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Formulation and Physical, Chemical, and Sensorial Characterization of Pomegranate and Beetroot Juice

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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

The rising demand for antioxidant-rich functional beverages underscores their potential health benefits, particularly for cardiovascular health. This study developed a blended juice comprising beetroot, pomegranate, gooseberry, and ginger, analyzed across ten treatments with varying proportions of beetroot and pomegranate. The study assessed key physicochemical properties, including Total Phenolic Content (TPC), Total Flavonoid Content (TFC), Antioxidant Activity, and Anthocyanin levels. The quality evaluation involved physical and chemical analyses, measuring Total Soluble Solids (TSS), pH, total acidity, and ascorbic acid content using AOAC (2005) methods. TSS was measured in Brix, pH with a digital meter, and ascorbic acid by visual titration. TPC was determined using the Folin-Ciocalteau reagent, TFC with an aluminum chloride method, and antioxidant activity via a DPPH assay. Anthocyanin content was measured spectrophotometrically. The sensory evaluation identified the treatment with a higher pomegranate

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percentage (T9) as the most preferred. T9 also exhibited the highest TPC (1,432.28 mg GAE/L), TFC (611.61 mg QE/L), and Antioxidant Activity (87.53%), indicating a strong correlation between these compounds and the juice's health benefits. Storage studies of T9 over 21 days revealed a gradual decline in pH, TSS, Vitamin C, and antioxidant activity, highlighting the importance of proper storage conditions. This research demonstrates the potential of beetroot-pomegranate blends in creating a health-promoting beverage, with T9 emerging as the most beneficial and consumer-accepted formulation.

Keywords: Antioxidant; beetroot; health benefits; juice; pomegranate.

1. INTRODUCTION

Antioxidant compounds can be acquired from a variety of plant matrices, most notably from fruits high in phytochemicals and well renowned for their health advantages, fruits high in phytochemical which are commonly referred to as superfruits. Several different juice products have antioxidant potency due to their high content of polyphenols [1]. Fruits and vegetables are high in antioxidant components such as ascorbic acid, carotenoids, flavonoids, and other phenolics [2]. Vegetables and fruits are a rich source of bioactive components, which has demonstrated that they can promote health without using supplements [3]. Antioxidants can safely interact with free radicals and prevent the chain reaction, reducing free radicals which result in oxidative damage to biological components, including lipids, proteins, and nucleic acids. The most common antioxidant compounds present in fruits and vegetables, as well as several beverages, are vitamin C, vitamin E, and polyphenols. Polyphenols are polyhydroxylated phytochemicals, which have common structures [4]. Consuming freshly squeezed fruit juices can help prevent degenerative diseases such as cardiovascular problems and several types of cancer. In India, people of all income and age groups consume fruit and vegetable juices, making it a popular practice for maintaining good health [5].

Beetroot is a taproot vegetable belonging to the Amaranthaceous and the subfamily Chenopodiaceae. Beetroot is a native of the Mediterranean region. Germany, France, and various European nations, Africa, and South America cultivated it [6]. The world production of beetroot in 2018 was 274 million tonnes with France, the USA, Russia, Germany, and Ukraine being the top five producers [7]. Beetroot is a popular and simple-to-grow vegetable in India, consistently ranking among the top 10 [8]. Beetroot is mostly grown in the Indian states of Himachal Pradesh, Haryana, Maharashtra, West Bengal, and Uttar Pradesh [9]. The beetroot productivity in India is 20-25 tons per hectare per year [10]. Beetroot is a popular short-duration crop in Pune, Maharashtra [11]. Drinking beetroot juice is also a more convenient option than consuming the whole vegetable eating beetroot chips, or using beetroot powder. Beetroot juice is a rich source of dietary polyphenols [12,13].

