



# Optimization of Blending Ratios and Quality Evaluation of Mandarin (*Citrus reticulata* Blanco) based Cordial

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## ABSTRACT

**Background:** The present investigation was conducted during 2025-26 in the Horticulture Laboratory, School of Agricultural Sciences (SoAS), G.D. Goenka University, Gurugram, Haryana, with the objective of optimizing suitable blending ratios and evaluating the quality and storage stability of mandarin-based cordial.

**Methods:** Four combinations of mandarin and strawberry were formulated using different flavouring ingredients, viz., ginger (Combination A), peppermint (Combination B), sweet basil (Combination C) and tamarind (Combination D), with three blending ratios under each combination. Among the treatments, T3 comprising 55% mandarin + 40% strawberry + 5% ginger in Combination A, T2 comprising 60% mandarin + 35% strawberry + 5% peppermint in Combination B, T2 comprising 60% mandarin + 35% strawberry + 5% sweet basil in Combination C and T3 comprising 55% mandarin + 40% strawberry + 5% tamarind in Combination D were found to be the most acceptable on the basis of organoleptic evaluation using a 9-point hedonic scale by a diverse panel comprising male and female evaluators of different age groups from 20 to 75 years. These four treatments were subsequently selected for storage evaluation. The selected cordials were standardized to 25% fruit juice/pulp, 30% total soluble solids, 1.50% acidity and 600 ppm sodium benzoate, filled into 500 ml glass bottles and stored under ambient conditions. Quality attributes were evaluated at monthly intervals for 150 days.

**Result:** During storage, TSS, acidity, total sugars, microbial counts and browning index showed a gradual increasing trend, whereas ascorbic acid, pH and organoleptic quality exhibited a decreasing trend. The magnitude of these changes varied among the selected treatments. Among the treatments, T3 of Combination D (55% mandarin + 40% strawberry + 5% tamarind) exhibited the slowest rate of undesirable changes in chemical attributes and retained comparatively better-quality during storage followed by T3 of Combination A (55% mandarin + 40% strawberry + 5% ginger). At the end of 150 days of storage, T3 of Combination D recorded the highest overall sensory acceptability, indicating superior retention of desirable quality characteristics and better storage stability compared with the other treatments. Thus, the study demonstrated that 55% mandarin + 40% strawberry + 5% tamarind (D-T3) was the most promising formulation for the preparation of an acceptable and comparatively stable mandarin-based cordial under ambient storage conditions (18.55 to 26.39°C).

**Key words:** Cordial, Ginger, Mandarin, Peppermint, Strawberry, Sweet basil, Tamarind.

## INTRODUCTION

India stands tall among the world's leading producers of fruits and vegetables after China, thanks to its diverse climate that nurtures a wide array of crops. Fruits hold a special place, celebrated for their vibrant hues, unique flavors and refreshing qualities. The mandarin (*Citrus reticulata* Blanco), a member of the Rutaceae family is particularly cherished for its distinctive taste, enticing aroma and rich nutritional profile, boasting vitamin C, carotenoids, organic acids and other phytochemicals (Shorbagi *et al.*, 2022). The presence of cryptoxanthin pigment endows it with antioxidant properties. Among the citrus family, the Nagpur mandarin and kinnow mandarin reign supreme in popularity. Yet, their fleeting postharvest life and seasonal nature call for innovative processing and value-addition techniques. Transforming mandarins into a variety of processed delights-such as juice, ready-to-serve beverages, squash and cordial drinks, alongside marmalade creations can enhance their use and offer a fresh path to minimize waste while preserving the fruit's appealing qualities (Putnik *et al.*, 2017). The peel of the

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mandarin, rich in ascorbic acid, polyphenolic antioxidants and carotenoids, finds its place in the realms of cosmetics and confectionery (Anwar *et al.*, 2008).

Strawberry (*Fragaria × ananassa* Duch.) is cherished for its vibrant hue, delightful flavor and enchanting aroma standing as a remarkable source of vitamin C, anthocyanins, phenolics and other bioactive compounds (Giampieri *et al.*, 2012). Its delicate nature and fleeting freshness make processing a crucial method for prolonging its use. As a commercial fruit, strawberry holds immense potential for processing and finds its way into an array of products such as purees, RTS, squash, juice, jams, preserves, candy and even alcoholic drinks (Sharma *et al.*, 2009). Some studies have hinted at the health benefits of strawberry consumption, including the reduction of blood Low-density lipoprotein (LDL) cholesterol levels, total cholesterol, the oxidation of LDL cholesterol and the moderation of blood sugar spikes following high-sugar meals seen after high-fat meals (Basu *et al.*, 2014). Merging strawberry with mandarin could weave together the distinct citrus and berry notes, offering a visually appealing and nutritionally rich beverage.

