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Development and quality evaluation of a blended ready-to-serve beverage from Chayote (*Sechium edule*) and Sohiong (*Prunus nepalensis*) of Meghalaya

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Abstract
Chayote (*Sechium edule*) is an underutilized vegetable with good nutritional value but bland flavour, while Sohiong (*Prunus nepalensis*), a wild indigenous cherry of Meghalaya, is rich in vitamin C, anthocyanins and antioxidants. Blending these fruits offers a promising approach for developing a nutritious RTS beverage. Chayote juice to sohiong juice ratio (3:2, 1:1, 2:3) and juice content (10–18%) were selected as independent variables and optimized using full factorial design. Fifteen treatments were evaluated in triplicate for TSS, pH, titratable acidity, ascorbic acid and sensory attributes. ANOVA ($P \leq 0.05$) showed significant effects of process variables on all quality parameters. Highest TSS (14.233 °Brix) was in T_9, pH (4.767) in T_{13}, titratable acidity (0.307%) in T_8 and ascorbic acid (19.076 mg/100g) in T_4. Sensory indices revealed no single formulation was highest for every attribute; T_5 (1:1 chayote–sohiong, 12% juice) showed consistent performance and was identified as optimum, supported by TSS (13.567 °Brix), pH (4.33), acidity (0.203%) and ascorbic acid (17.386 mg/100g), all within FSSAI norms.

Keywords: Sohiong, Chayote, Blended RTS beverage, Full factorial design

Introduction

Fruit-based beverages constitute a significant segment of the non-alcoholic beverage industry due to their refreshing characteristics, nutritional value and convenience. Ready-to-serve (RTS) beverages are designated for direct consumption and are typically prepared by extracting juice from ripe fruits and mixing with water, sugar and additives. However, several nutrient-rich fruits remain underutilized because of undesirable characteristics (Rathinasamy *et al.*, 2022) [1]. Blending of fruit juices is an effective approach to enhance flavour, colour, stability, nutritional quality and consumer acceptability (Jain *et al.*, 2004) [2], while also utilizing locally available underutilized raw materials and reducing post-harvest losses.

The northeastern region of India is endowed with a rich diversity of indigenous fruits and vegetables with high nutritional and functional potential, yet many remain inadequately explored for commercial beverage development. Chayote (*Sechium edule*), an underutilized cucurbit of the Cucurbitaceae family, is rich in bioactive compounds with antioxidant properties. The fruit contains ~90–95% moisture, is low in fat and calories, and is rich in minerals, phenolics and flavonoids, with high potassium and low sodium content (Gopalan *et al.*, 1995; Cadena-Iñiguez *et al.*, 2025) [4, 3]. However, chayote juice alone exhibits a bland taste, low colour intensity and comparatively low consumer appeal.

Sohiong (*Prunus nepalensis*), a wild indigenous edible fruit of the Rosaceae family native to the northeastern hills, particularly Meghalaya, is known as "Khasi cherry." The term literally means "black fruit" in the Khasi dialect, referring to the deep purple colour of the ripe fruit due to high anthocyanin content. It is rich in anthocyanin (358.86 mg/100g), beta-carotene (0.215 mg/100g), ascorbic acid (46 mg/100g) and minerals including phosphorus (115 mg/100g), iron (9.6 mg/100g), zinc (2.42 mg/100g) and potassium (530 mg/100g) (Rymbai *et al.*, 2016) [5]. Sohiong has been successfully incorporated into juices, squash, mixed fruit leathers and fermented beverages with improved sensory quality and antioxidant activity (Kuna *et al.*, 2018; Laloo *et al.*, 2025) [6, 7]. Therefore, blending mildly flavoured, nutrient-rich chayote juice with anthocyanin-rich, intensely coloured sohiong juice offers a promising approach for developing a functional RTS beverage with improved colour, flavour, antioxidant capacity and overall acceptability. The present study was undertaken to develop and evaluate the quality attributes of a chayote–sohiong blended RTS beverage, aiming to promote value addition, reduce post-harvest losses and support utilization of underutilized locally available fruits.

