RESEARCH PAPER

Process Standardization for Development of Amla *(Phyllanthus emblica)* RTS Concentrate and Its Quality Evaluation

Vipul Chaudhary[1], Vijay Kumar Singh[2], Harsh Prakash Sharma[3], Vaishali[4], Ankur Mahendra Arya[5], Lalit Kumar[6] and Shashank Verma[7]

[1&6]Assistant Professor, [2]Associate Professor, [7]Research Scholar, Mahamaya College of Agricultural Engineering and Technology Ambedkar Nagar, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

[3]Associate Professor, College of Post-Harvest Technology & Food Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh, India

[4]Assistant Professor, Department of Agricultural Engineering, National Post Graduate College, Barhalganj, Gorakhpur, Uttar Pradesh, India

[5]Assistant Professor, Department of Agricultural Engineering, Raja Balwant Singh College of Agriculture, Bichpuri, Agra, Uttar Pradesh, India

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ABSTRACT

The present study was conducted to "Process standardization for development of Amla *(Phyllanthus emblica)* RTS Concentrate and Its Quality Evaluation". Based on physicochemical, nutritional, and sensory parameters. Four formulations (T1 to T4) with progressively increasing sugar concentrations were developed to assess their impact on Total Soluble Solids (TSS), acidity, vitamin-C content, pH, energy value, and carbohydrate levels. Results revealed that TSS increased significantly from 45.50 °Brix in T1 to 73.83 °Brix in T4, correlating with improved sweetness, shelf-stability, and energy density. Acidity decreased inversely with sugar concentration, enhancing palatability by reducing the natural astringency of Amla. Vitamin-C retention was highest in T4 (29.21 mg/100ml), attributed to the protective effect of sugar against oxidative degradation during processing. Concurrently, pH values rose from 2.167 to 2.767, indicating a softer acidic profile favorable for consumption. Carbohydrate and energy contents increased significantly with sugar levels, reaching 73.76% and 307 Kcal/100g, respectively, in T4. Sensory evaluation using a 9-point hedonic scale demonstrated that all organoleptic attributes appearance, taste, flavour, texture, and overall acceptability were significantly enhanced in T4, which recorded the highest acceptability score (8.01). These improvements were directly associated with optimized sugar levels, which balanced taste, enhanced mouthfeel, and preserved the natural colour and aroma of Amla. The study concludes that the T4 formulation (73.83 °Brix) is the most suitable variant for commercial production of Amla RTS Concentrate beverage, offering a balanced profile of nutrition, taste, and consumer preference. This optimized formulation demonstrates strong potential for functional beverage development with improved acceptability and therapeutic value.

Keywords: Amla (Phyllanthus emblica), RTS Concentrate, Sugar, Vitamin-C and Sensory quality

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INTRODUCTION

Amla (*Phyllanthus emblica* L.), commonly known as Indian gooseberry, is a highly revered fruit in India and Southeast Asia due to its exceptional medicinal, nutritional, and therapeutic properties. It is categorized as a minor subtropical fruit crop but plays a major role in traditional health systems such as Ayurveda**,** Unani and Siddha where it is used as a rejuvenator and a cure for various ailments including digestive disorders, respiratory conditions, and skin diseases **(Baliga *et al.*, 2022).** Amla is considered a functional food because of its rich composition of ascorbic acid (Vitamin C)**,** polyphenols**,** tannins and flavonoids which exhibit strong antioxidant and anti-inflammatory properties **(Kumar *et al.*, 2021).**

India leads the world in amla production, cultivating over 50,000 hectares of land and producing more than 300,000 tonnes annually **(NHB, 2023).** Major cultivating states include Uttar Pradesh, Madhya Pradesh, Maharashtra, Gujarat, and Karnataka. Among them, Uttar Pradesh is the largest producer**,** contributing over 60% of the national output**.** The district **of** Pratapgarh has earned the distinction of being the **"**Amla Capital of India" due to its large-scale commercial orchards, some of which date back to 1936. Improved varieties like Banarasi, Chakaiya, and Francis are widely cultivated here, and farmers have long

**Author for Correspondence: vipulchaudhary.in@gmail.com*

adopted grafting techniques to ensure uniformity and quality of fruit **(Pathak *et al.*, 2002).** In recent years, the region has also seen the rise of small- and medium-scale processing units producing value-added products such as murabba, juice, candy, powder, and Concentrate although the level of mechanization and quality control remains varied and inconsistent **(Singh *et al.*, 2021).** Despite the increasing market demand, there is a lack of standardized processing protocols especially for beverages like RTS Concentrate, leading to variability in nutritional quality and shelf stability.

