the acidity level of beverage was significantly ($P<0.05$) decreased. So, lemon flavored pseudo stem beverage from V₁ had minimum changes in acidity level (0.28%) at R₂ condition. Comparing these two natural flavors, Lemon flavored pseudo stem beverage from V₁ had the desirable acidity content during R₂ storage condition. Del Caro et al. (2004) reported that Titrable acidity was decreased during storage. This might be due to conversion of acids into salts and sugars by enzymes particularly invertase [18]. Hirdyani, H. (2015) reported that there was a significant decrease in titratable acidity content during storage condition; this was due to the decreasing amount of Kinnow juice in the respective blends [15].

3.2.4 Changes in Vitamin C

Significant difference ($P>0.05$) was observed in the vitamin C content of the ambient (R₁) and refrigerated (R₂) stored sample. The vitamin C content of the sample was decreased from initial day to 45th day. So, the vitamin C level of beverage was significantly decreased. So, lemon flavored pseudo stem beverage from V₁ had minimum changes in vitamin C content (0.59 mg) at R₂ condition. Comparing these two natural flavors, Lemon flavored pseudo stem beverage from V₁ had the desirable vitamin C content

during R₂ storage condition. Singh et al (2018) reported that Vitamin C content decreased significantly during storage under 25°C as compared to 10°C. The reduction in Vitamin C during storage could be due to its oxidation to dehydro-ascorbic acid [19]. Similar results were shown by Majumdar et al. (2009) reported 74% loss of vitamin C in cucumber-litchi-lemon juice after six months of storage [20].

3.3 Sensory Evaluation

The prepared banana pseudo stem beverage was organoleptically evaluated by using 9 point hedonic scale. It was observed that the highest sensory score was obtained for lemon flavored pseudo stem beverage. Based on nutritional and sensory score, lemon flavored pseudo stem beverage was highly accepted than mint flavored one. Figs. 1,2,3 and 4 illustrate the sensory characteristics based on the mean scores for all the quality attributes (colour and appearance, flavour, consistency, taste and overall acceptability) of the beverage samples stored at two different temperatures. Initially, all the flavored beverage samples got a score of nearly (8.2 to 8.5) by all the panel members for all of the above quality attributes. During the shelf life storage study, there was observed minimum changes in the sensory score for refrigerated stored lemon flavored samples with an overall quality attributes score of nearly (7.8 to 8) (Figs. 1 and 3). There were few changes in the sensory score for refrigerated stored mint flavored samples with overall quality attributes score of nearly (7.0 to 7.2) (Figs. 2 and 4). In the

ambient condition stored samples, there were slight changes in all the above sensory quality observed for the first 30 days, thereafter, there was a deteriorates in the quality attributes of ambient condition stored samples. So, the rapid changes were observed in consistency and taste of the beverage at the end of the 45th day.

Based on sensory evaluation, the lemon flavored pseudo stem RTS beverage was had higher acceptability till their storage studies. Comparing two banana varieties, lemon flavored pseudo stem RTS beverage from V₁ was highly accepted by consumer (Fig. 5).

3.4 Microbial Changes of Banana Pseudostem Beverage

Initially there was no microbial count observed in the developed beverage samples. There was no bacterial, fungi growth observed in the refrigerated samples, throughout their shelf life study for 45 days. In the case of the ambient condition stored samples, there was no growth seen over the 25 days storage period. After that, slight growth of bacteria was observed concerning the total plate count (0.98×10^{-6} CFU/mL) at the completion of 30 days. The quality of ambient condition stored samples started deteriorates after 30 days, and there was higher bacteria growth observed (2×10^{-6} CFU/mL) at end of 45 days, but it was within the permitted limit. There was no fungi growth seen over the 45 days ambient storage period. FSSAI (2017) reported that the microbiological