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Materials and Methods

The investigation was carried out in the Department of Food Processing Technology and Engineering, College of Food Technology (CAU-I), Lamphelpat, Imphal, Manipur during 2025–2026.

Raw materials

Fresh light green chayote, sugar and mineral water were procured from the local market of Imphal, Manipur, and sohiong fruits were imported from Shillong, Meghalaya, and stored in a deep freezer until further use. Analytical-grade chemicals were sourced from the departmental laboratory.

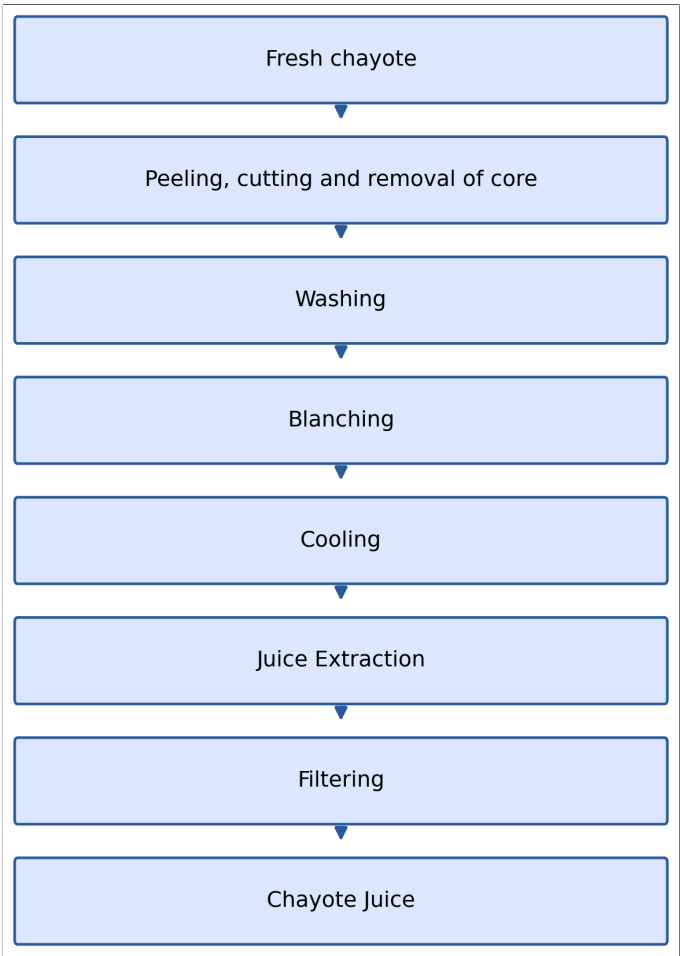
Preparation of chayote juice

Preparation of sohiong juice

Preparation of blended RTS beverage

Blended RTS beverages were prepared by combining chayote and sohiong juices in different proportions, with the final TSS standardized to 12 °Brix in accordance with FSSAI guidelines.