Herbs and spices can infuse fruit-based beverages with a balance of unique flavors, aromas and bioactive elements. Ginger (*Zingiber officinale* Roscoe) is renowned for its fiery kick, thanks to gingerols and shogaols that define its distinctive zest and biological prowess (Mao *et al.*, 2019; Maghraby *et al.*, 2023). Peppermint (*Mentha × piperita* L.) offers a brisk, cooling sensation, a refreshing breeze carried by menthol and other essential oils (Mahendran and Rahman, 2021). Sweet basil (*Ocimum basilicum* L.) is a treasure trove of volatile and phenolic compounds, such as linalool and eugenol, which weave its signature fragrance (Brindisi and Simon, 2023). Tamarind (*Tamarindus indica* L.) is cherished in beverages for its sweet-tart allure, a balance of organic acids and sugars (Caluwé *et al.*, 2010). Imagine a vibrant elixir where the natural ripened mandarin and the juicy sweetness of strawberry balance with a medley of handpicked herbs and the tangy embrace of tamarind. This concoction promises not just a burst of flavor but the potential for a functional cordial that tantalizes the senses. Cordial is a type of beverage that contains 25% fruit pulp or juice, 30% TSS, 1.50% acidity and uses 600 ppm sodium benzoate or 350 ppm KMS as a preservative (FSSAI, 2023). Merging strawberry, mandarin with herbs and or spices could weave together the distinct citrus and berry notes, offering a visually appealing and nutritionally rich beverage. However, there is limited information on the systematic optimization of mandarin-strawberry blending ratios with complementary herbs and spices for cordial development. Comparative evaluations of the physicochemical, sensory and storage stability of such blended cordials under ambient conditions are also scarce. Consequently, this study was conducted to optimize the blending ratios and evaluate the quality and storage stability of the developed mandarin-based cordial.

## MATERIALS AND METHODS

The current study was conducted during 2025-26 at the Horticulture Laboratory, School of Agricultural Sciences,

G D Goenka University, Sohna, Gurugram, Haryana. Fresh mandarin, strawberry, ginger, peppermint, sweet basil and tamarind were procured locally from Sohna market for cordial preparation.

### Extraction and preparation of mandarin juice, strawberry pulp, ginger juice, peppermint, sweet basil juice extract and tamarind pulp

Fresh, fully ripe and high-quality mandarin and strawberry fruits, free from physical damage, decay and visible microbial infection were selected for juice and pulp preparation. Mandarin fruits were chosen at the fully ripe stage based on characteristic peel color, firmness, flavor and absence of defects, while strawberries were selected at the fully ripe stage with a uniform red color, good firmness and freedom from bruising and spoilage. The fruits were thoroughly washed with clean water to remove adhering dirt and extraneous matter. For mandarin juice extraction, the fruits were manually peeled, the segments were separated and the juice was extracted using a mixer-cum-grinder. The extracted juice was filtered through double-layered muslin cloth to remove seeds and coarse particles and collected in clean, sterilized containers whereas, strawberry pulp was prepared from washed and de-calyxed fruits by blending in a mixer-cum-grinder followed by filtration through muslin cloth to obtain a smooth and uniform pulp. For the preparation of ginger extract, fresh, healthy and mature ginger rhizomes were washed, peeled and grated. The grated ginger was combined with water at a material-to-water ratio of 1:2 (w/v) and left to stand for 15 minutes, followed by grinding and filtration through a double-layered muslin cloth. Peppermint and sweet basil extracts were prepared using fresh, tender and healthy leaves. The leaves were thoroughly washed, drained and ground separately with water at a material-to-water ratio of 1:2 (w/v). The resulting extracts were filtered through a double-layered muslin cloth to obtain clear and uniform extracts. For tamarind extraction, high-quality ripe tamarind pulp, free from seeds, fibres and foreign matter was used. The pulp was mixed with water at a ratio of 1:2 (w/v) and soaked for 30 minutes at room temperature to facilitate the release of soluble constituents. The soaked material was then manually macerated, followed by filtration through double-layered muslin cloth to obtain a homogeneous tamarind pulp.

