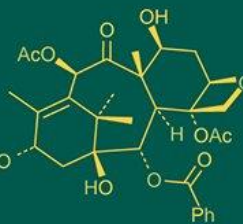
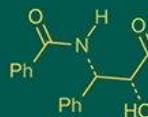


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Influence of sugar sources and blending proportions on sensory evaluation of beetroot blended watermelon wine during maturation

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Abstract

The present investigation was conducted at Post-Harvest Technology Laboratory, Section of Horticulture, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the years 2022-2023 and 2023-2024 to study the changes in sensory parameters of beetroot blended watermelon wine during maturation. Sensory attributes viz., taste, aroma, colour, appearance, astringency and overall acceptability were evaluated at fresh stage and after 2, 4, 6 and upto 8 months maturation of beetroot blended watermelon wine. From the investigation it was observed that the highest score secured for taste, aroma, colour, appearance, astringency and overall acceptability were recorded in beetroot blended watermelon wine prepared by using honey as a sugar source and blending at proportion of 80:20 (Watermelon pulp: Beetroot juice).

Keywords: Beetroot blended watermelon wine, blending proportions, sugar sources, sensory evaluation, maturation

Introduction

Wine is one of the oldest fermented beverages and is traditionally produced from grapes; however, several fruits and vegetables have also been successfully utilized for wine production because of their rich nutritional composition, natural sugars, pigments and bioactive compounds. In recent years, increasing consumer demand for functional and value-added beverages has encouraged researchers to explore underutilized fruits and vegetables for the development of novel wines with enhanced nutritional and sensory properties (Swami *et al.* 2014) [15]. Blending different raw materials before fermentation has emerged as an effective approach to improve flavour, colour, aroma and overall acceptability while enhancing the nutritional value of wine.

Watermelon (*Citrullus lanatus* Thunb.) is an important cucurbitaceous fruit cultivated widely in tropical and subtropical regions. Watermelon has a distinct feature of sweet taste with high moisture content. The nutritional profile of watermelon, consumption of 100 g watermelon provides 30 kcal. It contains almost 92% water and 7.55% of carbohydrates out of which 6.2% are sugars and 0.4% dietary fiber. It serves as a good source of vitamins and phytochemicals that have chemo preventive effect against cancer. Watermelon contains large amount of beta carotene and are significant source of lycopene. It is enriched with carotenoid, vitamin C, citrulline, carotenoids, flavonoids and fat and cholesterol free, thus considered as low caloric fruit. Additionally, it is a source of B vitamins, especially B₁ and B₆, as well as minerals such as potassium and magnesium. (Collins *et al.* 2005) [4]. Despite its nutritional importance, watermelon is highly perishable because of its high moisture content, resulting in considerable post-harvest losses during peak production seasons. Conversion of watermelon into wine offers an effective value-addition strategy that can enhance its shelf life and market potential.

Beetroot (*Beta vulgaris* L.) is a nutritionally important root vegetable recognized for its intense red-violet pigments (betalains), phenolic compounds, flavonoids, dietary nitrates and ascorbic acid. Betalains, particularly betacyanins and betaxanthins, possess strong antioxidant, anti-inflammatory and antimicrobial properties and contribute to the characteristic colour of beetroot (Clifford *et al.* 2015) [3].

Incorporation of beetroot juice into fruit wine not only enhances colour intensity but also enriches the beverage with health-promoting phytochemicals and improves its functional value.

Blending is an important approach in wine formulation for achieving a desirable balance of flavour, aroma, taste and mouthfeel. Combining different raw materials in appropriate proportions can complement their individual characteristics and enhance the overall sensory quality of the final product. In addition, the choice of sugar source influences fermentation and contributes to the development of desirable flavour and sensory attributes.

Material and Methods

The laboratory experiment was conducted during 2022-2023 and 2023-2024 at the Post-Harvest Technology Laboratory, Horticulture Section, College of Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications and twelve treatment combinations. The experiment comprised two factors. The first factor consisted of three sugar sources i.e. S₁- Canesugar, S₂- Honey and S₃- Jaggery. While the second factor consisted of four blending proportions of watermelon pulp and beetroot juice viz., B₁- 70:30, B₂- 80:20, B₃- 90:10 and B₄- 100:00. The total soluble solids (TSS) of the must were adjusted and maintained at 24 °Brix. Fully matured watermelon fruits and beetroot were procured from the local market of Akola, Maharashtra, during February of both experimental years. The experiment was conducted for two consecutive years and pooled data were used for the present study.

