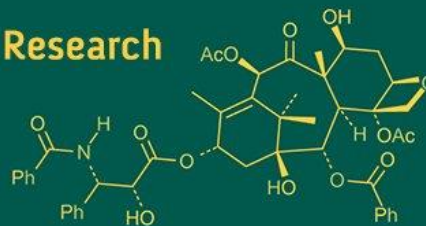


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Gunwanti Devchand Gedam
Ph.D. Scholar, Department of
Fruit Science, Indira Gandhi
Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Prabhakar Singh
Professor, Department of Fruit
Science, Indira Gandhi Krishi
Vishwavidyalaya, Raipur,
Chhattisgarh, India

Deepthi Patel
Associate Professor,
Department of Fruit Science,
Indira Gandhi Krishi
Vishwavidyalaya, Raipur,
Chhattisgarh, India

Ravindra Soni
Associate Professor,
Department of Microbiology,
Indira Gandhi Krishi
Vishwavidyalaya, Raipur,
Chhattisgarh, India

Sanjay Kumar Bharya
Assistant Professor,
Department of Plant Molecular
Biology and Biotechnology,
Indira Gandhi Krishi
Vishwavidyalaya, Raipur,
Chhattisgarh, India

Corresponding Author:
Gunwanti Devchand Gedam
Ph.D. Scholar, Department of
Fruit Science, Indira Gandhi
Krishi Vishwavidyalaya,
Raipur, Chhattisgarh, India

Sensory evaluation and economic assessment of blended wine from pomegranate (*Punica granatum* L.) and mahua (*Madhuca indica*) with different sugar sources

Gunwanti Devchand Gedam, Prabhakar Singh, Deepthi Patel, Ravindra Soni and Sanjay Kumar Bhariya

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Abstract

The present study investigates the sensory attributes and economic assessment of pomegranate and mahua blended wine during the year 2024-2025 and 2025-2026. Pomegranate (*P. granatum* L.) and mahua (*M. indica*) utilized to prepare blended wine with different sugar sources i.e., sugar and jaggery. The yeast starter culture of brewer's yeast (*Saccharomyces cerevisiae* var. *ellipsoideus*) @ 5 % used to inoculate blended juice. Sensory and economics analysis revealed that blended wine prepared from the treatment T₄ [Cane sugar + Pomegranate juice (70 %) + Mahua juice (30 %)] was most preferred. The treatment T₄ showed maximum scores of colour, taste, flavour, viscosity and overall acceptability during both seasons as well as the pooled mean. The benefit: cost ratio recorded maximum under the same treatment.

Keywords: Pomegranate, mahua, sensory evaluation, economics assessment, yeast

Introduction

Wine is a type of "alcoholic beverage" that has been made for thousands of years utilising yeast to ferment grapes, berries, apples, and other fruits. Since ancient times, wine has been a favourite beverage all over the world under the names Madeira, Sula, etc. Wine contains resveratrol and polyphenols, therefore it have beneficial effects on human health (Kalt, 2010)^[9]. Fruit wines are undistilled alcoholic beverages that are more flavourful, nutritious, and contain mild stimulants. Fruit wine offers vitamins, minerals, and vitality. Wine possesses a long shelf life, is a by-product of a typical sugar metabolism through alcoholic fermentation of yeast. Wine is a healthy and safe beverage. Since ancient times, wine has been used as both nourishment and medicinal (Chaudhary and Yadav 2014)^[6].

Sugar sources acts as the primary substrate for converting fruit juice into alcohol. While microorganisms can metabolize proteins and fats in nutrient-scarce environments, yeast cells prioritizes sugar to produce ethanol, lactic acid, and carbon dioxide. This process continues until sugar is decreased or environmental conditions become unfavourable for yeast growth (Saranraj *et al.*, 2017)^[13].

Punicaceae Horan. (*Lythraceae* Jaume St.-Hil.) is a family has one genus *Punica*, with two species: *Punica granatum* L. and *P. protopunica* Balf. e. taxonomically, the genus name *Punica* L. is derived from a feminized Roman designation for Carthage, an ancient city in northern Tunisia famous for highest quality pomegranates were historically exported to Italy. During antiquity, the fruit was originally designated as *Malum punicum* means the "apple of Carthage." Carl Linnaeus subsequently established the binomial nomenclature by pairing the genus with the specific epithet *granatum*, which means granular or composed of grains. This botanical description utilized within the United States as common name "seedy apple" (Anon., 2006)^[2].