### Standardization of blends for cordial

The various combinations alongwith their treatments of mandarin, strawberry, ginger, peppermint, sweet basil and tamarind pulp or juice or extract were used to determine the best combination for palatable cordial through organoleptic evaluation.

### Combinations (A)

- T1: 65% Mandarin+30% Strawberry+5% Ginger
- T2: 60% Mandarin+35% Strawberry+5% Ginger
- T3: 55% Mandarin+40% Strawberry+5% Ginger

**Combinations (B)**

T1: 65% Mandarin+30% Strawberry+5% Peppermint  
 T2: 60% Mandarin+35% Strawberry+5% Peppermint  
 T3: 55% Mandarin+40% Strawberry+5% Peppermint

**Combinations (C)**

T1: 65% Mandarin+30% Strawberry+5% Sweet basil  
 T2: 60% Mandarin+35% Strawberry+5% Sweet basil  
 T3: 55% Mandarin+40% Strawberry+5% Sweet basil

**Combinations (D)**

T1: 65% Mandarin+30% Strawberry+5% Tamarind  
 T2: 60% Mandarin+35% Strawberry+5% Tamarind  
 T3: 55% Mandarin+40% Strawberry+5% Tamarind

**Objectives**

1. To find out the best treatments from each combination on the basis of organoleptic evaluation.
2. To study the chemical attributes and shelf life of best treatment from each combination during storage.
3. To find out the best treatment in terms of quality attributes and shelf life.

**Preparation of cordial**

The blended cordial was meticulously crafted by combining mandarin and strawberry with distinct additives: A- ginger, B- peppermint, C- sweet basil and D- tamarind in different ratios, in carefully measured proportions according to the treatment combinations. Each formulation consistently contained 25% total juice content. A sugar syrup was expertly prepared by dissolving the precise amount of sugar in potable water followed by heating until fully dissolved. The syrup was then filtered through a double-layered muslin cloth to ensure purity and cooled to room temperature. The extracted juice blend was thoroughly integrated with the sugar syrup and the cordial was precisely standardized to 30% total soluble solids (TSS) and 1.50% titratable acidity by adjusting the sugar and citric acid levels. Initially, 250 ml cordial of each treatment from each combination was prepared to identify the optimal treatment. The best four treatments were then further developed for storage screening to determine the most effective blending combination for the cordial. Sodium benzoate was added to achieve a concentration of 600 ppm as a preservative during storage. The cordial was thoroughly mixed to ensure a uniform blend and promptly filled into 5 pre-sterilized 500 ml glass bottles for those four combinations, leaving approximately 1.6 cm of headspace. The bottles were sealed with crown corks, pasteurized at 85°C for 30 minutes into water bath, rapidly cooled to room temperature and stored under ambient conditions (18.55 to 26.39°C) for subsequent physicochemical, sensory and storage evaluation. All types of chemical, ingredients and other materials were sourced from Horticulture Lab.

**Storage studies**

Five liters of the finest cordial blend were crafted from the optimal treatment of each combination, then lovingly decanted into 500 ml glass bottles, leaving a 1.6 cm breath