The sensory quality of wines from different treatment combinations was evaluated by a semi-trained panel of five judges. The samples were coded and served individually and fresh water was provided for rinsing the mouth between successive samples. The wines were evaluated for various quality attributes viz. colour, taste, aroma, appearance, astringency and overall acceptability using a 9-point hedonic scale as described by Amerine *et al.* (1986) [1]. The judges recorded their responses on a standardized sensory evaluation proforma and the mean scores obtained for each sensory attribute were calculated and reported.

Hedonic scale

- Like extremely - 9 Like slightly - 6 Dislike moderately - 3

- Like very much - 8 Neither like nor dislike - 5 Dislike very much - 2
- Like moderately - 7 Dislike slightly - 4 Dislike extremely - 1

Results and Discussion

Sensory parameters

1. Taste

The data pertaining to the taste score of beetroot blended watermelon wine are presented in Table 1. The results revealed that the highest taste scores at fresh, 2, 4, 6 and 8 months of maturation were recorded in treatment combination S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)], with scores of 6.5, 7.6, 7.8, 8.1 and 8.6, respectively. In contrast, the lowest taste scores were recorded in S₃B₄ [Jaggery + 100:00 (Watermelon pulp: Beetroot juice)], with corresponding scores of 5.2, 6.1, 6.4, 6.6 and 7.1, respectively.

The interaction between sugar sources and blending proportions significantly influenced the taste of beetroot blended watermelon wine. Treatment S₂B₂ consistently recorded the highest taste scores throughout the maturation period, indicating the favourable contribution of honey and 80:20 blending proportion to the development of desirable taste characteristics. A progressive improvement in taste score was observed from the fresh stage to 8 months of maturation, which may be attributed to the gradual development and integration of desirable flavour compounds during maturation. Acidity is an important quality attribute of wine, contributing to its characteristic taste and flavour while also enhancing its keeping quality by providing protection against microbial spoilage (Sim and Morris, 1984) [14].

After 8 months of maturation, the wine prepared with honey as the sugar source and 80:20 blending proportion of watermelon pulp and beetroot juice (S₂B₂) received a taste score of 8.6, corresponding to the sensory category “Like extremely” on the 9-point hedonic scale. The superior taste of this treatment may be attributed to the favourable balance of sweetness, acidity and other flavour components developed during maturation. The present findings are in agreement with the observations reported by Kakade (2019) [10], Dakore (2021) [5], Kadage (2021) [9], Pali *et al.* (2022) [12] and Gorivale *et al.* (2025) [7] who also reported improvement in the sensory quality of wines during maturation.

Table 1: Effect of different sugar sources and blending proportions on taste score of beetroot blended watermelon wine

Treatments (SxB)	Score				
	Fresh Wine	At 2 Months of Maturation	At 4 Months of Maturation	At 6 Months of Maturation	At 8 Months of Maturation
S ₁ B ₁	5.9	6.8	7.3	7.6	8.1
S ₁ B ₂	6.4	7.5	7.7	8.0	8.5
S ₁ B ₃	6.2	7.2	7.5	7.7	8.3
S ₁ B ₄	5.7	6.6	7.1	7.3	7.7
S ₂ B ₁	6.0	7.0	7.4	7.6	8.1
S ₂ B ₂	6.5	7.6	7.8	8.1	8.6
S ₂ B ₃	6.0	7.1	7.3	7.5	8.0
S ₂ B ₄	5.8	6.7	7.2	7.4	7.9
S ₃ B ₁	5.4	6.3	6.5	6.8	7.2
S ₃ B ₂	5.6	6.5	6.9	7.1	7.6
S ₃ B ₃	5.5	6.4	6.7	6.9	7.4
S ₃ B ₄	5.2	6.1	6.4	6.6	7.1

2. Aroma

The aroma scores of beetroot blended watermelon wine as influenced by sugar sources, blending proportions and maturation period are presented in Table 2. The results revealed that the highest aroma scores at fresh, 2, 4, 6 and 8 months of maturation were recorded in treatment combination S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)], with scores of 6.7, 7.8, 7.9, 8.2 and 8.5, respectively. In contrast, the lowest aroma scores were recorded in treatment combination S₃B₄ [Jaggery + 100:00 (Watermelon pulp: Beetroot juice)], with corresponding scores of 5.4, 6.5, 6.5, 6.8 and 7.0, respectively.