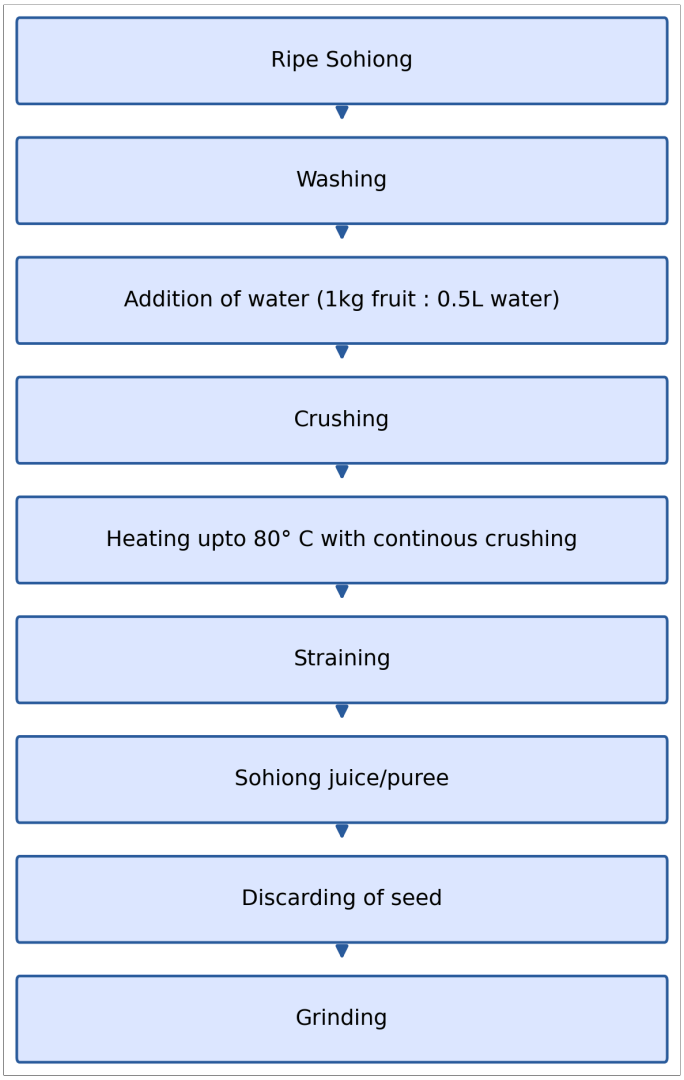
Mass balance $RTS = CJ + SJ + S + W$ and solid balance [(RTS × TSS_{RTS}) = (CJ × TSS_{CJ}) + (SJ × TSS_{SJ}) + (S)] equations were applied to determine the required quantities of chayote juice (CJ), sohiong juice (SJ), sugar (S) and water (W).



Sugar syrup was prepared by dissolving sugar in water, added to the blended juices, and the mixture was homogenized using a blender. The beverage was then pasteurized, filled into pre-sterilized bottles and sealed airtight using a hand-operated crown corking machine. Bottles were sterilized by immersion in water maintained above 100 °C and boiled for 30 minutes, then cooled to room temperature before chemical and sensory evaluation.

Experimental design

A full factorial experimental design was employed. The fruit juice content varied from 10% to 18%, while the chayote juice to sohiong juice ratio was adjusted at 3:2, 1:1 and 2:3, selected based on previous literature and preliminary trials. A total of 15 treatments (T_1–T_{15}) were formulated, each conducted in triplicate to reduce experimental error. Each sample was analysed for TSS, titratable acidity, pH, ascorbic acid content and sensory attributes. The experiment study was conducted using a full factorial experimental design, which includes all possible combinations of the selected factor levels. The experimental layout employed for blending Chayote and Sohiong juices is presented in table 3.1.



In the present investigation, the fruit juice content of the blended beverages was varied from 10% to 18% while the ratio of chayote juice to sohiong juice was adjusted at 3:2, 1:1 & 2:3. The selected levels of the variables were based on previous literature reviews and preliminary experimental trials.

A total of 15 experimental treatments were formulated and evaluated with each treatment conducted in triplicate to reduce experimental error. The treatments were designated as T1, T2….T15 as details in Table 3.1. Each blended RTS beverage sample was analyzed for total soluble solids (TSS), titratable acidity, pH, ascorbic acid content and sensory attributes.

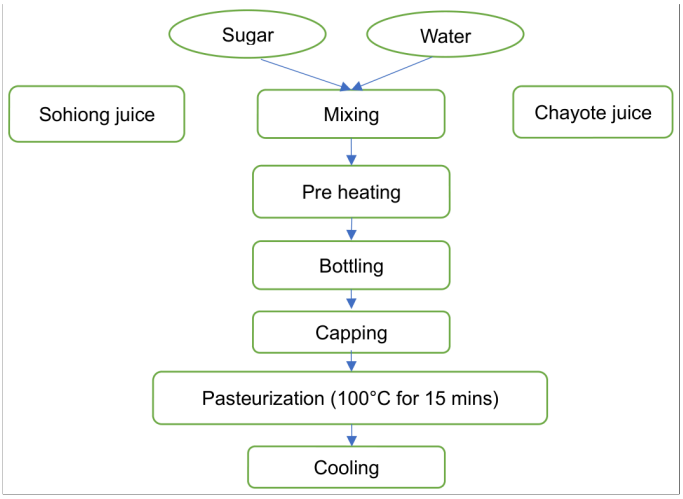
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Table 3.1. Experimental design for blended RTS beverage