of space at the top. These bottles were sealed with care and set aside for storage trials at the gentle embrace of ambient temperatures, ranging from 18.55 to 26.39°C. Over the course of five months, like a watchful guardian, monthly observations were made, noting the changes during storage in TSS, acidity, ascorbic acid (vitamin-C), total sugars, pH, browning, microbial growth and organoleptic qualities. These findings are detailed as a hand refractometer from Erma Inc. in Tokyo, Japan, served as our lens to measure the sample's TSS, with results expressed in percentages (28-62%). The TSS values, observed at ambient temperatures, were adjusted to 20°C using a reference table and the sample average was reported as a percentage of the total TSS level (Ranganna, 2010). The acidity content was unveiled through a meticulous process where 5 ml of an aliquot was carefully extracted and titrated with phenolphthalein as the guiding light, against a standard N/10 NaOH solution. The ultimate aim was the emergence and steadfastness of a delicate pink hue. The total acidity was quantified and expressed as anhydrous citric acid per 100 millilitres or grams of the sample. To gauge the amount of ascorbic acid (vitamin C) in a 50 ml volumetric flask, 5 millilitres or grams of the sample were procured. The sample's volume was then expanded with a 3% HPO<sub>3</sub> (metaphosphoric acid) solution. Following this, the 2, 6-dichlorophenol indophenol sodium salt dye solution was employed to determine a 5 ml aliquot. The final tint was a gentle pink that lingered for at least fifteen seconds (Ranganna, 2010). To measure total sugars, Fehling's solutions A and B were employed with methyl blue serving as the sentinel during the boiling process. The pH was gauged using the INSIF digital pH meter model (IE-702), meticulously calibrated and standardized with buffers at pH values of 4.0 and 7.0. Non-enzymatic browning was unveiled through the alcoholic extraction method outlined by Ranganna (1986). A precise portion of the sample was meticulously blended with 30 mL of 60% aqueous ethanol, then spun in a centrifuge at 1500 rpm for 15 minutes. The resulting supernatant was passed through Whatman No. 1 filter paper, yielding a crystal-clear extract. This extract's absorbance was gauged at 440 nm using a UV-Vis spectrophotometer with 60% aqueous ethanol serving as the blank. The absorbance reading at 440 nm was noted as the non-enzymatic browning index (Ranganna, 1986). This method of using the absorbance of an alcoholic extract at 440 nm as a browning index has also been documented for fruit and fruit-based products whereas, the microbiological quality of the samples was explored through the classic lens of the standard plate count technique. With meticulous care, serial dilutions of the samples were crafted in a sterile procedure with distilled water and aliquots were gently placed onto Nutrient Agar (NA) to reveal the hidden world of bacterial inhabitants, while Rose Bengal Agar (RBA) served as the stage for yeasts and molds to make their appearance. These inoculated plates, like tiny ecosystems

were nurtured under ideal conditions until colonies blossomed, their numbers recorded as log<sub>10</sub> colony-forming units (CFU) per mL of sample. This microbiological analysis of fruit beverages, employing culture media and standard plate-count methods, aligns with the time-honoured analytical practices for fruit products (Ranganna, 1986). To assess the organoleptic charm of cordial, a semi-trained panel of nine judges including different ages of males and females ranges from 20 to 75 years embarked on a sensory journey, scoring on a 9.0-point Hedonic Rating Scale (Amerine *et al.*, 1965).

### Statistical analysis

The studies were conducted in three replications and the computer program SPSS (Statistical Package for Social Sciences) was employed to perform the statistical analysis of the data using the completely randomized design (CRD) as outlined by Panse and Sukhatne (1985).

## RESULTS AND DISCUSSION

### Best blending combination

Out of these four combinations, first one we have selected one of suitable and best combination from each combination basis on organoleptic evaluation by panel of semi trained judges on 9-point hedonic scale. Thereafter, we have been found one best treatment from each given combinations (Table 1) and that after we studied of their storability and evaluate quality attributes and shelf life of those four treatments and finally, we have been found only one treatment out of those four treatments in terms of good quality attributes and shelf life. The organoleptic evaluation showed significant differences among the various mandarin–strawberry and spice-herb cordial formulations. The most preferred formulation was D-T3 (55% mandarin + 40% strawberry + 5% tamarind) with a score of 8.33, followed by A-T3 (8.30), C-T2 (8.20) and B-T2 (8.12).

The higher preference for these formulations might be due to the balanced mix of mandarin and strawberry with the flavoring ingredients, creating a desirable taste and flavor. Similarly, Kesavanath *et al.* (2015) found that a mix of 70% starfruit juice and 30% sweet orange juice was the best for cordial development. Patil (2021) reviewed the best cordial formulation using kiwi, guava and mint in the ratio of 8g:18g:3g, respectively whereas, Said and Jena (2025) revealed that the treatment T2 comprised chayote with mandarin at 1:1 ratio was best for beverage formulation.

### Total soluble solids (%)

The Total Soluble Solids (TSS) in Table 2 significantly increased gradually during storage (18.55 to 26.39°C) across all treatments, with the smallest increase observed in D-T3 (55% mandarin + 40% strawberry + 5% tamarind), rising from 30.00 to 30.87% over 150 days, followed by A-T3. Consequently, D-T3 demonstrated comparatively better TSS stability than the other formulations. The increase in TSS during storage is attributed to the hydrolysis of sugars from polysaccharides to mono and disaccharides. Similar findings were reported by Meera *et al.* (2021) in pineapple and passionfruit based probiotic drink, Bhagat *et al.* (2025) in blended syrup from mandarin and passionfruit and by Lather *et al.* (2026) in a fruit-herbs blended beverage.