Armenia and Israel are well known to produce and consume pomegranate wine as part of their traditional diets. In Italy, specifically in Sicily, historical literature indicates that pomegranate wine beverages called as "Sciadde," although this practice has now disappeared. (Cardinale *et al.*, 2021)^[4]. Mahua is also known as Mowarh in the north, Mahul in Orissa and Illipi in the south of India.

In Sanskrit, it is also called as Madhusakha, Madhuka, Madhudruma, Madhupuspa and "Gudapuspa." The term "madhu" (means "honey") is derived from the Sanskrit word "madhu" refers to the flowers contains extraordinarily high sugar (66-72% of dry weight) (Surve *et al.* 2024) ^[15]. The term blended wine is used to define as the final product, while blending practices refer to the technological approaches by which it is produced. Blending is done to achieve several important goals. Primarily, it enhances the quality of wine by optimizing color, aroma, and taste by integrating different varietal characteristics. Secondly, it ensures consistency for the maintenance of uniform sensory profiles for various production batches and vintages. Blending contributes to complexity by adding depth to flavor and aroma through combining different wine components. Finally, it promotes balance by adjusting the tannin structure, acidity, and sweetness, resulting in a well-rounded final product (Beara *et al.* 2026) ^[3].

Materials and Methods

The investigation was carried at Processing Laboratory, Department of Fruit Science and Functional Food Laboratory, Department of Plant Molecular Biology and Biotechnology, COA, IGKV, Raipur, CG during the year 2024-2025 and 2025-2026. The experimental design was laid out in Factorial Completely Randomized Designs with ten treatments and three replications during. The factor *i.e.*, A-Sugar sources (A₁- Cane sugar and A₂- Jaggery) and B-Fruit Juices [B₁- Pomegranate juice (100%), B₂- Pomegranate juice (90%) + Mahua juice (10%), B₃- Pomegranate juice (80%) + Mahua juice (20%) B₄- Pomegranate juice (70%) + Mahua juice (30%) and B₅- Pomegranate juice (60%) + Mahua juice (40%)].

Preparation of must for fermentation

Mature fresh fruits of Pomegranate procured from Lalpur market of Raipur and dried flower of mahua from Processing centre storage facility in Rajnandgaon, Chhattisgarh during the year 2024-2025 and 2025-2026. The juice was extracted from pomegranate and mahua (dried flowers soaked for 12 hours and potassium metabisulphite @ 150 ppm was added) and filtered through muslin cloth collected and blended in different bottles according to ratios mentioned under the Table 1.

Table 1: Treatment details

Treatment symbols	Notations	Treatment details
T ₁	A ₁ B ₁	Cane sugar + Pomegranate juice (100%)
T ₂	A ₁ B ₂	Cane sugar +Pomegranate juice (90%) + Mahua juice (10%)
T ₃	A ₁ B ₃	Cane sugar + Pomegranate juice (80%) + Mahua juice (20%)
T ₄	A ₁ B ₄	Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)
T ₅	A ₁ B ₅	Cane sugar + Pomegranate juice (60%) + Mahua juice (40%)
T ₆	A ₂ B ₁	Jaggery + Pomegranate juice (100%)
T ₇	A ₂ B ₂	Jaggery + Pomegranate juice (90%) + Mahua juice (10%)
T ₈	A ₂ B ₃	Jaggery + Pomegranate juice (80%) + Mahua juice (20%)
T ₉	A ₂ B ₄	Jaggery + Pomegranate juice (70%) + Mahua juice (30%)
T ₁₀	A ₂ B ₅	Jaggery + Pomegranate juice (60%) + Mahua juice (40%)

Preparation of yeast culture

The commercial wine yeast (brewer’s yeast) strain *S. cerevisiae* var. *ellipsoideus* was utilized for fermentation. To prepare the active starter culture, the pomegranate juice was adjusted to an initial total soluble solids (TSS) level of approximately 10 to 11 °Brix. According to the experimental treatments, the TSS was adjusted upward to 22 °Brix using two different sugar sources: cane sugar and jaggery in separate 500 mL reagent bottles. To inhibit wild yeast strains and spoilage microorganisms, sodium benzoate was added into the juice at concentration of 150 ppm and allowed to stand for four hours. After this it was supplemented with diammonium hydrogen phosphate (DAHP) @ 0.1% to act as nitrogen source. The treated juice was inoculated with 0.5 g L⁻¹ of *S. cerevisiae* var. *ellipsoideus* and secured with airlock. After 48 hours, upon observing vigorous bubbling the active yeast culture was considered to be ready. This prepared inoculant was subsequently added to the bulk fermentation must at a concentration of 5% (v/v) to initiate the primary fermentation stage.