Pomegranates are a fruit from the Punicaceae family, cultivated since ancient times for their delicious taste [14]. Pomegranates originate from central Asia and are cultivated in various Mediterranean countries including Iran, Spain, Egypt, India, China, and the United States. They are also grown in both Near and Far East countries [15] (Ahed J Alkhatib 2021). Currently, there are several countries around the world where pomegranates are grown. These countries include Afghanistan, Bangladesh, Chile, China, Cyprus, Egypt, France, Georgia, India, Iran, Iraq, Israel, Italy, Lebanon, Mexico, Morocco, Myanmar, Portugal, Spain, Syria, Tajikistan, Thailand, Tunisia, Turkey, Turkmenistan, the USA, and Vietnam [16]. Pomegranates are cultivated on a global scale across approximately 300,000 hectares of land, resulting in a total production of around 3.0 million metric tons. Globally India holds the top position in worldwide pomegranate production, contributing 0.81 million metric tons with a productivity rate of 7.40 tons per hectare [17]. Cultivation of pomegranate expanded to more than 300,000 ha worldwide with an estimated production of over 4,500,000 t/year [18]. India is the world’s leading country in the production of pomegranate around 3 lakh ha and production is 3.0 million tonnes [19]. Maharashtra is the leading State with 82 thousand ha area under pomegranate cultivation, Karnataka 13.6 thousand ha and Gujarat with 5.8 thousand ha, Andhra Pradesh and Tamil Nadu stood 2.8 thousand, 0.5 thousand ha of pomegranate cultivation in India [20]. India is the world's top producer of fruits and vegetables, but sadly, a significant amount is wasted due to inappropriate handling and poor postharvest management. Fruits and vegetables are naturally nutritious, and refreshing, and have a variety of delicious flavors [21]. Pomegranates are an ancient fruit that can be cultivated in semi-arid, arid, and poor soil and produce high yields. Because they can flourish in low moisture and endure saltwater water, they are widely distributed and cultivated worldwide [22].

Pomegranate and beetroot juice have been shown to have cardiovascular protective effects. Ellagitannins and anthocyanins in pomegranate juice have antioxidant and anti-atherogenic effects, while beetroot juice consumption can help lower blood pressure due to its high nitrate content [23].

The present work aimed to prepare a nutritious drink by blending beetroot juice, pomegranate juice, and a small amount of gooseberry, and ginger extract in an appropriate ratio, such that the blending is accepted to increase the efficiency in terms of health benefits and desirability.

2. MATERIALS AND METHODS

2.1 Materials

Raw materials: The fully matured, fresh pomegranate, beetroot, Gooseberry, and ginger were purchased from the local market of Phagwara district, Punjab, India.

Chemicals: Aluminum chloride ($AlCl_3$) (98% pure), sodium nitrite ($NaNO_2$) (98% pure), sodium hydroxide (NaOH) (97% pure), and sodium carbonate (Na_2CO_3) (99.5% pure) were supplied by LOBA Chemie Pvt. Ltd. Gallic acid (98% pure) and quercetin (99% pure) were procured from Sigma-Aldrich in India. The Folin-Ciocalteu reagent (FCR) and 2,2-diphenyl-1-picrylhydrazyl (DPPH) (98% pure), along with ethanol (C_2H_5OH) (95% pure), 2, indophenol 6-dichlorophenol, 3% metaphosphoric acid, 95% ethanolic HCL, also provided by LOBA Chemie Pvt. Ltd., India. Distilled water (DI) was obtained from Lovely Professional University.

2.2 Juice Preparation

Preparation of beetroot juice, Beetroot was peeled out and sliced, crushed in a laboratory grinder, then the juice was extracted by using a sujatha mixer the extracted juice was again filtered by using a four-layer muslin cloth to remove the remaining pomace.

After thoroughly washing the Pomegranate fruits they were cut into quarters with the help of a stainless steel knife. Arils were separated, and juice was extracted. Extracted juice was again filtered by using a four-layer muslin cloth to remove the remaining pomace. The freshly prepared juice was then transferred to a sterilized glass bottle for further use.