### Acidity (%)

An acidity of blended cordial consistently significantly increased across all treatments in Table 3 at room temperature (18.55 to 26.39°C), with D-T3 exhibiting the smallest rise (1.50 to 1.86%) by 150 days, followed closely by A-T3. This indicates that D-T3 maintains superior acidity stability compared to other formulations. The increase in acidity is likely due to the production of organic acids and the breakdown of pectic compounds (Conn and Stumpf, 1976). Abeywickrama and Jayasooriya (2010) also observed a similar acidity increase in kerala-based cordial and Pavithra

**Table 1:** Screening of best blending ratio for the preparation of cordial developed from mandarin, strawberry and various combinations.

| Combinations | Treatments | Formulations     | Organoleptic score | Rating |
|--------------|------------|------------------|--------------------|--------|
| A            | T1         | 65% M+30% S+5% G | 7.95               | LM     |
| A            | T2         | 60% M+35% S+5% G | 7.88               | LM     |
| A            | T3         | 55% M+40% S+5% G | 8.30               | LVM    |
| B            | T1         | 65% M+30% S+5% P | 7.90               | LM     |
| B            | T2         | 60% M+35% S+5% P | 8.12               | LVM    |
| B            | T3         | 55% M+40% S+5% P | 7.95               | LM     |
| C            | T1         | 65% M+30% S+5% S | 7.92               | LM     |
| C            | T2         | 60% M+35% S+5% S | 8.20               | LVM    |
| C            | T3         | 55% M+40% S+5% S | 7.85               | LM     |
| D            | T1         | 65% M+30% S+5% T | 7.94               | LM     |
| D            | T2         | 60% M+35% S+5% T | 7.87               | LM     |
| D            | T3         | 55% M+40% S+5% T | 8.33               | LVM    |
| SE.m±        |            |                  | 0.03               |        |
| CD at 5%     |            |                  | 0.10               |        |

G- Ginger, P- Peppermint, Sb- Sweet basil and T- Tamarind.

LM- Like moderately and LVM- Like very much

and Mini (2023) reported comparable findings in Dragon Fruit (*Hylocereus undatus*) based blended RTS beverage.

#### Vitamin C (mg/100ml)

The vitamin C content in all blended cordial combinations slowly significantly dwindled over the 150 days of storage (18.55 to 26.39°C) mentioned in Table 4. By the end of this period, DT<sub>3</sub> emerged as the best performing treatment, retaining the highest vitamin C content at 21.90 mg/100 ml, with AT<sub>3</sub> trailing closely at 21.64 mg/100 ml. This decline in vitamin C can be chalked up to the oxidation of ascorbic acid into dehydroascorbic acid, a process fueled by oxygen trapped within the containers and the product's own molecular nooks and crannies. Throughout the storage,

DT<sub>3</sub> demonstrated a notably superior ability to hold onto its vitamin C. In a similar vein, Harendra *et al.* (2026) observed a decrease in vitamin C from 59.66 to 58.78 mg/100 mL during the storage of an RTS drink concocted from aonla, rangpur lime and ginger blends. A downward trend was also noted by Rehman *et al.* (2020) in the ascorbic acid levels of RTS prepared from olive and mandarin blends. Similarly, Begum and Premakumar (2021) reported comparable findings in a functional beverage based on bitter gourd.

#### pH

The pH of all blended cordial combinations showed a significant gradual decrease over 150 days of storage (18.55 to 26.39°C) mentioned in Table 5. Initially, AT<sub>3</sub>

**Table 2:** Changes in TSS (%) of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | TSS (%) of different best blend combinations |                         |                         |                         |
|----------------------------------------|----------------------------------------------|-------------------------|-------------------------|-------------------------|
|                                        | AT355% M+40%<br>S+5% G                       | BT260% M+35%<br>S +5% P | CT260% M+35%<br>S +5% S | DT355% M+40%<br>S +5% T |
| 0 day                                  | 30.00                                        | 30.00                   | 30.00                   | 30.00                   |
| 30 days                                | 30.25                                        | 30.27                   | 30.22                   | 30.16                   |
| 60 days                                | 30.37                                        | 30.44                   | 30.34                   | 30.25                   |
| 90 days                                | 30.61                                        | 30.80                   | 30.60                   | 30.40                   |
| 120 days                               | 30.90                                        | 31.30                   | 31.00                   | 30.60                   |
| 150 days                               | 31.48                                        | 31.97                   | 31.56                   | 30.87                   |
| SE.m±                                  | 0.06                                         | 0.06                    | 0.06                    | 0.05                    |
| CD at 5%                               | 0.18                                         | 0.17                    | 0.17                    | 0.15                    |