Treatments	Independent variables		Dependent variables
	Fruit juice content (%)	Chayote juice: Sohiong juice	
T_1	10	3:2	a) TSS, b) pH, c) Titratable Acidity, d) Ascorbic Acid, e) Sensory Evaluation
T_2	10	1:1	
T_3	10	2:3	
T_4	12	3:2	
T_5	12	1:1	
T_6	12	2:3	
T_7	14	3:2	
T_8	14	1:1	
T_9	14	2:3	
T_{10}	16	3:2	
T_{11}	16	1:1	
T_{12}	16	2:3	
T_{13}	18	3:2	
T_{14}	18	1:1	
T_{15}	18	2:3	

Quality evaluation

- *TSS* was determined using a digital refractometer (HI96801) following Srivastava *et al.* (1993) [8].
- *pH* was measured with an electronic pH meter (KONVIO neer) after calibration with pH 7 and pH 4 standard buffers, following Ranganna (2001) [9].
- *Titratable acidity* was determined by titration against 0.1 N NaOH using phenolphthalein as indicator and expressed as percentage anhydrous citric acid (Ranganna, 2010) [10].
- *Ascorbic acid* was estimated by the dye (2,6-dichlorophenol indophenol) titrimetric method of Dinesh *et al.* (2015) [11] and Adebayo (2015) with minor modifications, using 4% oxalic acid for extraction and centrifugation at 8500 rpm for 10 min.
- *Sensory evaluation* was conducted using a 9-point hedonic scale (Amerine *et al.*, 1965) [12] by 25 untrained panellists (20–27 years, both genders) for appearance/colour, flavour/taste, texture (mouthfeel), texture (consistency), aroma/odour, after taste and overall acceptability. Sensory indices (%) were calculated as per Madhu (1999) [13].



Determination of total soluble solids

The total soluble solids (TSS) of the blended Chayote-Sohiong RTS beverages were determined using a Digital Refractometer (HI96801) following the method recommended by Srivastava *et al.* (1993) [8]. A drop of the sample was placed on the prism surface and the TSS value was directly read from the digital display in degree Brix and was programmed to automatically correct TSS reading for measurements taken at different temperatures.

Determination of pH

The pH is the measurement of the logarithm of inverse of hydrogen ions in the solution.

$$pH=-\log(H^+)$$

Where, H^+ = Hydrogen ion concentration (g/L)



Digital Refractometer (HI96801)

The pH values were determined with the help of electronic pH meter (KONVIO neer), the procedure recommended by Ranganna (2001) [9]. The electronic pH meter was calibrated using 7 pH and 4 pH standard buffer solutions. Then the electrode was dipped in the test solution (20 mL) and the reading was taken from the display.

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Digital pH meter (KONVIO neer)

Determination of titratable acidity

The total titratable acidity of the blended chayote-sohiong Ready-To-Serve beverages was determined by titration against N/0.1 Sodium Hydroxide (NaOH) using phenolphthalein as an indicator following the method described by Ranganna (2010) [10].

For the analysis, 10 ml mL of the sample was taken in a conical flask and few drops of 1% phenolphthalein solution were added as an indicator. The sample was then titrated with 0.1N NaOH until the appearance of a faint permanent pink colour which marked the end point. The titre value was recorded and used to calculate the titratable acidity expressed as percentage anhydrous citric acid.