To prepare ginger for juicing, by selecting fresh ginger roots and washing them thoroughly to remove any dirt. Then, use a peeler to peel the ginger. Slicing the ginger into smaller pieces and manually grating. then strain the ginger to extract the juice and remove any pulp and fibers.

Gooseberry juice, start by taking ripe fruits, washing and deseeding them. Then, blend or juice the pieces, strain the juice, and store it in a clean, airtight container.

After that, the extracted juice of beetroot, pomegranate, ginger, and gooseberry juices should be blended in different ratios respectively. Then sugar (5%) was added to the juice properly and then the mixture was filtered through muslin cloth.

The blended juice was prepared by following the Table 1 combinations of juice of each fruit.

2.3 Sensory Evaluation

A panel of ten members conducted the sensory evaluation of the beetroot and pomegranate juice blends after preparation following sensory qualities were assessed: taste, odor, color, mouthfeel, and overall acceptability. The presentation order of the samples to the panel was randomized, and potable water was provided to rinse the mouth between evaluations to prevent the transfer of sensory attributes from one sample to the other. According to the method, each sensory attribute was scored on a 9-point Hedonic Scale, ranging from 9 to 1, respectively (liked extremely and disliked extremely).

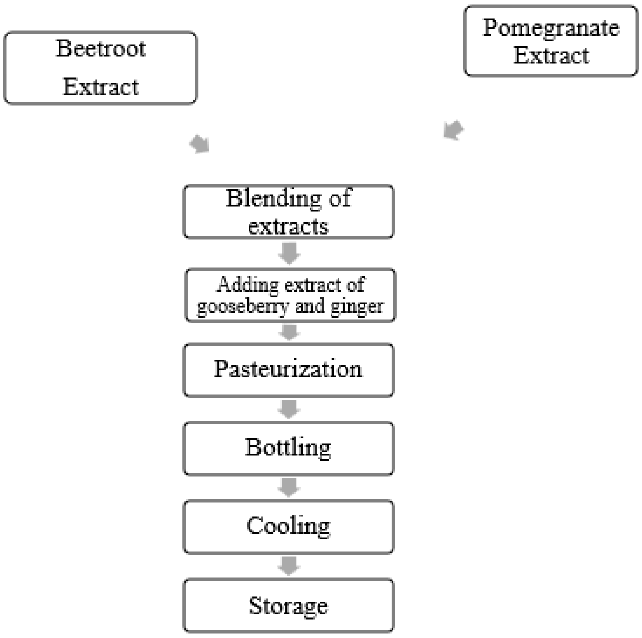

Fig. 1. Extraction and storage process of juice
[25,26]

Table 1. Treatments details used for the study

T_1- 70% Beetroot + 20% Pomegranate + 5% goose berry+ 5%Ginger
T_2- 65% Beetroot + 25% Pomegranate + 5%goose berry+ 5% Ginger
T_3- 60% Beetroot + 30% Pomegranate + 5% goose berry + 5%Ginger
T_4- 55% Beetroot + 35% Pomegranate + 5% goose berry + 5%Ginger
T_5- 50% Beetroot + 40% Pomegranate + 5% goose berry+ 5% Ginger
T_6- 45% Beetroot + 45% Pomegranate +5% goose berry + 5%Ginger
T_7- 40% Beetroot + 50% Pomegranate +5% goose berry + 5%Ginger
T_8- 35% Beetroot + 55% Pomegranate +5% goose berry + 5%Ginger
T_9- 30% Beetroot + 60% Pomegranate +5% goose berry + 5%Ginger
T_{10}-25% Beetroot + 65% Pomegranate +5% goose berry+ 5%Ginger

2.4 Physical and Chemical Analyses

Total soluble solids (TSS), pH, total acidity, and ascorbic acid content were determined as quality indexes. General parameters were measured following the official methods AOAC [24]: The TSS are measured using a digital refractometer and expressed in °Brix, followed by Ranganna [27]. The pH of the juice, blended juice, was recorded with the help of a digital pH meter (Deluxe pH meter model 101). Ascorbic acid was determined by visual titration, using 2, indophenol 6-dichlorophenol method and expressed as mg/100mL juice. Total and reducing sugars were determined according to Ranganna [27].