Despite its health benefits, the consumption of fresh amla is limited due to its astringent taste and high acidity which makes it less acceptable to consumers in raw form **(Rai *et al.*, 2020).** This necessitates its transformation into value-added products such as ready-to-serve (RTS Concentrate) beverages which are more palatable and easier to preserve.

RTS Concentrate beverages have gained popularity in recent years due to their convenience shelf stability and ability to deliver functional ingredients in a consumer-friendly form. Developing a stable and acceptable amla RTS Concentrate beverage requires attention to formulation parameters such as TSS (total soluble solids)**,** acidity**,** pH and flavor which directly influence the sensory quality and nutritional retention of the product **(Sharma *et al.*, 2021).**

Several studies have reported successful utilization of amla in processed forms such as juices, squashes, candies, and murabba. However, there is limited research on the standardization of RTS Concentrate beverages with optimized formulation and comprehensive quality evaluation covering physicochemical, nutritional and organoleptic **aspects (Mitra & Roy 2022).** This forms the core rationale for the present study.

There is increasing global interest in functional beverages that promote health and wellness. Consumers are shifting from synthetic carbonated drinks toward natural, plant-based alternatives with therapeutic benefits **(Goswami *et al.*, 2023).** Amla RTS Concentrate fits perfectly within this trend, provided its taste and shelf-life are optimized through proper processing. The successful development of a standardized amla RTS Concentrate beverage would not only reduce post-harvest losses but also generate value-added market opportunities for growers and processors, especially in rural India.

MATERIALS AND METHODS

Procurement of raw materials.

The Amla fruits, sugar, and food color were purchased from the local market.

Experimental Details

Treatments

The experiment comprised of four treatment combinations. The details of various treatments and their combination are presented in table.1

Table 1: Details of treatment combinations

S.N.	Treatments	Notation
1.	**Amla Juice: Sugar (100:40)**	**T_1**
2.	**Amla Juice: Sugar (100:60)**	**T_2**
3.	**Amla Juice: Sugar (100:80)**	**T_3**
4.	**Amla Juice: Sugar (100:100)**	**T_4**

Other details of experiment:

1) Color:**1gm**
2) Number of treatments: **04**
3) Number of replications: **03**
4) Experimental design: **RBD**
5) Quantity of RTS Concentrate in each bottle: **100ml**
6) Storage temperature: **Ambient**

Preparation of Amla RTS Concentrate:

Amla RTS Concentrate E is prepared by first selecting fresh, ripe, and healthy amla fruits, which are thoroughly washed to remove dirt and impurities. After deseeding the fruits are pulped and extract juice, which is filtered to remove solids. Sugar is added gradually with constant stirring, based on the initial TSS. The mixture is heated in an open kettle at 90–95°C with regular Brix checking using a refractometer. Once the desired concentration is achieved, the juice is cooled to around 65–70°C. The hot Concentrate is then filled into sterilized PET Bottles, sealed immediately, cooled, labeled, and stored in a cool, dry place. This high Brix Concentrate is suitable for long-term storage.