**Table 3:** Changes in acidity (%) of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | Acidity (%) of different best blend combinations |                         |                         |                         |
|----------------------------------------|--------------------------------------------------|-------------------------|-------------------------|-------------------------|
|                                        | AT355% M+40%<br>S+5% G                           | BT260% M+35%<br>S +5% P | CT260% M+35%<br>S +5% S | DT355% M+40%<br>S +5% T |
| 0 day                                  | 1.50                                             | 1.50                    | 1.50                    | 1.50                    |
| 30 days                                | 1.55                                             | 1.58                    | 1.57                    | 1.53                    |
| 60 days                                | 1.58                                             | 1.63                    | 1.62                    | 1.58                    |
| 90 days                                | 1.67                                             | 1.73                    | 1.70                    | 1.66                    |
| 120 days                               | 1.80                                             | 1.84                    | 1.81                    | 1.75                    |
| 150 days                               | 1.96                                             | 2.01                    | 1.99                    | 1.86                    |
| SE.m±                                  | 0.02                                             | 0.02                    | 0.02                    | 0.01                    |
| CD at 5%                               | 0.05                                             | 0.06                    | 0.06                    | 0.04                    |

**Table 4:** Changes in vitamin C (mg/100 ml) of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | Vitamin C (mg/100 ml) of different best blend combinations |                         |                         |                         |
|----------------------------------------|------------------------------------------------------------|-------------------------|-------------------------|-------------------------|
|                                        | AT355% M+40%<br>S+5% G                                     | BT260% M+35%<br>S +5% P | CT260% M+35%<br>S +5% S | DT355% M+40%<br>S +5% T |
| 0 day                                  | 22.55                                                      | 22.22                   | 22.35                   | 22.48                   |
| 30 days                                | 22.42                                                      | 22.14                   | 22.17                   | 22.39                   |
| 60 days                                | 22.27                                                      | 21.97                   | 22.00                   | 22.28                   |
| 90 days                                | 22.06                                                      | 21.78                   | 21.82                   | 22.18                   |
| 120 days                               | 21.88                                                      | 21.60                   | 21.68                   | 22.05                   |
| 150 days                               | 21.64                                                      | 21.37                   | 21.46                   | 21.90                   |
| SE.m±                                  | 0.04                                                       | 0.04                    | 0.04                    | 0.04                    |
| CD at 5%                               | 0.11                                                       | 0.10                    | 0.13                    | 0.13                    |

recorded the highest pH (3.54), while BT<sub>2</sub> had the lowest (3.42). After 150 days of storage, DT<sub>3</sub> maintained the highest pH (3.27) followed by AT<sub>3</sub>, whereas BT<sub>2</sub> recorded the lowest value (3.12). The gradual decline in pH might be attributed to the increase in acidity during storage. Khalid *et al.* (2019) observed similar results, noting a reduction in pH from 4.66 to 3.82 in strawberry and date blended RTS drink, while Rani *et al.* (2018) reported similar findings in mandarin and strawberry mixed fruit juice.

### Total sugars

Over 150 days of storage, the total sugars content in all the blended cordial combinations went up quite a bit mentioned in Table 6. Out of all the combinations, DT<sub>3</sub> showed a pretty

steady and favorable increase in total sugars, going from 26.63% on day one to 27.00% by day 150. This suggests that DT<sub>3</sub> has better storage stability, making it the top choice among the treatments we looked at. Harendra *et al.* (2026) saw similar at ambient condition (18.55 to 26.39°C) results with a blended RTS made from aonla, rangpur lime and ginger whereas, Verma (2025) noticed the same with guava-based blended squash.