2.5 Determination of Total Phenolic Content of Beetroot and Pomegranate Blended Juice

The total phenolic content of the blended juice was measured using the Folin-Ciocalteau reagent. A 20 µL juice sample was diluted with 1.6 mL distilled water, mixed with 100 µL Folin-Ciocalteau reagent, and 300 µL saturated Na_2CO_3 (20%). The mixture was heated at 40 °C for 30 minutes and cooled in an ice bath, and its absorbance was measured at 765 nm using a UV/Vis spectrophotometer (Systronics AU-2701). Results were expressed as mg gallic acid equivalent (GAE)/L [28].

2.6 Determination of Total Flavonoid Content of Beetroot and Pomegranate Blended Juice

The total flavonoid content of blended juice was measured by aluminum chloride ($AlCl_3$) according to the spectrophotometric method using quercetin as a standard. Firstly, 0.5 mL of fresh juice was taken in a test tube and 1.5 mL of methanol, 0.1 mL of 10%($AlCl_3$), 0.1 mL of 1M potassium acetate, and 2.8 mL of distilled water were added into a tube. This tube was left at room temperature for 30 min after which the absorbance of the reaction mixture was measured at 415 nm with a UV/ Visible spectrophotometer (Systronics AU-2701). The total flavonoid content of fresh juice was expressed as mg quercetin equivalent (QE) /L. Quercetin was used as a reference compound to produce the standard curve [28].

2.7 Antioxidant Activity Assay

DPPH Test: The total antioxidant activity of blended juice was determined using a 2, 2-diphenyl-l-picrylhydrazyl (DPPH) radical scavenging assay. The antioxidant activity of the beetroot pomegranate blended juice was achieved by the method of [29], Briefly, 100 µL of juice diluted at 1:100 with methanol: water (6:4) and 2 mL of 0.1 mM DPPH in methanol were mixed. After 30 min of reaction, the absorbance was determined at 517 nm with a UV/ Visible spectrophotometer (Systronics AU-2701). For the background correction, the mixture was prepared without DPPH.

The antioxidant activity was determined according to the equation mentioned below:

$$Inhibition\ of\ DPPH\ (\%) = \frac{(\text{Absorbance Control} - \text{Absorbance sample})}{(Absorbance\ control)}$$

2.8 Determination of Total Anthocyanin Content

Total anthocyanins present in all samples were determined by the spectrophotometric method as per Ranganna [27]. 50 mL of 95% ethanolic HCL was added to the 10 mL sample and transferred into the volumetric flask. The sample was stored at 4 ℃ overnight in an airtight volumetric flask. The sample was kept in the dark for 2 hrs measuring its optical density at 535 nm with UV/ Visible spectrophotometer (Systronics AU-2701).

Anthocyanins were calculated and expressed as mg/100 mL using the formula given below

$$\text{Total optical density} = \frac{OD\ value\ at\ 535nm \times volume\ made\ up\ for\ colour\ estimation}{weight\ of\ sample} \times 100$$

The E value for 1% solution (i.e. 10 mg per 1 mL) at 535 nm is equal to 982 therefore, the absorbance of a solution of 1 mg per mL is equal to 98.2.

$$\text{Total Anthocyanin Content (mg/100g)} = \frac{Total\ optical\ density}{98.2}$$

98.20 = Extraction coefficient (Ranganna 2009).

2.9 Statistical Analysis

Beetroot pomegranate beverages are evaluated for various physicochemicals using the mean values obtained from the analyses of variance (ANOVA).