Fermentation

The different treatments of blending were inoculated with a 5% (v/v) active culture of *S. cerevisiae* var. *ellipsoideus* in reagent bottles. The containers were immediately sealed using water-filled airlocks to visually monitor (CO₂) gas evolution with all joints tightly wrapped in plastic (cling) film to prevent oxygen exposure. The reagent bottles were manually agitated 2–3 times daily. Gas bubble formation and eventual cessation within the airlock system were used to closely monitor the fermentation initiation. Fermentation was completed when no more bubbles were coming out. It took nearly 15 to 20 days to complete the fermentation process. After siphoning, the liquid was clarified with the aid of 1.0 g l⁻¹ bentonite to recover wine of crystal clear quality finish. Wine clarification was achieved by three time racking process at fifteen days interval to eliminate lees and suspended solids. The resulting clarified wine was distributed into pre-sterilized 1000 mL reagent bottles.

Sensory evaluation of wine

Sensory evaluation of the blended pomegranate-mahua wine was conducted at baseline (0 months) and subsequently at 0, 2, 4, 6 and 8 months of storage. A panel of judges assessed the experimental samples using a 9-point hedonic scale, following the methodology described by Amerine *et al.* (1965) ^[1]. The evaluated sensory attributes included colour, flavour, taste, viscosity, appearance, astringency, and overall acceptability. Separate scores were assigned to each parameter, and the mean values were calculated to determine the final sensory profiles. The sensory evaluation was conducted using a standard 9-point hedonic scale, where numerical scores corresponded to specific verbal descriptors of consumer acceptance: 9 (Like extremely), 8 (Like very much), 7 (Like moderately), 6 (Like slightly), 5 (Neither like nor dislike), 4 (Dislike slightly), 3 (Dislike moderately), 2 (Dislike very much) and 1 (Dislike extremely).

Economics of blended pomegranate-mahua wine

The economics of wine can be calculated through benefit: cost ratio by the formula

Benefit: cost = $\frac{\text{Net return}}{\text{total cost}}$

Results and discussion

1. Sensory evaluation of blended pomegranate-mahua wine during storage

Colour

The organoleptic score for the colour of blended pomegranate-mahua wine showed increasing trend under the different treatment combinations with an advancement of storage period. The maximum colour scores (8.20, 8.16, 8.18 & 8.30, 8.36, 8.33 & 8.56, 8.50, 8.53 & 8.67, 8.63, 8.65 & 9.20, 9.23, 9.18) were recorded under the treatment T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)], while the minimum colour scores of 6.30, 6.26, 6.28 & 6.73, 6.60, 6.66 & 7.23, 7.26, 7.25 & 8.20, 8.17, 8.18 & 8.30, 8.30, 8.28, respectively were demonstrated under the treatment T₈ [Jaggery + Pomegranate juice (80%) + Mahua juice (20%)] at 0, 2, 4, 6 and 8 months of storage of wine during first and second year of observation as well as based on pooled mean. The improvement in the colour due to the precipitation of the total soluble solids during the maturation of wine. Similar observation were also documented by Singh *et al.* (2022)^[14] in pomegranate wine, Matwa and Topno (2023)^[11] in orange wine and Ngaihling and Topno (2023)^[12] in pomegranate wine.

Taste

It is apparent from the findings of present experiment the organoleptic taste scores of blended pomegranate-mahua wine were recorded maximum taste scores (7.86, 7.77, 7.81 & 8.13, 8.16, 8.15 & 8.50, 8.60, 8.55 & 9.03, 9.04, 9.03 & 9.18, 9.16, 9.17) were found under the treatment T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)], while the minimum taste of (6.43, 6.56, 6.50 & 7.00, 6.86, 6.93 & 7.30, 7.26, 7.43 & 7.56, 7.66, 7.61 & 7.96, 8.13, 8.05 and 6.46, 6.36, 6.41 & 6.83, 6.73, 6.78 & 7.25, 7.06, 7.15 & 7.66, 7.60, 7.68 & 8.03, 7.96, 8.00, respectively) were observed under the treatment T₉ [Jaggery + Pomegranate juice (70%) + Mahua juice (30%)] at 0, 2, 4, 6 and 8 months of storage of wine during first and second year of observation as well as based on pooled mean. The continuous increasing trends in taste score of blended pomegranate-mahua wine with advancement of storage period from freshly prepared to 8 months. Acidity plays pivotal role as imparts taste to wine as well as protecting the wine from spoilage. Similar findings were noticed by Singh *et al.* (2022)^[14] in pomegranate wine, Chang *et al.* (2023)^[5] in sapota wine and Matwa and Topno (2023)^[11] in orange wine.