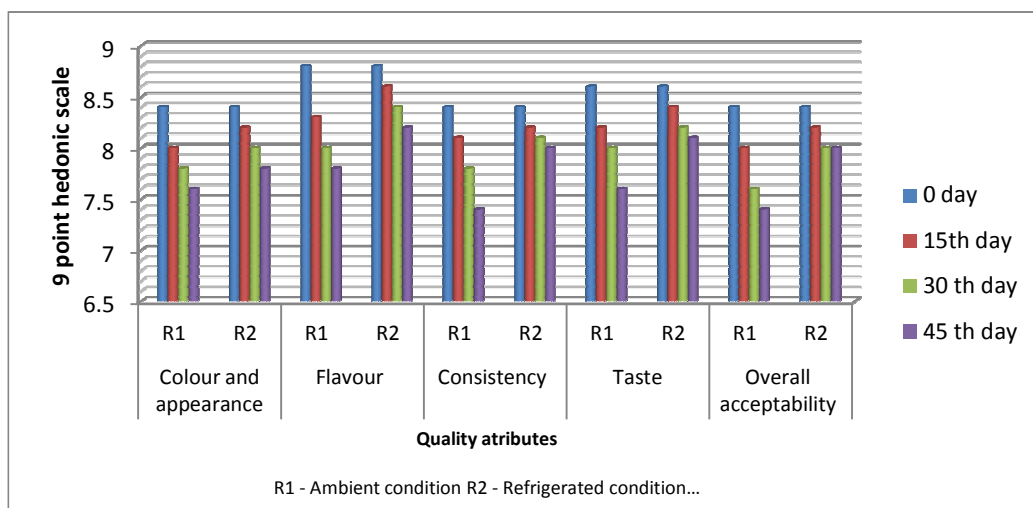


Fig. 1. V₁ sensory profile of lemon flavored pseudo stem RTS beverage during storage at ambient and refrigerated condition

Table 2. Changes in control and lemon flavored banana pseudostem RTS beverage during storage period

Parameters	Storage temperature	Non- flavored		Lemon flavored			
		V ₀		V ₁		V ₂	
		Initial	Final	Initial	Final	Initial	Final
pH	R ₁	5.7±0.043 ^d	6.4±0.165 ^a	3.28±0.075 ^d	5.08±0.152 ^a	3.23±0.068 ^d	5.14±0.076 ^a
	R ₂	5.7±0.020 ^d	6.5±0.048 ^a	3.28±0.063 ^d	4.75±0.158 ^a	3.23±0.081 ^d	4.86±0.069 ^a
TSS	R ₁	3.0±0.003 ^d	4.5±0.146 ^a	12.0±0.084 ^c	14.8±0.352 ^a	12.0±0.028 ^d	15.0±0.367 ^a
	R ₂	3.0±0.019 ^d	4.3±0.114 ^a	12.0±0.169 ^c	14.0±0.381 ^a	12.0±0.120 ^d	14.4±0.225 ^a
Acidity	R ₁	0.17±0.001 ^a	0.12±0.003 ^d	0.35±0.009 ^a	0.23±0.005 ^d	0.38±0.010 ^a	0.24±0.008 ^d
	R ₂	0.17±0.003 ^a	0.13±0.002 ^d	0.35±0.007 ^a	0.28±0.005 ^d	0.38±0.004 ^a	0.25±0.003 ^d
Vitamin C	R ₁	0.61±0.011 ^a	0.31±0.004 ^d	0.77±0.001 ^a	0.50±0.007 ^d	0.73±0.018 ^a	0.49±0.015 ^d
	R ₂	0.61±0.013 ^a	0.41±0.005 ^d	0.77±0.021 ^a	0.59±0.005 ^d	0.73±0.015 ^a	0.56±0.003 ^d

ambient temperature (R₁), refrigerated temperature (R₂), V₀ - control V₁- ottu vazhai (syn Muppattai), V₂- vayal vazhai,
^{a-d}Values are means of 4 replicates. Means in the same column followed by different superscripts are significantly different at P<0.05

Table 3. Changes in mint flavored banana pseudostem RTS beverage during storage period