The calculations were performed using the equivalent weight of citric acid (64.04) or its milliequivalent weight (0.06404) as specified in the standard method.

$$\text{Acidity (\%)} = \frac{\text{Vol. of NaOH used (ml)} \times \text{Norm. of NaOH} \times \text{Equi. wt. of citric acid} \times 100}{\text{Vol. of sample (ml) titrated}}$$

Determination of ascorbic acid (mg/100g)

The Vitamin C content of blended Chayote-Sohiong RTS samples was determined using the method followed by Dinesh *et al.* (2015) [11] and Adebayo (2015) with minor modification. The reagents required were:

(a) **4% (w/v) Oxalic acid:** 40g of oxalic acid were dissolved in 1000 mL of distilled water.

(b) **Dye solution:** 42 mg of sodium bicarbonate and 52 mg of 2, 6-dichlorophenol indophenol were dissolved in 200 mL of distilled water.

(c) **Ascorbic acid stock standard:** (1 mg/mL): 100 mg L-Ascorbic acid was dissolved in 100 mL of 4% oxalic acid.

(d) **Ascorbic acid working standard:** (100µg/mL): 10 mL of the ascorbic acid stock standard was diluted to 100 mL with 4% oxalic acid.

Sample extraction

5g of the prepared sample was accurately weighed mixed with 10 mL of 4% oxalic acid. The final volume of the extract was made up to 100 mL with 4% oxalic acid in a standard flask. The homogenate was then transferred into clean dried centrifuge tubes of 50 mL. The samples were centrifuged at 8500 rpm for 10 mins at room temperature. The supernatant was collected into vials while the residue was discarded.

Blank titration

5 mL of working standard solution with addition of 10 mL of 4% oxalic acid in a 100 mL conical flask was titrated against the Dye solution till the working standard appears rose pink in colour. The amount of dye consumed is equivalent to the amount of ascorbic acid.

Sample titration

Similarly, 5 ml of the supernatant of the centrifuged sample with addition of 10 mL of 4% oxalic acid in a 100 mL conical flask was titrated against the Dye solution till the working standard appears rose pink in colour. Same titration procedure was followed for all samples. The amount of ascorbic acid in sample was calculated by following formula:

$$\text{Amount of ascorbic acid} \frac{\text{mg}}{100\text{g}} \text{of sample} = \frac{0.5}{V_1} \times \frac{V_2}{5} \times \frac{100}{\text{Weight of sample}} \times 100$$

Where, 0.5 = mg of standard ascorbic acid taken for titration

V_1 = Volume of dye consumed by 0.5 mg of standard ascorbic acid (mL)

V_2 = Volume of dye consumed by 5 mL of test sample (mL)

100= Corresponds to total volume of the extract (mL)

100 = Ascorbic acid content/100g of the sample

5 = Weight of sample taken for extraction (g)

5 = Volume of the test sample taken for titration (mL)

Sensory evaluation

The sensory evaluation of developed RTS beverages was carried out by using 9-point hedonic scale (Amerine *et al.,* 1965) [12] for organoleptic quality and overall acceptability of the beverages. The 9-degree hedonic scale had boundary indications: 'like extremely' (Jain *et al.*, 2004) [2] – 'dislike extremely' (Amerine *et al.*, 1965) [12]. The assessment included the following quality attributes: colour and appearance, taste aroma and overall acceptability. It was conducted by a group of 25 untrained panellists (of the age group 20-27) from both genders. Coded samples were provided to the panellists for the evaluation in 15 ml glass cup. The judges were given pallet cleanser (water) in between two testings for rinsing their mouth. The sensory evaluation sheet used during experiments is given in

Statistical analysis

ANOVA was performed for each response variable, with significance assessed using the *F*-statistic at a 95% confidence level ($P \leq 0.05$). Treatment means were compared using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Quality of raw materials

Fresh chayote and sohiong juices were analysed for TSS, pH and titratable acidity. TSS ranged from 2.47 to 5.25 °Brix for chayote juice (mean 3.86 ± 0.5 °Brix) and 6.60 to 17.40 °Brix for sohiong juice (mean 12.03 ± 0.3 °Brix). The pH of chayote juice varied between 6.0 and 6.70 (mean 6.35 ± 0.04), while sohiong juice ranged from 3.50 to 4.80 (mean 4.15 ± 0.26), in close agreement with Das *et al.* (2021) [14]. Titratable acidity ranged from 0.21 to 0.36 in chayote

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juice and 1.15 to 3.32 in sohiong juice, with mean values of 0.28 ± 0.05 and 2.23 ± 0.06, respectively. Considering the high pH of chayote juice, blending with sohiong juice was done to achieve acceptable acidity as per Food Safety and Standards Regulations (2011).