The results indicated a progressive improvement in aroma score with advancement of the maturation period,

irrespective of the treatment combinations. The higher aroma scores observed in S₂B₂ may be attributed to the favourable interaction between honey and 80:20 blending proportion, which possibly enhanced the development and retention of desirable volatile and flavour compounds during maturation. After 8 months of maturation, the wine under S₂B₂ recorded an aroma score of 8.5, corresponding to the sensory category “Like extremely” on the 9-point hedonic scale, indicating superior aroma quality and greater sensory acceptability. The present findings are in accordance with the observations reported by Kakade (2019) ^[10], Dakore (2021) ^[5], Kadage (2021) ^[9], Pali *et al.* (2022) ^[12] and Gorivale *et al.* (2025) ^[7] who reported improvement in the sensory characteristics of wines during maturation.

Table 2: Effect of different sugar sources and blending proportions on aroma score of beetroot blended watermelon wine

Treatments (SxB)	Fresh Wine	Score			
		At 2 Months of Maturation	At 4 Months of Maturation	At 6 Months of Maturation	At 8 Months of Maturation
S ₁ B ₁	6.3	7.4	7.6	7.8	8.1
S ₁ B ₂	6.5	7.7	7.8	8.0	8.4
S ₁ B ₃	6.3	7.4	7.6	7.9	8.2
S ₁ B ₄	5.8	7.0	7.1	7.5	7.5
S ₂ B ₁	6.2	7.3	7.4	7.8	8.0
S ₂ B ₂	6.7	7.8	7.9	8.2	8.5
S ₂ B ₃	6.3	7.5	7.7	8.0	8.3
S ₂ B ₄	5.9	7.1	7.2	7.6	7.7
S ₃ B ₁	5.5	6.7	6.7	6.9	7.1
S ₃ B ₂	5.7	6.7	7.0	7.3	7.4
S ₃ B ₃	5.6	6.8	6.9	7.1	7.3
S ₃ B ₄	5.4	6.5	6.5	6.8	7.0

3. Colour

Colour is one of the important sensory attributes influencing the visual acceptability of wine. The sensory scores presented in Table 3 showed a clear improvement in colour acceptability with advancement of the maturation period. Among the treatment combinations S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)] consistently exhibited superior colour acceptability, with scores increasing from 6.6 at the fresh stage to 8.5 after 8 months of maturation. The corresponding scores at 2, 4 and 6 months were 7.6, 7.8 and 8.1 respectively. In contrast, S₃B₄ [Jaggery + 100:00 (Watermelon pulp: Beetroot juice)] recorded the lowest colour scores of 5.4, 6.4, 6.5, 6.7 and 7.0 at fresh, 2, 4, 6 and 8 months of maturation respectively.

The improvement in colour score during maturation may be attributed to the gradual stabilization and harmonization of pigment and other colour contributing compounds in the wine. The higher acceptability of S₂B₂ could be associated with the optimum proportion of beetroot juice, which

imparted an attractive colour to the wine without adversely affecting its visual characteristics. Honey as a sugar source may have further favoured the development of desirable sensory characteristics during maturation.

After 8 months of maturation, the S₂B₂ treatment recorded a colour score of 8.5, corresponding to the “Like extremely” category on the 9-point hedonic scale. Thus, the combination of honey with an 80:20 ratio of watermelon pulp to beetroot juice proved effective in enhancing the colour quality and visual acceptability of the matured wine. The improvement in the colour might be due to the precipitation of the TSS during the maturation as discussed earlier which resulted in the clarified wine after 6 months of maturation (Kumar *et al.* 2016) ^[11]. The result of the present investigation is supported by the findings of Dhokane (2017) ^[6], Rajvaidya (2017) ^[13], Dakore (2021) ^[5], Kadage (2021) ^[9] and Gorivale *et al.* (2025) ^[7].

Table 3: Effect of different sugar sources and blending proportions on colour score of beetroot blended watermelon wine

Treatments (SxB)	Fresh Wine	Score			
		At 2 Months of Maturation	At 4 Months of Maturation	At 6 Months of Maturation	At 8 Months of Maturation
S ₁ B ₁	5.9	7.0	7.2	7.4	8.1
S ₁ B ₂	6.5	7.5	7.7	8.0	8.5
S ₁ B ₃	6.2	7.3	7.4	7.7	8.3
S ₁ B ₄	5.7	6.8	7.0	7.1	7.7
S ₂ B ₁	6.4	7.4	7.6	7.9	8.3
S ₂ B ₂	6.6	7.6	7.9	8.1	8.6
S ₂ B ₃	6.3	7.4	7.6	7.8	8.4
S ₂ B ₄	5.8	6.9	7.1	7.2	7.8
S ₃ B ₁	5.4	6.4	6.6	6.7	7.1
S ₃ B ₂	5.6	6.7	6.9	7.0	7.5
S ₃ B ₃	5.5	6.6	6.8	6.8	7.4
S ₃ B ₄	5.3	6.3	6.5	6.6	7.0