Flavour

Based on the results of present investigation, it can be concluded that the flavour score of blended pomegranate-mahua wine was significantly influenced under the different treatment combinations and were recorded. The maximum flavour scores (7.73, 7.60, 7.66 & 7.87, 7.77, 7.81 & 8.33, 8.46, 8.40 & 8.60, 8.53, 8.56 & 9.00, 9.03, 9.01) were obtained under the T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)] at 0, 2, 4, 6, and 8 months of storage of wine. The minimum flavour scores of 5.30, 5.26, 5.28 & 6.57, 6.40, 6.48 & 6.70, 6.93, 6.81 & 7.53, 7.33, 7.43 & 8.06, 7.76, 7.91, respectively were showed under the treatment T₈ [Jaggery + Pomegranate juice (80%) + Mahua juice (20%)] at 0, 2, 4, 6 and 8 months of storage of wine

during first and second year of observation as well as based on pooled mean. The current results align with the findings of Veena (2011)^[16], noted that the flavour of blended grape wine was rated as fair after aging. Additionally, Kakade (2019)^[8] reported that the flavour score of bael wine steadily improved over a seven-month aging period due to the effect of sugar concentration.

Viscosity

It is clear from the findings of present experiment that the organoleptic score for the viscosity of blended pomegranate-mahua wine showed increasing trend under the different treatment combinations with an advancement of storage period. The maximum viscosity scores (6.73, 6.63, 6.68 & 7.26, 7.26, 7.26 & 7.60, 7.83, 7.71 & 8.26, 8.37, 8.32 & 8.57, 8.60, 8.58) were observed under the treatment T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)], while the minimum viscosity scores of 5.29, 5.30, 5.29 & 6.23, 6.20, 6.21 & 6.46, 6.50, 6.48 & 7.20, 7.33, 7.26 & 7.40, 7.43, 7.42, respectively were demonstrated under the treatment T₈ [Jaggery + Pomegranate juice (80%) + Mahua juice (20%)] from the fresh to 8 months of storage of wine with an interval of 2 months during first and second year of observation as well as based on pooled mean. The continuous increase in viscosity is due to advancement of storage period from fresh to 8 months. Similar findings were reported by Kakade (2019)^[8] in blended mandarin and grape wine and Kadge (2021)^[7] in blended Nagpur mandarin-pomegranate-grape wine.

Overall acceptability

The results with reference to overall acceptability of blended pomegranate-mahua wine was significantly varied under the different combinations of treatments evaluated at 0, 2, 4, 6 and 8 months of storage exhibited increasing trend during storage period. The maximum overall acceptability scores (7.23, 7.27, 7.25 & 7.80, 7.83, 7.82 & 8.30, 8.37, 8.33 & 8.33, 8.30, 8.33 & 9.07, 9.10, 9.08) were found under the T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)], while the minimum overall acceptability percentage of 6.03, 6.10, 6.07 & 6.67, 6.60, 6.63 & 7.07, 7.17, 7.12 & 7.07, 7.10, 7.08 & 7.93, 7.87, 7.90, respectively were demonstrated under the treatment T₈ [Jaggery+ Pomegranate juice (80%) + Mahua juice (20%)] at 0, 2, 4, 6 and 8 months of storage of wine during first and second year of observation as well as based on pooled mean. The results from the present study are similar with the findings of Kumar *et al.* (2022)^[10] in pineapple wine, Singh *et al.* (2022)^[14] in pomegranate wine and Matwa and Topno (2023)^[11] in orange wine.

2. Benefit: Cost ratio of blended pomegranate-mahua wine

The maximum benefit: cost ratio (7.36 & 7.06) was recorded under the treatment T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)] during both the year. However, the minimum benefit: cost ratio (2.09 and 1.95) were obtained under the treatment T₆ [Jaggery + Pomegranate juice (100%)]. The results from the present study are similar with the findings of Kumar *et al.* (2022)^[10] in pineapple wine, Singh *et al.* (2022)^[14] in pomegranate wine and Matwa and Topno (2023)^[11] in orange wine.