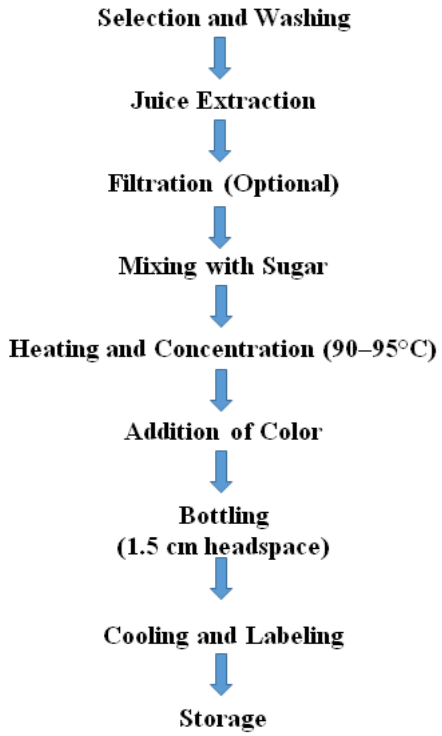

Figure 1: Flow chart for the preparation of Amla RTS Concentrate

Preparation of Amla Drink

Materials Required

1. Amla RTS concentrate (15 ml)
2. Potable water (100 ml)
3. Salt (optional)
4. Ice cubes (optional).

Procedure

The ready-to-serve (RTS) beverage was formulated by diluting 15 ml of standardized amla RTS concentrate with 100 ml of potable water under controlled conditions. The mixture was thoroughly homogenized to ensure uniform dispersion of soluble solids. Organoleptic properties were optimized, through the addition of minimal quantities of salt to achieve a balanced taste profile. The final beverage was served at chilled temperature to enhance sensory acceptability and overall consumer preference.

Methods of Analysis

The analyses of different properties of amla RTS Concentrate were done to produce a commercially valuable product with good quality. Analysis of the product also aided to be aware of the relative changes in the quality factors influenced by different amla RTS Concentrate

Chemical analysis of amla RTS Concentrate:

The amla RTS Concentrate the best acceptable products were analyzed for proximate composition, TSS, Energy, Acidity, Vitamin-C, total carbohydrates and pH content using standard methods for all the Chemical parameters in triplicate.

Organoleptic Evaluation of Amla RTS Concentrate:

Organoleptic evaluation of Amla RTS Concentrate and evaluation was carried out in this experiment. The 9 point Hedonic Scale was used to compare the control with the formulated samples. Sensory evaluation was conducted in sensory evaluation laboratory, Department of agricultural engineering (Process and Food Engineering). The panelists were selected solely on the basis of interest, time available and lack of allergies to food ingredients used in study. On every occasion, the panelists were provided with coded disposable paper cups containing the sample under investigation. Sensory evaluation was carried out under ambient conditions. A comfortable area without distractions (isolated booths) under fluorescent lighting and controlled temperature was used. Water was supplied to clean the pallets between the evaluations of two samples. Samples were tested for different parameters like appearance color, taste, texture, flavor, and overall acceptability. All these tests including the testing for consumer acceptance was done by sensory panelist according to 9 point hedonic scale for sensory evaluation as described by **(Peryam and Giradot 1952).**

RESULTS AND DISCUSSION

Amla products have become popular across different sections of populations both in urban and rural India. The study aimed to Process standardization for development of Amla *(Phyllanthus emblica)* RTS Concentrate and evaluate its quality based on physicochemical and nutritional parameters. The results of the proximate composition of various formulations (T1 to T4) are summarized in Table 1. Each treatment represented a specific formulation with increasing sugar concentrations, influencing the Total Soluble Solids (TSS), acidity, vitamin-C content, pH, energy, and carbohydrate levels.

Table 1: Proximate composition of Amla RTS Concentrate:

Treatments	TSS (°Brix)	Acidity (%)	Vitamin-C (mg/100ml)	pH	Energy (Kcal/ 100g)	Carbohydrates (%)
T_1	45.50	1.087	18.593	2.167	295.333	70.200
T_2	55.50	1.047	21.680	2.267	297.667	71.250
T_3	60.83	0.953	24.833	2.500	303.333	72.670
T_4	73.83	0.660	29.207	2.767	307.000	73.760
C.D.	0.39	0.027	0.803	0.131	3.885	0.319
SE(m)	0.096	0.008	0.228	0.037	1.101	0.090
SE(d)	0.136	0.011	0.322	0.053	1.558	0.128
C.V.	0.283	1.434	1.673	2.662	0.634	0.218

Total Soluble Solids (TSS °Brix):

TSS, a critical parameter for RTS Concentrate beverages, increased significantly with the sugar concentration across treatments. The values ranged from **45.50 °Brix in T1** to **73.83 °Brix in T4**. TSS is primarily indicative of the soluble sugars and acids present in the beverage, impacting taste, preservation, and consumer acceptability. This progressive increase aligns with findings by **Kumar et al. (2017)**, who reported that higher sugar levels enhance the sensory sweetness and microbial stability of fruit-based beverages. T4, with the highest TSS, ensures better shelf stability and palatability, suggesting that elevated sugar content support RTS Concentrate the commercial viability of the RTS Concentrate product.