Sensory Evaluation Score Card

Name of Product: **Date:**

Name of Evaluator: **Age of Evaluator:**

Please evaluate given samples and assess the products in terms of general acceptability on a 9-point hedonic scale.

Characteristics	Sample No.				
Appearance/Colour					
Flavour/Taste					
Texture/ Mouthfeel					
Texture/ Consistency					
Smell/odour					
After taste					
Overall Acceptability					

Score Index:

Hedonic Rating Scale

Degree of liking	Score Index
Like extremely	9
Like very much	8
Like moderately	7
Like slightly	6
Neither like nor dislike	5
Dislike slightly	4
Dislike moderately	3
Dislike very much	2
Dislike extremely	1

Remarks if any:

Signature of the Evaluator

Quality of chayote–sohiong blended beverage

The developed beverages were analysed for TSS, pH, titratable acidity, ascorbic acid and sensory attributes. ANOVA revealed that both juice content and chayote:sohiong ratio had a significant influence ($P \leq 0.05$) on TSS, pH, titratable acidity and ascorbic acid content, and sensory attributes also exhibited significant variations among treatments. DMRT results indicated that treatments assigned different superscript letters differed significantly from one another.

Effect on TSS: TSS values ranged from 11.367 to 14.233 °Brix and were maintained around the predetermined 12 °Brix in compliance with FSSAI standards (minimum 10%). An increase in juice content generally resulted in higher TSS, with the highest values recorded at 14% juice content, particularly in 2:3 and 1:1 ratios. The formulation T_{12} (16% juice, 2:3) recorded a TSS of 12.067 °Brix, closest to the standardized level and statistically at par with T_{11} (12.167 °Brix) and T_{14} (12.367 °Brix). The highest TSS (14.233 °Brix) was recorded in T_9. Sohiong juice contains higher natural sugars and soluble solids than chayote, hence treatments with a higher sohiong proportion showed increased TSS.

Effect on pH: pH values ranged from 4.090 to 4.767, indicating an acidic nature suitable for RTS beverages. The lowest pH (4.09) was recorded in T_1 (10% juice, 3:2), attributed to higher relative acidity at lower juice concentration, while the highest pH (4.767) was observed in T_{13} (18% juice, 3:2), indicating reduced acidity with increasing juice content and higher proportion of the less acidic chayote. Formulations with increased sohiong proportion generally exhibited lower pH, reflecting the naturally higher acidity of sohiong fruit. All formulations recorded pH values within the acceptable acidic range for RTS beverages as per FSSAI recommendations.

Effect on titratable acidity: Acidity ranged from 0.144% to 0.307%, indicating considerable variation among treatments. The highest acidity (0.307%) was recorded in T_8 (14% juice, 1:1), statistically at par with T_9 (0.290%) and T_{10} (0.303%), attributed to the combined effect of higher juice concentration and the acidic nature of sohiong. The lowest acidity (0.144%) was observed in T_{13} (18% juice, 3:2), indicating a reduction in acidity with increased juice content and higher chayote proportion. The values are comparable with earlier findings on blended RTS beverages, where initial titratable acidity ranged from 0.20% in papaya–ginger–honey RTS (Debnath *et al.*, 2022) [15] to 0.32% in *Garcinia cambogia* RTS (Bensi, 2024) [16].

Effect on ascorbic acid: Ascorbic acid content ranged from 10.383 to 19.076 mg/100g. The highest content (19.076 mg/100g) was recorded in T_4 (12% juice, 3:2), statistically at par with several treatments, while the lowest (10.383 mg/100g) was observed in T_{11} (16% juice, 1:1), possibly due to dilution effects and processing losses. Formulations with a higher sohiong proportion generally exhibited comparatively higher ascorbic acid content, reflecting the naturally higher vitamin C content of sohiong fruit.