The SPSS statistical programme (Version 23.0, IBM Corporation, Somers, NY, USA) was used to analyze variance (ANOVA) and Tukey multiple range tests. The data are shown as mean values with standard deviations and are considered substantially different when p<0.05, n=3 is used.

3. RESULTS AND DISCUSSION

3.1 Sensory Evaluation

Table 2 presents the sensory evaluation results for ten treatments based on five parameters: The evaluation parameters included color and appearance, taste, flavour, mouth feel, and overall acceptability, assessed using a 9-point hedonic scale. The sensory evaluation of various beetroot and pomegranate juice combinations revealed significant differences in appearance, taste, flavor, mouthfeel, and overall acceptability. Treatment T_9, which contained the highest concentration of pomegranate juice, received the highest scores across all sensory attributes, with a perfect score of 7.8 for appearance and overall acceptability. In contrast, Treatment T_1, with the lowest concentration of pomegranate juice, received the lowest scores, ranging from 2.9 for appearance to 2.9 for overall acceptability. The taste, flavor, and mouthfeel of the juice combinations also showed significant enhancements with higher concentrations of pomegranate juice. Treatment T_9 received the highest scores for taste 7.9, flavor 7.4, and mouthfeel 7.7, while Treatment T_1 received the lowest scores. Overall, the sensory analysis indicates that the combination of beetroot and pomegranate juice can be optimized to create a functional beverage with enhanced sensory and nutritional properties. Increasing the concentration of pomegranate juice leads to significant improvements in appearance, taste, flavor, mouthfeel, and overall acceptability. These findings are consistent with previous research [30].

Table 3 presents the physicochemical analysis of blended juice from beetroot and pomegranate across ten different treatments, measuring pH, Total Soluble Solids (TSS) in °Brix, and Vitamin C content (mg/100ml). The pH values range from 3.14±0.55 (T_3) to 4.35±0.57 (T_{10}), with no significant differences among the treatments. TSS values are relatively consistent across treatments, ranging from 13.81±0.58 (T_2) to 14.97±0.62 (T_{10}). Vitamin C content varies more significantly, from 10.03±0.21 (T_1) to 13.06±0.11 (T_{10}), with T_{10} having the highest content and T_1 the lowest.

The physicochemical analysis of the blended beetroot and pomegranate juice treatments revealed significant variations in pH, TSS, vitamin C content, and titratable acidity, reflecting the impact of different juice proportions. The pH values ranged from 3.14 in treatment T_3 to 4.35 in treatment T_{10}, with a noticeable increase in pH as the proportion of pomegranate juice increased. This trend suggests that pomegranate juice, which has a relatively higher pH, moderates the acidity of the blend. Similar results were reported by [30]. The Total Soluble Solids (TSS) values, which ranged from 13.81 °Brix in T_2 to 14.97 °Brix in T_{10}, remained relatively consistent across treatments, indicating that the blend's sweetness was maintained within a narrow range despite variations in juice proportions. Similar results have been reported by [31] kinnow juice blended with pomegranate and ginger juice. The vitamin C content showed a significant increase across the treatments, starting from 10.03 mg/100 mL in T_1 and reaching 13.06 mg/100 mL in T_{10}. This increase can be attributed to the higher concentration of

Table 2. Sensory analysis of a different combination of beetroot and pomegranate juice