4. Appearance

The sensory evaluation of appearance of beetroot blended watermelon wine is presented in Table 4. The appearance scores showed a progressive improvement with advancement of the maturation period. Among the treatment combinations, S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)] consistently recorded the highest scores, increasing from 6.5 at the fresh stage to 8.3 after 8 months, with intermediate scores of 7.7, 7.8 and 8.2 at 2, 4 and 6 months, respectively. In contrast, S₃B₄ [Jaggery + 100:00 (Watermelon pulp: Beetroot juice)] recorded the lowest appearance scores of 5.3, 6.4, 6.5, 6.9 and 7.1 at fresh, 2, 4, 6 and 8 months, respectively.

The gradual improvement in appearance during maturation may be attributed to the clarification and stabilization of the wine, together with the progressive integration of colour and

other visual characteristics. The superior performance of S₂B₂ suggested that the combination of honey and an optimum beetroot juice proportion produced a more attractive and visually harmonious wine. The 80:20 blending ratio appears to have provided sufficient beetroot contribution to enhance the appearance without compromising the characteristic visual quality of watermelon wine.

Similarly, it is evident that, appearance scored after 8 months matured beetroot blended watermelon wine prepared by using honey as a sugar source and blending proportion of 80:20 (Watermelon pulp: Beetroot juice) during maturation is adjudged as 'Like Very Much'. The results mentioned above are in conformity with the findings of Belkhede (2019) ^[2], Dakore (2021) ^[5], Kadage (2021) ^[9] and Gorivale *et al.* (2025) ^[7].

Table 4: Effect of different sugar sources and blending proportions on appearance score of beetroot blended watermelon wine

Treatments (SxB)	Score				
	Fresh Wine	At 2 Months of Maturation	At 4 Months of Maturation	At 6 Months of Maturation	At 8 Months of Maturation
S ₁ B ₁	6.0	7.0	7.3	7.6	7.7
S ₁ B ₂	6.3	7.5	7.6	8.0	8.2
S ₁ B ₃	6.2	7.2	7.3	7.8	8.0
S ₁ B ₄	5.7	6.8	7.0	7.4	7.5
S ₂ B ₁	6.1	7.1	7.4	7.7	7.8
S ₂ B ₂	6.5	7.7	7.8	8.2	8.3
S ₂ B ₃	6.3	7.4	7.4	7.9	8.1
S ₂ B ₄	5.8	6.9	7.1	7.5	7.6
S ₃ B ₁	5.4	6.5	6.7	7.0	7.2
S ₃ B ₂	5.6	6.8	6.9	7.3	7.4
S ₃ B ₃	5.5	6.6	6.8	7.1	7.3
S ₃ B ₄	5.3	6.4	6.5	6.9	7.1

5. Astringency

Astringency is an important mouthfeel attribute that contributes to the sensory perception and acceptability of wine. The data presented in Table 5 showed a distinct maturation-dependent improvement in the astringency scores of beetroot blended watermelon wine. The highest scores were consistently recorded for S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)], increasing from 6.6 at the fresh stage to 8.4 at 8 months. The corresponding scores at 2, 4 and 6 months were 7.6, 8.0 and 8.2, respectively. In comparison, S₃B₄ [Jaggery + 100:00 (Watermelon pulp: Beetroot juice)] registered the lowest scores throughout the maturation period (5.3-7.2).

The marked enhancement in astringency acceptability with maturation may be associated with the gradual

transformation and stabilization of phenolic constituents, resulting in a smoother and more harmonious mouthfeel. The superior response of S₂B₂ indicates that the 20 per cent beetroot juice level provided an appropriate contribution of phenolic and flavour components without imparting excessive harshness, while honey may have helped maintain a desirable sensory balance.

After 8 months of maturation, S₂B₂ received a score of 8.4, categorized as "Like very much", demonstrating its superior mouthfeel acceptability. Comparable improvement in sensory characteristics of blended wines during maturation has been reported by Belkhede (2019) ^[2], Dhokane (2017) ^[6], Dakore (2021) ^[5], Kadage (2021) ^[9] and Gorivale *et al.* (2025) ^[7].