### Organoleptic quality

The organoleptic scores of all blended cordial formulations significantly declined gradually during 150 days of storage showed in Table 7. DT<sub>3</sub> retained the highest sensory acceptability, decreasing from 8.33 to 7.88 followed by AT<sub>3</sub>

**Table 5:** Changes in pH of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | pH of different best blend combinations |                         |                         |                         |
|----------------------------------------|-----------------------------------------|-------------------------|-------------------------|-------------------------|
|                                        | AT355% M+40%<br>S+5% G                  | BT260% M+35%<br>S +5% P | CT260% M+35%<br>S +5% S | DT355% M+40%<br>S +5% T |
| 0 day                                  | 3.54                                    | 3.42                    | 3.47                    | 3.52                    |
| 30 days                                | 3.50                                    | 3.37                    | 3.44                    | 3.49                    |
| 60 days                                | 3.44                                    | 3.32                    | 3.39                    | 3.46                    |
| 90 days                                | 3.37                                    | 3.25                    | 3.30                    | 3.40                    |
| 120 days                               | 3.30                                    | 3.19                    | 3.23                    | 3.34                    |
| 150 days                               | 3.22                                    | 3.12                    | 3.16                    | 3.27                    |
| SE.m±                                  | 0.02                                    | 0.02                    | 0.02                    | 0.02                    |
| CD at 5%                               | 0.06                                    | 0.07                    | 0.06                    | 0.06                    |

**Table 6:** Changes in total sugars (%) of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | Total sugars (%) of different best blend combinations |                         |                         |                         |
|----------------------------------------|-------------------------------------------------------|-------------------------|-------------------------|-------------------------|
|                                        | AT355% M+40%<br>S+5% G                                | BT260% M+35%<br>S +5% P | CT260% M+35%<br>S +5% S | DT355% M+40%<br>S +5% T |
| 0 day                                  | 26.77                                                 | 26.60                   | 26.68                   | 26.63                   |
| 30 days                                | 26.83                                                 | 26.73                   | 26.75                   | 26.67                   |
| 60 days                                | 26.90                                                 | 26.90                   | 26.81                   | 26.75                   |
| 90 days                                | 26.96                                                 | 27.00                   | 26.90                   | 26.82                   |
| 120 days                               | 27.10                                                 | 27.15                   | 27.05                   | 26.91                   |
| 150 days                               | 27.23                                                 | 27.33                   | 27.28                   | 27.00                   |
| SE.m±                                  | 0.05                                                  | 0.06                    | 0.06                    | 0.05                    |
| CD at 5%                               | 0.16                                                  | 0.18                    | 0.17                    | 0.15                    |

**Table 7:** Changes in organoleptic evaluation on 9-point hedonic scale of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | Organoleptic evaluation (9-point hedonic scale) of different best blend combinations |                         |                         |                         |
|----------------------------------------|--------------------------------------------------------------------------------------|-------------------------|-------------------------|-------------------------|
|                                        | AT355% M+40%<br>S+5% G                                                               | BT260% M+35%<br>S +5% P | CT260% M+35%<br>S +5% S | DT355% M+40%<br>S +5% T |
| 0 day                                  | 8.30                                                                                 | 8.12                    | 8.20                    | 8.33                    |
| 30 days                                | 8.25                                                                                 | 8.00                    | 8.07                    | 8.27                    |
| 60 days                                | 8.15                                                                                 | 7.75                    | 7.90                    | 8.20                    |
| 90 days                                | 8.00                                                                                 | 7.40                    | 7.50                    | 8.10                    |
| 120 days                               | 7.70                                                                                 | 7.10                    | 7.22                    | 8.02                    |
| 150 days                               | 7.26                                                                                 | 6.60                    | 6.94                    | 7.88                    |
| SE.m±                                  | 0.04                                                                                 | 0.04                    | 0.04                    | 0.04                    |
| CD at 5%                               | 0.13                                                                                 | 0.12                    | 0.12                    | 0.11                    |

**Table 8:** Changes in microbial count ( $\log_{10}$  CFU/mL) of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | Microbial count ( $\log_{10}$ CFU/mL) of different best blend combinations |              |              |              |
|----------------------------------------|----------------------------------------------------------------------------|--------------|--------------|--------------|
|                                        | AT355% M+40%                                                               | BT260% M+35% | CT260% M+35% | DT355% M+40% |
|                                        | S+5% G                                                                     | S +5% P      | S +5% S      | S +5% T      |
| 0 day                                  | 1.25                                                                       | 1.29         | 1.26         | 1.22         |
| 30 days                                | 1.30                                                                       | 1.37         | 1.32         | 1.26         |
| 60 days                                | 1.41                                                                       | 1.44         | 1.40         | 1.30         |
| 90 days                                | 1.50                                                                       | 1.53         | 1.52         | 1.37         |
| 120 days                               | 1.63                                                                       | 1.66         | 1.66         | 1.48         |
| 150 days                               | 1.80                                                                       | 1.85         | 1.83         | 1.60         |
| SE.m±                                  | 0.02                                                                       | 0.02         | 0.02         | 0.02         |
| CD at 5%                               | 0.06                                                                       | 0.07         | 0.06         | 0.05         |