Sensory attributes: Sensory responses were converted into percentage indices. The highest appearance score (90.20%) was recorded in T_{14} (18% juice, 1:1), followed by T_{15} (89.00%); the lowest (76.88%) was observed in T_{10} and T_{13}. Appearance scores improved with increasing sohiong proportion, suggesting its positive contribution to colour intensity. The highest flavour index (84.88%) was recorded in T_5 (12% juice, 1:1), closely followed by T_4 and T_{15} (84.44% each); the lowest (76.44%) was in T_6. The highest mouthfeel index (83.55%) was observed in T_5, followed by T_4 (83.10%), while the lowest (73.78%) was in T_{11}. The highest consistency index (85.78%) was recorded in T_3 (10% juice, 2:3), followed by T_5 (84.44%). The highest aroma index (79.50%) was observed in T_{14}, while the lowest (71.00%) was in T_{12}. For after taste, the highest score was recorded in T_5 (81.00%), while the lowest (69.33%) was in T_6. The highest overall acceptability (86.22% and 86.00%) was observed in T_5 (12% juice, 1:1) and T_{15} (18% juice, 2:3), respectively, indicating that balanced or sohiong-dominant blends were most preferred; the lowest (76.00%) was recorded in T_6 (12% juice, 2:3). The reduced flavour and aroma in some treatments were attributed to the use of deep-frozen sohiong prior to processing.

Optimization of process parameters

Full factorial analysis revealed significant differences among treatments for TSS, pH, titratable acidity and ascorbic acid, while sensory scores were converted into percentage indices. Different treatments recorded maximum scores for individual attributes: appearance in T_{14}, flavour in T_5, mouthfeel in T_5, consistency in T_3, aroma in T_{14}, after taste in T_5 and overall acceptability in T_5. Based on ranking of all sensory indices, treatment T_5 (1:1 chayote:sohiong, 12% juice content) showed consistent performance, securing 1st rank in flavour, mouthfeel, after taste and overall acceptability, 2nd in consistency, 3rd in aroma and 4th in appearance, while also meeting regulatory quality requirements. Hence, T_5 was considered the optimum formulation. It recorded a TSS of 13.567 °Brix, pH of 4.33 and titratable acidity of 0.203%, at par with FSSAI regulations, along with a significantly higher ascorbic acid content of 17.386 mg/100g.

Summary and conclusion

Sohiong (*Prunus nepalensis*) and chayote (*Sechium edule*) are underutilized fruits of the northeastern region, valued for their high nutritional and functional properties. Sohiong is rich in anthocyanins, antioxidants and acidity, while chayote contributes vitamins and bioactive compounds but has a bland taste and poor post-harvest stability. To utilize these locally available fruits effectively, a blended RTS beverage was developed by blending chayote and sohiong juices in varying ratios with added sugar and water, followed by homogenization and manual bottle pasteurization.

ANOVA demonstrated that juice content and chayote-to-sohiong ratio significantly influenced chemical parameters (TSS, pH, titratable

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acidity and ascorbic acid) as well as sensory attributes. DMRT analysis confirmed significant differences among treatments, while sensory indices were used to rank formulations for overall acceptability. Among the 15 treatments, T_9 recorded the highest TSS (14.233 °Brix), T_{13} the maximum pH (4.767), T_8 the highest titratable acidity (0.307%) and T_4 the highest ascorbic acid content (19.076 mg/100g). Treatment T_5, containing 12% juice content with a 1:1 chayote–sohiong ratio, was identified as the optimal formulation, exhibiting a balanced combination of colour, flavour, TSS (13.567 °Brix), pH (4.33), acidity (0.203%) and ascorbic acid content (17.386 mg/100g).

The study demonstrates that appropriate blending of underutilized fruits can enhance nutritional quality, functional properties and consumer acceptability of RTS beverages. Future research may focus on optimizing storage conditions, packaging and evaluating shelf-life stability to further improve the commercial potential of chayote–sohiong blended beverages.

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