Table 5: Effect of different sugar sources and blending proportions on astringency score of beetroot blended watermelon wine

Treatments (SxB)	Score				
	Fresh Wine	At 2 Months of Maturation	At 4 Months of Maturation	At 6 Months of Maturation	At 8 Months of Maturation
S ₁ B ₁	5.9	7.1	7.5	7.5	7.7
S ₁ B ₂	6.5	7.6	7.9	8.1	8.3
S ₁ B ₃	5.9	7.1	7.4	7.6	7.8
S ₁ B ₄	5.7	6.9	7.2	7.4	7.6
S ₂ B ₁	6.1	7.2	7.6	7.7	7.9
S ₂ B ₂	6.6	7.6	8.0	8.2	8.4
S ₂ B ₃	6.4	7.3	7.8	8.0	8.2
S ₂ B ₄	5.8	7.0	7.3	7.3	7.4
S ₃ B ₁	5.4	6.5	6.8	6.9	7.4
S ₃ B ₂	5.6	6.7	7.0	7.1	7.4
S ₃ B ₃	5.5	6.6	6.9	7.0	7.3
S ₃ B ₄	5.3	6.4	6.7	6.9	7.2

6. Overall acceptability

The overall acceptability scores provide a cumulative indication of the sensory quality of the wine and its potential consumer preference. As shown in Table 6, maturation resulted in a consistent enhancement of overall acceptability across the treatments. The wine under S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)] exhibited the most favourable sensory response, with scores increasing from 6.7 at the fresh stage to 8.6 after 8 months. The corresponding scores at 2, 4 and 6 months were 7.7, 8.0 and 8.3 respectively. In contrast, S₃B₄ [Jaggery + 100:00 (Watermelon pulp: Beetroot juice)] recorded comparatively lower scores of 5.4, 6.3, 6.6, 6.8 and 7.0 over the same maturation period.

The marked improvement in overall acceptability with maturation could be attributed to the gradual development of a balanced sensory profile through the interaction of flavour,

aroma, colour and mouthfeel components. The consistently higher performance of S₂B₂ indicates that honey, together with an 80:20 blending ratio, provided a suitable combination for developing desirable sensory characteristics. The maturation period further enhanced the harmony among these attributes, thereby increasing the overall preference for the wine.

At 8 months, S₂B₂ achieved an overall acceptability score of 8.6, placing it in the “Like very much” category of the 9-point hedonic scale. The superiority of this treatment highlights the importance of both sugar source and blending proportion in optimizing the sensory quality of matured blended wine. Similar improvements in overall sensory acceptability during wine maturation have been reported by Govinda (2016) ^[8], Kakade (2019) ^[10], Dakore (2021) ^[5], Kadage (2021) ^[9], Pali *et al.* (2022) ^[12] and Gorivale *et al.* (2025) ^[7].

Table 6: Effect of different sugar sources and blending proportions on overall acceptability score of beetroot blended watermelon wine

Treatments (SxB)	Score				
	Fresh Wine	At 2 Months of Maturation	At 4 Months of Maturation	At 6 Months of Maturation	At 8 Months of Maturation
S ₁ B ₁	6.1	7.2	7.5	7.6	8.0
S ₁ B ₂	6.6	7.6	7.9	8.2	8.5
S ₁ B ₃	6.0	7.0	7.3	7.5	7.7
S ₁ B ₄	5.8	6.8	7.1	7.2	7.5
S ₂ B ₁	6.3	7.3	7.6	7.8	8.1
S ₂ B ₂	6.7	7.7	8.0	8.3	8.6
S ₂ B ₃	6.5	7.5	7.8	8.1	8.4
S ₂ B ₄	5.9	6.9	7.2	7.4	7.6
S ₃ B ₁	5.5	6.6	6.8	6.9	7.2
S ₃ B ₂	5.7	6.7	7.0	7.2	7.5
S ₃ B ₃	5.6	6.5	6.9	7.1	7.4
S ₃ B ₄	5.4	6.3	6.6	6.8	7.0

Conclusion

The present study demonstrated that maturation markedly improved the sensory quality and acceptability of beetroot blended watermelon wine. The scores for taste, aroma, colour, appearance, astringency and overall acceptability showed a progressive increase during the 8-month maturation period. Among the treatment combinations, S₂B₂ [Honey + 80:20 (Watermelon pulp: Beetroot juice)] consistently exhibited superior sensory performance and attained the highest scores for all evaluated attributes at 8 months of maturation. The wine was rated in the “Like very much” category, indicating its high sensory acceptability. Therefore, the use of honey as a sugar source combined with 80:20 watermelon pulp to beetroot juice ratio can be considered a suitable treatment for producing a desirable and highly acceptable matured beetroot blended watermelon wine.

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