Parameters	Storage temperature	Mint flavored			
		V ₁		V ₂	
		Initial	Final	Initial	Final
Ph	R ₁	3.41±0.040 ^d	5.02±0.020 ^a	3.52±0.039 ^d	5.17±0.154 ^a
	R ₂	3.41±0.070 ^d	4.78±0.003 ^a	3.52±0.078 ^d	4.88±0.019 ^a
TSS	R ₁	12.0±0.056 ^c	14.6±0.387 ^a	12.0±0.197 ^d	14.8±0.261 ^a
	R ₂	12.0±0.007 ^d	14.1±0.152 ^a	12.0±0.304 ^d	14.2±0.463 ^a
Acidity	R ₁	0.33±0.004 ^a	0.25±0.001 ^d	0.35±0.002 ^a	0.24±0.008 ^d
	R ₂	0.33±0.006 ^a	0.27±0.002 ^d	0.35±0.003 ^a	0.27±0.008 ^d
Vitamin c	R ₁	0.76±0.006 ^a	0.49±0.010 ^d	0.71±0.014 ^a	0.48±0.001 ^d
	R ₂	0.76±0.015 ^a	0.56±0.003 ^d	0.71±0.017 ^a	0.58±0.012 ^c

ambient temperature (R₁), refrigerated temperature (R₂), V₀ - control V₁- ottu vazhai (syn Muppattai), V₂- vayal vazhai,

^{a-d}Values are means of 4 replicates. Means in the same column followed by different superscripts are significantly different at P<0.05

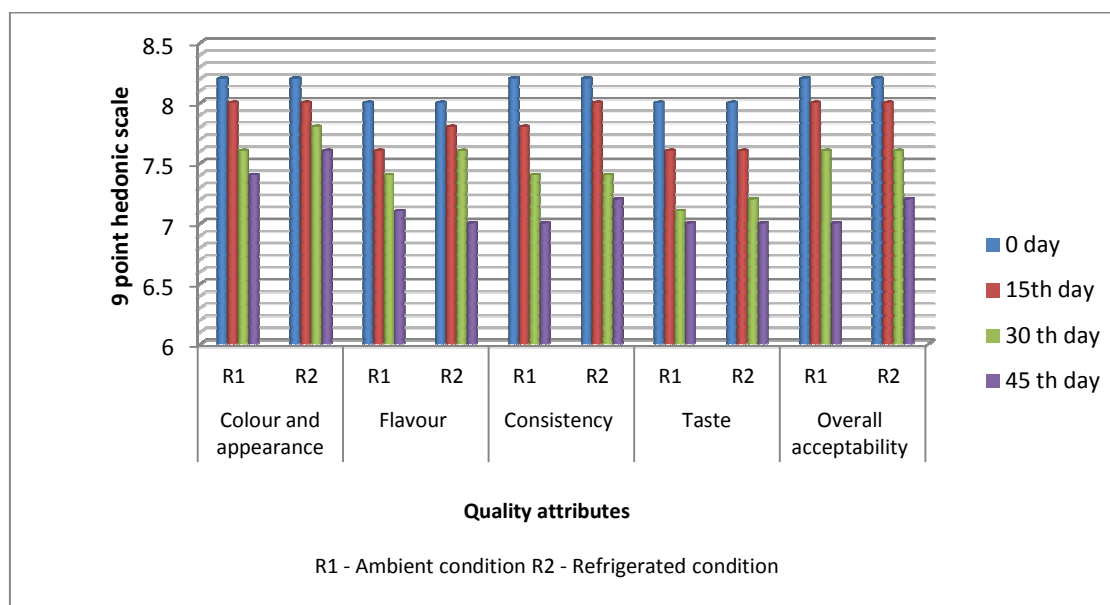


Fig. 2. V₁ - sensory profile of mint flavored pseudo stem RTS beverage during storage at ambient and refrigerated condition

requirements of fruit juices, carbonated beverage, ready to serve beverage including fruit beverages were not more than 50 CFU/ml for TPC, not more than 2 CFU/ml for YMC [21]. The study results indicated that microbial quality of pseudo stem beverage was satisfactory. It was still remain fresh for up to 45 days at refrigerated condition. It was safe for consumption. The quality of banana pseudo stem beverage was safely maintained by pasteurization process and

could be preserved by the addition of potassium metabisulphite. Afreen et al (2018) in his study reveals that no bacterial growth was observed in the freshly made RTS beverage samples. Therefore, there was no total plate count in these samples [22]. Swarnalakshmi et al (2019) reported that total plate count was found to be <10 which showed that the product would still remain fresh for 30-45 days when refrigerated [23].