Treatments	Appearance and Colour	Taste	Flavor	Mouth Feel	Overall Acceptability
T_1	2.9± 0.20^{d}	3.9±0.55^{f}	2.9±0.89^{f}	3.9± 0.56^{f}	2.9± 0.43^{g}
T_2	3.9± 0.66^{cd}	4.9±0.79^{e}	3.9± 0.57^{e}	4.9± 0.67^{e}	3.9± 0.56^{f}
T_3	3.9± 0.78^{cd}	5.9±0.67^{d}	4.9± 0.76^{d}	5.9± 0.66^{d}	4.9± 0.65^{de}
T_4	4.9± 0.44^{bc}	5.9±0.98^{d}	4.9± 0.76^{d}	5.9± 0.78^{d}	5.9± 0.56^{c}
T_5	4.9± 0.66^{bc}	6.9±0.44^{c}	5.9± 0.30^{c}	6.9± 0.36^{c}	5.9± 0.89^{c}
T_6	5.9± 0.43^{b}	6.9±0.57^{c}	5.9± 0.60^{c}	6.9± 0.76^{c}	6.9± 0.54^{b}
T_7	5.9± 0.57^{b}	7.8±0.67^{ab}	6.8± 0.53^{b}	7.6± 0.63^{ab}	6.9± 0.67^{b}
T_8	4.9± 0.79^{bc}	5.9±0.67^{d}	4.9± 0.25^{d}	5.9± 0.90^{d}	5.9±0.56^{c}
T_9	7.8± 0.67^{a}	7.9±0.99^{a}	7.4± 0.84^{a}	7.7± 0.84^{a}	7.8± 0.45^{a}
T_{10}	3.9± 0.67^{cd}	4.9± 0.20^{e}	3.9± 0.77^{e}	4.9± 0.20^{e}	4.8± 0.12^{de}

Data are expressed mean in triplicates ± standard deviation.

Table 3. Physicochemical Analysis of Blended Juice of Beetroot Pomegranate

Treatments	pH	TSS(°Brix)	Vitamin C (mg/100mL)
T_1	3.48±0.60^a	14.12±0.54^a	10.03±0.21^f
T_2	3.70±0.57^a	13.81±0.58^a	10.45±0.12^{ef}
T_3	3.14±0.55^a	14.80±0.63^a	10.87±0.30^e
T_4	3.80±0.57^a	14.44±0.58^a	11.08±0.42^{de}
T_5	3.81±0.55^a	14.24±0.54^a	11.57±0.38^d
T_6	4.03±0.56^a	14.01±0.62^a	11.98±0.24^{cd}
T_7	4.20±0.58^a	14.34±0.54^a	12.29±0.41^b
T_8	4.29±0.58^a	14.89±0.57^a	12.68±0.23^b
T_9	4.32±0.56^a	14.91±0.59^a	12.98±0.34^a
T_{10}	4.35±0.57^a	14.97±0.62^a	13.06±0.11^a

Data are expressed mean in triplicates ± standard deviation

pomegranate juice, which is rich in vitamin C, thereby enhancing the nutritional value of the juice blend [32]. Support this observation. The analysis shows that increasing the proportion of pomegranate juice in the blend not only enhances the vitamin C content but also contributes to a more balanced and desirable acidity, without significantly altering the sweetness as indicated by the TSS values. The juice blends with a higher proportion of pomegranate, such as T_9 and T_{10}, offer improved nutritional benefits and a better balance of physicochemical properties, making them potentially more appealing to consumers.

Table 4 presents the physico-chemical characterization of blended juice from beetroot and pomegranate for ten different samples, including Total Phenolic Content (mgGAE/L), Total Flavonoid Content (mgQE/L), Antioxidant Activity, and Anthocyanin (mg/100mL). The total phenolic content (TPC) ranged from 1,048.03 mg GAE/L in treatment T_1 to 1,432.28 mg GAE/L in T_{10}. The TPC showed a consistent increase across the treatments as the proportion of pomegranate juice in the blend increased. This trend is likely due to the higher phenolic content naturally present in pomegranate juice, which is known for its rich polyphenolic compounds. The substantial increase in TPC from T_1 to T_{10} underscores the significant contribution of pomegranate juice to the phenolic profile of the blend, enhancing its potential health benefits due to the well-documented antioxidant properties of phenolic compounds. The total flavonoid content (TFC) varied from 348.43 mg QE/L in T_3 to 611.61 mg QE/L in T_{10}. The treatments with higher pomegranate content, such as T_9 and T_{10}, exhibited the highest flavonoid levels, which aligns with the understanding that pomegranate juice is an excellent source of flavonoids. These bioactive compounds are crucial for their antioxidant, anti-inflammatory, and cardioprotective properties. The significant variation in TFC across treatments indicates that the flavonoid content in the blended juice can be effectively modulated by adjusting the ratio of beetroot to pomegranate juice. Similar results were recorded [33] and [28] in pomegranate juice.