Acidity (%):

Acidity decreased from **1.087% in T1** to **0.660% in T4**, indicating a statistically significant difference (CD = 0.027%). The reduction in titratable acidity is inversely correlated with sugar addition, as the buffering capacity increases, masking the perceived sourness of Amla juice. Lower acidity in higher sugar treatments enhances the sensory appeal of the beverage,

making it less astringent and more acceptable to a broader consumer base. Similar trends were noted by **Patel et al. (2016)** in RTS Concentrate drinks prepared from sour fruits, where sugar acts to balance the high organic acid content.

Vitamin-C Content (mg/100 ml):

Vitamin-C content ranged from **18.59 mg/100ml in T1** to **29.21 mg/100ml in T4**, showing a clear upward trend with sugar level. The highest retention in T4 is likely due to reduced oxidation during thermal processing and the protective effect of higher sugar concentration acting as a stabilizer for ascorbic acid. Amla is inherently rich in vitamin C, but its stability is often compromised during processing. According to **Ranganna (2015)**, sugar addition can enhance vitamin-C retention in fruit juices by lowering oxygen solubility and improving thermal stability during pasteurization.

pH:

The pH values showed an increasing trend from **2.167 in T1** to **2.767 in T4**, which is inversely proportional to acidity. The rise in pH with increasing sugar content indicates reduced free hydrogen ion concentration, likely due to sugar's buffering and dilution effects. Higher pH values suggest a softer acidic profile, making the RTS Concentrate more pleasant for consumption, especially for individuals sensitive to high-acid beverages. This is consistent with the findings of **Bhattarai et al. (2018)**, who highlighted that RTS Concentrate drinks with moderated pH values offer better sensory profiles and extended stability.

Energy (Kcal/100g):

Energy content significantly increased from **295.33 Kcal/100g in T1** to **307.00 Kcal/100g in T4**, primarily due to the higher sugar content which is directly related to calorie contribution. RTS Concentrate beverages serve as a quick source of energy, and higher sugar levels enhance their caloric density. Such formulations are particularly beneficial in addressing energy deficiency in children and elderly populations, as noted by **Sharma & Joshi (2015)**. The increase in energy also correlates positively with increased carbohydrate levels.

Carbohydrates (%):

Carbohydrate levels rose from **70.20% in T1** to **73.76% in T4**, consistent with the increasing sugar concentration used in each formulation. As carbohydrates are the main contributors to TSS and energy, their upward trend validates the observed rise in TSS and caloric values. This enhancement is desirable in RTS Concentrate beverages where higher carbohydrate content improves taste, mouthfeel, and consumer acceptability. The low coefficient of variation (0.218%) indicates excellent reproducibility and precision of results.

The progressive enhancement of TSS, pH, vitamin-C, energy, and carbohydrates, along with a concurrent reduction in acidity, demonstrates that increasing sugar concentration significantly improves the nutritional quality and sensory characteristics of Amla RTS Concentrate beverage. Among all the formulations tested, **Treatment T4 (73.83°Brix)** emerged as the most effective and balanced composition, exhibiting superior physicochemical properties and potential for large-scale production. The findings of this study suggest that optimized sugar incorporation not only enhances consumer acceptability but also contributes to nutrient retention, especially vitamin C, which is a key functional attribute of Amla. Thus, T4 can be recommended as the most suitable standardized formulation for commercial RTS Concentrate production.

Sensory Evaluation of Amla RTS Concentrate:

The sensory evaluation of Amla RTS Concentrate beverage formulations was carried out to assess consumer acceptability in terms of **appearance, taste, colour, flavour, texture**, and **overall acceptability**. The results, presented in **Table 2**, reflect the panel scores obtained using a 9-point hedonic scale. Treatments T1 to T4 correspond to increasing sugar concentrations and standardized processing levels.

Table 2: Evaluation of sensory attributes of *Amla* RTS Concentrate*:*

Treatments	Appearance	Taste	Colour	Flavour	Texture	Overall Acceptability
T_1	7.03	7.13	7.10	7.10	7.13	7.10
T_2	7.20	7.47	7.17	7.63	7.43	7.38
T_3	7.70	8.00	7.73	7.90	7.67	7.80
T_4	8.20	8.27	7.80	8.00	7.77	8.01
C.D.	0.403	0.462	0.274	0.212	0.313	0.198
SE(m)	0.114	0.131	0.078	0.060	0.089	0.064
SE(d)	0.162	0.185	0.110	0.085	0.125	0.090
C.V.	2.627	2.938	1.804	1.359	2.048	1.880

Appearance:

The appearance scores increased progressively from **7.03 in T1** to **8.20 in T4**, indicating that sugar concentration positively influenced the visual appeal of the RTS Concentrate beverage. T4 exhibited the most desirable appearance, likely due to improved clarity, brightness, and uniformity contributed by higher sugar and better formulation balance. Similar findings were reported by **Gopalan et al. (2019)**, where higher TSS levels improved the turbidity and brightness of herbal RTS Concentrate drinks, leading to better panel ratings.