**Table 9:** Changes in browning index (OD at 440 nm) of blended cordial from different best combinations during 150 days of storage period.

| Storage periods<br>(Monthly intervals) | Browning index (OD at 440 nm) of different best blend combinations |              |              |              |
|----------------------------------------|--------------------------------------------------------------------|--------------|--------------|--------------|
|                                        | AT355% M+40%                                                       | BT260% M+35% | CT260% M+35% | DT355% M+40% |
|                                        | S+5% G                                                             | S +5% P      | S +5% S      | S +5% T      |
| 0 day                                  | 0.09                                                               | 0.10         | 0.09         | 0.08         |
| 30 days                                | 0.13                                                               | 0.12         | 0.11         | 0.10         |
| 60 days                                | 0.15                                                               | 0.16         | 0.14         | 0.11         |
| 90 days                                | 0.18                                                               | 0.19         | 0.18         | 0.13         |
| 120 days                               | 0.20                                                               | 0.22         | 0.21         | 0.15         |
| 150 days                               | 0.25                                                               | 0.27         | 0.26         | 0.18         |
| SE.m±                                  | 0.01                                                               | 0.01         | 0.01         | 0.01         |
| CD at 5%                               | 0.03                                                               | 0.04         | 0.03         | 0.03         |

(8.30 to 7.26). The comparatively better sensory retention in DT<sub>3</sub> might be attributed to its favourable flavour and taste balance and reduced development of undesirable off-flavours and colour changes during storage. Similar declines in sensory quality during storage have been reported by Bharati *et al.* (2023) in sweet orange, guava and ginger RTS and Lather *et al.* (2026) in a fruit-herb blended beverage.

#### Microbial count ( $\log_{10}$ CFU/mL)

Over the course of 150 days, the microbial count in all blended cordial combinations gradually increased mentioned in Table 8. Among them, DT<sub>3</sub> stood out as the greater microbial stability, with its count inching up from 1.22 to 1.60  $\log_{10}$  CFU/mL, marking it as the most resilient blend. This gradual increase in microbial presence could be attributed to the waning power of preservatives and the inviting conditions for microbial proliferation over time. Malik *et al.* (2022) observed a similar trend in lemon cordial.

#### Browning index (OD)

As the days passed, the browning index in all cordial combinations also crept upward mentioned in Table 9, a subtle testament to the unfolding drama of non-enzymatic browning. Yet, DT<sub>3</sub> once again proved its mettle, with its browning index rising modestly from 0.08 to 0.18 OD at 440 nm, showcasing superior color stability. The increase in browning might be associated with ascorbic acid

degradation, sugar degradation and Maillard-type reactions during storage. This pattern of browning (OD at 440 nm) during the storage of fruit beverages echoes the findings of Buvé *et al.* (2021) and Koca *et al.* (2003).

## CONCLUSION

The current study unveiled the delightful potential of mandarin and strawberry in crafting a flavourful and long-lasting blended cordial. Among the concoctions tested, D-T3 (55% mandarin + 40% strawberry + 5% tamarind) emerged as the most preferred treatment, capturing the highest sensory approval and standing out as the top choice followed by A-T3. Over 150 days of ambient storage (18.55 to 26.39°C), there was a gradual rise in TSS, acidity, total sugars, microbial count and browning index, while vitamin C, pH and sensory quality gently waned. Notably, D-T3 showed the least alteration in physico-chemical properties, maintained vitamin C more effectively and experienced less microbial growth and browning, all while preserving its superior sensory appeal by the end of storage. These results suggest that blending tamarind with mandarin and strawberry achieves a harmonious blend of taste, aroma and overall sensory quality. Consequently, D-T3 shines as the most promising candidate for the commercial production of a high-quality mandarin-based cordial with enhanced shelf life under ambient conditions (18.55 to 26.39°C).

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## Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

## Conflict of interest

All authors declare that they have no conflicts of interest.

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