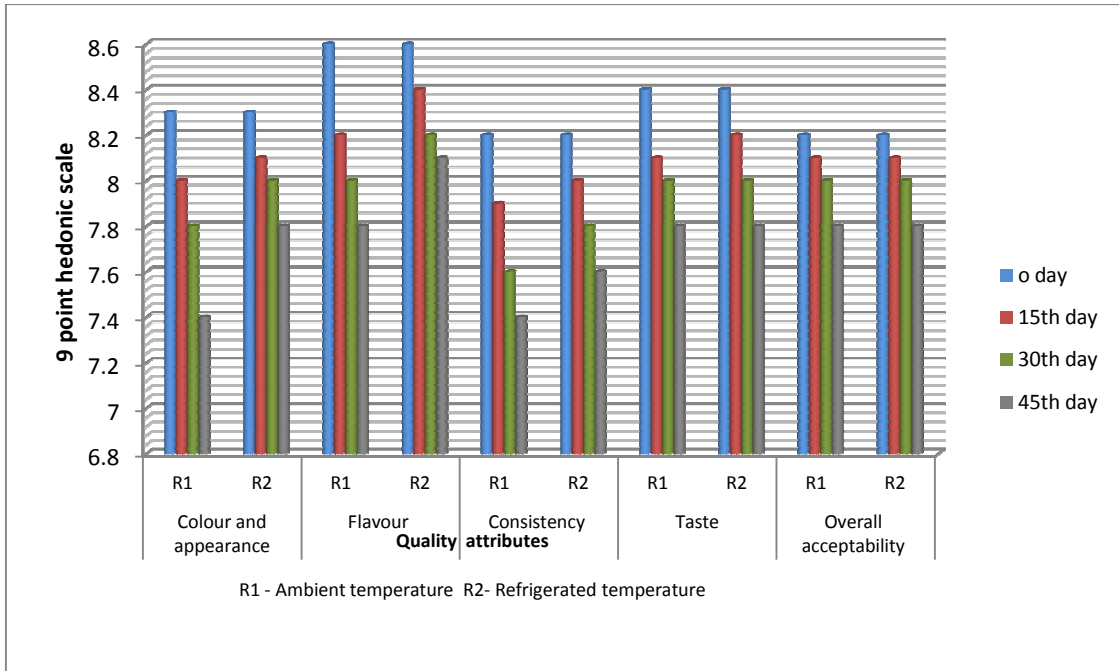


Fig. 3. V₂- sensory profile of lemon flavored pseudo stem RTS beverage during storage at ambient and refrigerated condition