Taste:

Taste scores ranged from **7.13 in T1** to **8.27 in T4**, with T4 scoring significantly higher (CD = 0.462). The improved sweetness and masking of natural astringency of Amla through optimized sugar content contributed to enhanced palatability. This is supported by **Bhardwaj and Mukherjee (2016)**, who demonstrated that sugar balancing in RTS Concentrate beverages from sour fruits like bael and amla is critical to taste enhancement and consumer acceptance.

Colour:

Colour ratings improved marginally from **7.10 (T1)** to **7.80 (T4)**, which could be attributed to enhanced product brightness and reduced oxidation during processing in higher-sugar formulations. Although the differences were less pronounced compared to taste and flavour, they were statistically significant (CD = 0.274). High sugar concentration may reduce browning and preserve the natural greenish-yellow hue of Amla extract, enhancing visual appeal.

Flavour:

Flavour scores increased from **7.10 (T1)** to **8.00 (T4)**. The highest rating in T4 reflects an optimal blend of sweetness and natural aroma of Amla. The improved flavour is a result of better masking of bitterness and astringency with sugar, as well as preservation of volatile flavour compounds due to proper thermal processing. These results are in line with **Ranganna (2015)** who emphasized that proper heat treatment combined with appropriate sugar levels preserves both volatile and non-volatile flavour components in fruit-based drinks.

Texture:

Texture scores ranged from **7.13 (T1)** to **7.77 (T4)**, indicating improved mouthfeel with increasing sugar concentration. Higher sugar levels improve the viscosity and smoothness of the drink, reducing the perception of coarseness sometimes associated with Amla pulp-based drinks. T4 provided the most uniform and pleasant texture as perceived by the panelists. A similar trend was observed by **Thakur et al. (2018)**, who found that increased solids in RTS Concentrate beverages enhanced mouthfeel and texture without causing heaviness or sedimentation.

Overall Acceptability:

The **overall acceptability** score increased significantly from **7.10 in T1** to **8.01 in T4**, with T4 being the most preferred formulation across all sensory parameters. The superior performance of T4 is attributed to its optimal balance of sweetness, acidity, flavour, and visual characteristics. The low coefficient of variation (1.880%) further confirms the consistency in panelists' preferences. These findings affirm the conclusions drawn in previous sensory studies, such as those by **Jain et al. (2020)**, where drinks with around 70–75 °Brix TSS scored highest for sensory quality in RTS Concentrate trials with Indian gooseberry and lime blends.

The sensory evaluation conclusively indicates that **T4 formulation (73.83 °Brix)** was superior across all attributes, including **appearance, taste, colour, flavour, texture**, and **overall acceptability**. These improvements are strongly correlated with optimized sugar levels and balanced acidity, which enhance sweetness, mask bitterness, and retain the characteristic flavour and appearance of Amla. Therefore, the T4 formulation can be considered the most acceptable and consumer-preferred variant of Amla RTS Concentrate beverage, suitable for commercial production and market introduction.

CONCLUSION

The present study established that sugar concentration is a critical factor in optimizing the quality attributes of Amla RTS beverage. A significant improvement in physicochemical parameters, including Total Soluble Solids, pH, vitamin-C retention, energy and carbohydrate content was observed with increasing sugar levels, while acidity decreased proportionally. Among the treatments, T4 (100:100 juice to sugar ratio) exhibited the most desirable profile, achieving the highest TSS (73.83 °Brix) and superior retention of vitamin C, indicating enhanced nutritional stability. Sensory evaluation further validated these findings with T4 attaining the highest scores across all organoleptic attributes, reflecting improved palatability and consumer acceptability. The optimized formulation effectively balanced the inherent astringency of Amla with desirable sweetness and flavour. Therefore, T4 is recommended as the standardized formulation for commercial RTS production, offering a nutritionally enriched, sensory acceptable and shelf-stable functional beverage with strong potential for value addition and agro industrial applications.

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