Antioxidant activity, measured by the ability of the juice to neutralize free radicals, ranged from 44.64% in T_1 to 87.53% in T_{10}. The increasing antioxidant activity from T_1 to T_{10} corresponds with the rising TPC and TFC, highlighting the synergistic effect of phenolic compounds and flavonoids in enhancing the antioxidant potential of the juice. The highest antioxidant activity observed in T_{10} suggests that the blend with the most pomegranate juice offers superior protection against oxidative stress, making it particularly beneficial for health-conscious consumers. Similar results were reported by [34] in beetroot-passion blended juice. Similar reported on beetroot juice blends with carrot and apple [35].

Anthocyanin content displayed an inverse relationship with the proportion of pomegranate juice in the blends. The anthocyanin levels decreased from 30.01 mg/100 mL in T_1 to 25.13 mg/100 ml in T_{10}. This decline can be attributed to the dilution effect as the concentration of beetroot juice, which is a richer source of anthocyanins compared to pomegranate juice, decreased in the blend. Anthocyanins are potent antioxidants known for their role in reducing the risk of chronic diseases, and their concentration in the juice blend is crucial for maintaining its vibrant color and health benefits. Results agreed with [33,36].

Table 4. Physico Chemical characterization of blended juice of beetroot and pomegranate

Sample	Total phenolic content (mgGAE/L)	Total flavonoid content (mgQE/L)	Antioxidant activity(%)	Anthocyanin (mg/100mL)
T_1	1048.03±7.22[f]	558.83±4.80[ab]	44.64±0.26[f]	30.01±0.31[a]
T_2	1065.37±5.29[f]	572.91±6.51[a]	51.36±0.31[e]	29.59±0.47[a]
T_3	1147.27±5.51[e]	348.43±4.27[c]	51.36±0.39[e]	28.72±0.55[b]
T_4	1200.50±7.75[de]	601.04±8.02[a]	59.25±0.60[d]	27.94±0.16[b]
T_5	1229.90±7.16[bc]	559.89±6.1[ab]	59.27±0.51[d]	26.91±0.22[de]
T_6	1261.95±7.22[c]	500.51±9.55[b]	67.99±0.81[c]	26.35±0.29[de]
T_7	1269.63±7.22[c]	506.94±2.36[b]	78.09±0.15[b]	26.16±0.25[de]
T_8	1376.16±8.53[b]	582.29±4.07[a]	80.60±0.38[b]	25.84±0.23[de]
T_9	1400.06±6.93[ab]	595.88±4.04[a]	85.69±0.34[a]	25.54±0.35[ef]
T_{10}	1432.28±3.35[a]	611.61±6.30[a]	87.53±0.44[a]	25.13±0.18[f]

Data are expressed mean in triplicates ± standard deviation.

Table 5. Effect of storage on physical-chemical parameters

T_9- 30 % Beetroot + 60% Pomegranate + 5% Gooseberry+ 5% Ginger				
PARAMETER	**0^{th} day**	**7^{th} day**	**14^{th} day**	**21^{st} day**
pH	4.35±0.56[a]	4.12±0.33[a]	3.78±0.45[a]	3.12±0.27[a]
TSS	14.97±0.59[a]	14.89±0.29[a]	14.72±0.34[a]	14.56±0.59[a]
Vitamin C	12.98±0.34[a]	12.02±0.22[a]	11.85±0.12[a]	11.50±0.15[a]
Antioxidant activity	85.69±0.34[a]	82.57±0.66[a]	79.22±0.67[a]	76±35±0.13[a]