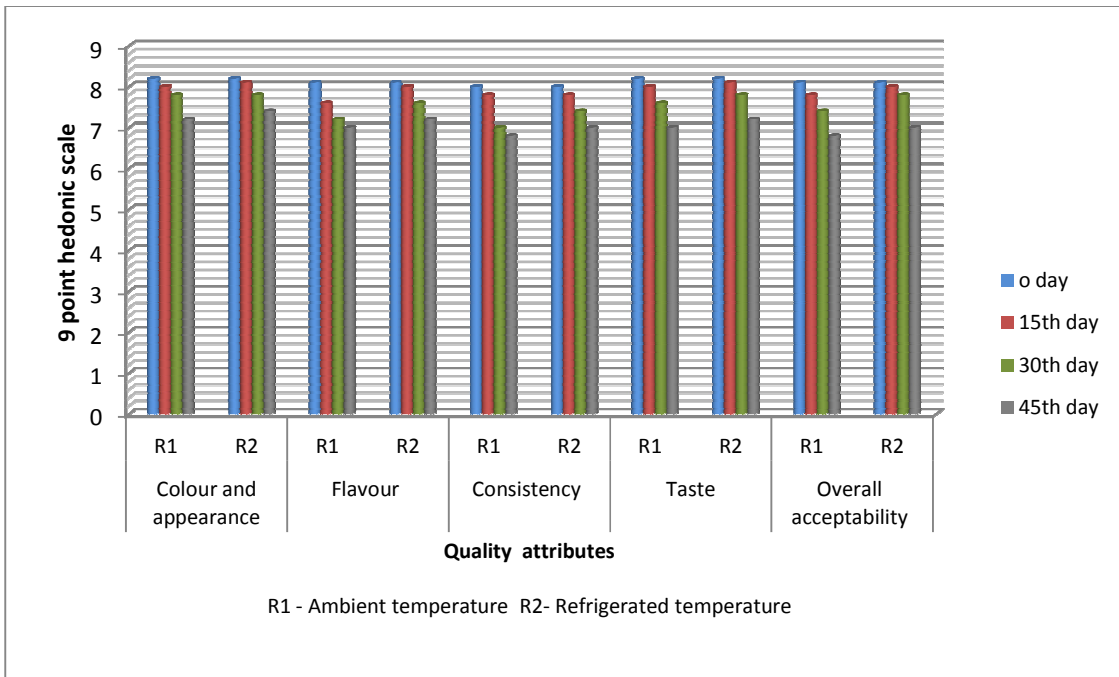


Fig. 4. V₂- sensory profile of mint flavored pseudo stem RTS beverage during storage at ambient and refrigerated condition

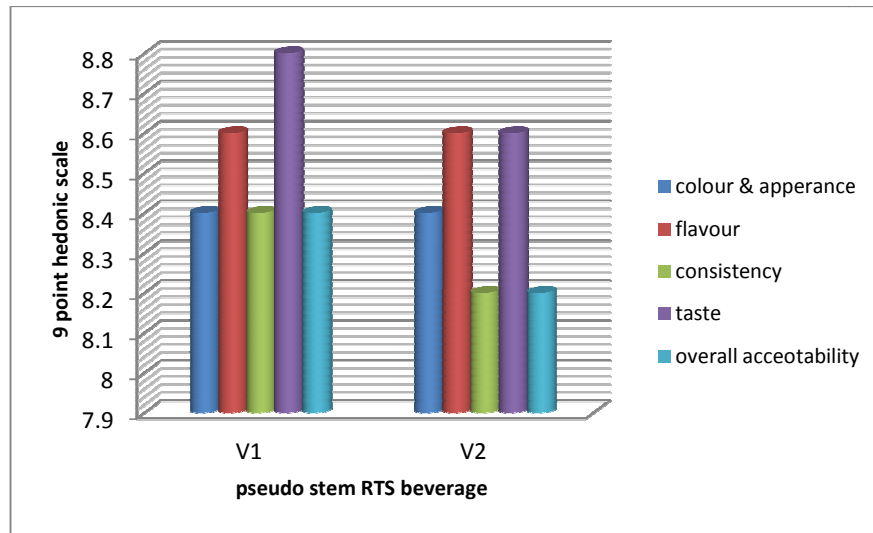


Fig. 5. Sensory profile for lemon flavored pseudo stem RTS beverage from two banana varieties

4. CONCLUSION

Nowadays, the people's food habits were changing towards the natural drinks in compare with artificial drinks. The acceptability of vegetable beverages may be improved by using natural flavors which enhancing the flavour, taste of beverage. From the storage studies, the lemon flavored pseudo stem beverage (Mupaddai variety V₁) was found to be the best in nutrient retention, juice yield and sensory evaluation. The storage studies reported that the pseudo stem beverage flavored with lemon juice could be successfully stored for period of 45 days with significant changes in physico-chemical parameters and sensory qualities. The pseudo stem beverage could be preserved at refrigerated temperature with desirable quality. The present study reported that this pseudo stem beverage possible to satisfy the consumer taste and preferences. It was found nutritionally as well as organoleptically desirable. It delivers the bioactive compounds to our body and it also recognized as functional beverage.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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