Physico Chemical characterization of the blended beetroot and pomegranate juice highlights the potential of these blends as functional beverages. The increase in TPC, TFC, and antioxidant activity with higher pomegranate content suggests that such blends can offer enhanced health benefits, particularly in terms of antioxidant protection. The decrease in anthocyanin levels with increasing pomegranate juice indicates a trade-off in the concentration of specific bioactive compounds. This analysis suggests that the optimal blend for maximizing antioxidant properties and maintaining a balance of phenolic compounds and anthocyanins might be one that carefully balances the proportions of beetroot and pomegranate juice, such as T_9, which offers high antioxidant activity while retaining a substantial anthocyanin content. This finding is crucial for the development of health-oriented beverages, where both bioactive compound concentration and sensory attributes, such as color, play significant roles in consumer acceptance.

3.2 Effect on Storage on Physical-Chemical Parameters

Table 5 presents the effect of storage on the physicochemical parameters of the T_9 blended juice, which contains 30% beetroot, 60% pomegranate, 5% amla, and 5% ginger, was analyzed over 21 days. The pH of the juice exhibited a gradual decline from an initial value of 4.35 on the 0^{th} day to 3.12 by the 21^{st} day. This reduction in pH suggests an increase in the acidity of the juice over time, likely due to the breakdown of organic acids and possible microbial activity that leads to the formation of additional acidic compounds. The total soluble solids (TSS) content showed a slight but consistent decrease from 14.97 °Brix on the 0^{th} day to 14.56 °Brix by the 21^{st} day. This minor reduction in TSS could be due to the hydrolysis of sugars and other soluble components into less soluble or volatile compounds during storage. The vitamin C content of the juice also showed a gradual decline from 12.98 mg/100 mL on the 0^{th} day to 11.50 mg/100 mL by the 21^{st} t day. The degradation of vitamin C is a common phenomenon in stored fruit juices, influenced by exposure to light, oxygen, and temperature fluctuations. This reduction in vitamin C impacts the nutritional value of the juice, as it directly affects the antioxidant properties and health benefits associated with its consumption. A similar observation was documented by [35] on beetroot juice blends with carrot and apple.

The antioxidant activity of the juice decreased from 85.69% on the 0^{th} day to 76.35% by the 21^{st}

day. This decline is likely due to the reduction in phenolic compounds and other bioactive components that contribute to the juice's antioxidant capacity. The decrease in antioxidant activity suggests a diminished ability of the juice to neutralize free radicals over time, which could affect its functional properties and consumer perception as a health-promoting beverage. Overall, the changes observed in the physicochemical parameters of the T_9 juice blend during storage highlight the susceptibility of the juice to degradation over time. These alterations could influence the juice's sensory qualities, nutritional value, and overall shelf life. To mitigate these effects, it may be necessary to explore storage conditions such as refrigeration, light protection, and the use of preservatives to help preserve the physicochemical integrity of the juice over extended periods. This study underscores the importance of understanding the storage stability of functional beverages, particularly those enriched with bioactive compounds, to ensure their efficacy and consumer acceptability over time.

4. CONCLUSION

This study investigated the effects of blending beetroot and pomegranate juices with other ingredients like gooseberry and ginger on the physicochemical, biochemical, and sensory properties of the resulting juice. The results showed that increasing the concentration of pomegranate juice led to significant improvements in appearance, taste, flavor, mouthfeel, and overall acceptability. The blended juice also exhibited enhanced antioxidant activity, total phenolic content, and total flavonoid content. Storage of the blended juice for 21 days resulted in a decrease in pH, vitamin C content, and antioxidant activity. Overall, the optimal blend ratio of 30% beetroot, 60% pomegranate, 5% gooseberry, and 5% ginger (T_9) showed the most promising results, making it a potential functional beverage for commercial production.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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