Table 2: Effect of sugar source and blending ratios on colour of blended pomegranate-mahua wine during storage

Treatments		Fresh			2 months			4 months			6 months			8 months		
		2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean
Individual effect of sugar sources and blending ratios on blended pomegranate-mahua wine																
A ₁		7.68	7.59	7.64	7.92	7.81	7.87	8.21	8.20	8.21	8.55	8.46	8.22	8.84	8.86	8.87
A ₂		6.65	6.46	6.56	6.82	6.64	6.73	7.30	7.29	7.30	8.22	8.19	8.21	8.31	8.30	8.31
F-test		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B ₁		7.11	7.05	7.08	7.33	7.08	7.20	7.73	7.70	7.71	8.35	8.30	8.32	8.51	8.55	8.55
B ₂		7.25	6.98	7.11	7.35	7.26	7.30	7.83	7.85	7.84	8.55	8.45	7.79	8.63	8.60	8.63
B ₃		6.85	6.78	6.81	7.26	7.16	7.21	7.51	7.56	7.54	8.25	8.23	8.24	8.40	8.40	8.38
B ₄		7.43	7.28	7.35	7.53	7.50	7.51	7.93	7.91	7.92	8.45	8.38	8.42	8.80	8.82	8.75
B ₅		7.20	7.05	7.12	7.40	7.13	7.26	7.78	7.70	7.74	8.35	8.28	8.32	8.55	8.55	8.63
F-test		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effect of sugar sources and blending ratios on blended pomegranate-mahua wine																
T ₁	A ₁ B ₁	7.50 ^{bc}	7.36 ^c	7.43 ^c	7.80 ^b	7.70 ^b	7.75 ^{bc}	8.20 ^{bc}	8.16 ^{bc}	8.18 ^{bc}	8.60 ^a	8.50 ^a	8.55 ^a	8.80 ^{ab}	8.87 ^{ab}	8.83 ^b
T ₂	A ₁ B ₂	7.76 ^b	7.66 ^b	7.71 ^b	8.06 ^b	8.02 ^{ab}	8.04 ^{ab}	8.30 ^{ab}	8.33 ^{ab}	8.31 ^b	8.70 ^a	8.57 ^a	8.63 ^a	8.97 ^{ab}	8.97 ^{ab}	9.00 ^a
T ₃	A ₁ B ₃	7.40 ^c	7.30 ^c	7.35 ^c	7.80 ^b	7.73 ^b	7.76 ^{bc}	7.80 ^d	7.86 ^d	7.83 ^d	8.30 ^a	8.30 ^{ab}	8.30 ^b	8.50 ^{bc}	8.50 ^{bc}	8.47 ^c
T ₄	A ₁ B ₄	8.20 ^a	8.16 ^a	8.18 ^a	8.30 ^a	8.36 ^a	8.33 ^a	8.56 ^a	8.50 ^a	8.53 ^a	8.67 ^a	8.63 ^a	8.65 ^a	9.20 ^a	9.23 ^a	9.18 ^a
T ₅	A ₁ B ₅	7.56 ^{bc}	7.46 ^{bc}	7.51 ^{bc}	7.86 ^c	7.50 ^b	7.68 ^c	8.20 ^{bc}	8.13 ^{bc}	8.16 ^c	8.50 ^a	8.33 ^{ab}	8.42 ^{ab}	8.73 ^{ab}	8.73 ^b	8.83 ^b
T ₆	A ₂ B ₁	6.73 ^d	6.73 ^d	6.73 ^d	6.86 ^d	6.46 ^c	6.66 ^d	7.26 ^e	7.23 ^e	7.25 ^f	8.10 ^c	8.10 ^b	8.10 ^b	8.23 ^c	8.23 ^d	8.27 ^d
T ₇	A ₂ B ₂	6.73 ^d	6.30 ^e	6.51 ^d	6.83 ^d	6.76 ^c	6.80 ^d	7.36 ^e	7.36 ^e	7.36 ^e	8.40 ^{abc}	8.33 ^{ab}	8.37 ^{ab}	8.23 ^c	8.23 ^d	8.27 ^d
T ₈	A ₂ B ₃	6.30 ^e	6.26 ^e	6.28 ^f	6.73 ^d	6.60 ^c	6.66 ^d	7.23 ^e	7.26 ^e	7.25 ^f	8.20 ^c	8.17 ^b	8.18 ^b	8.30 ^c	8.30 ^{cd}	8.28 ^d
T ₉	A ₂ B ₄	6.66 ^d	6.40 ^e	6.53 ^{de}	6.76 ^d	6.63 ^c	6.70 ^d	7.30 ^e	7.33 ^e	7.31 ^{ef}	8.23 ^c	8.13 ^b	8.18 ^b	8.40 ^c	8.40 ^{cd}	8.32 ^{cd}
T ₁₀	A ₂ B ₅	6.83 ^d	6.63 ^d	6.73 ^d	6.93 ^d	6.76 ^c	6.85 ^d	7.36 ^e	7.26 ^e	7.31 ^{ef}	8.20 ^c	8.23 ^b	8.22 ^b	8.37 ^c	8.37 ^{cd}	8.42 ^c
SEm±		0.095	0.076	0.071	0.084	0.138	0.093	0.070	0.069	0.065	0.108	0.104	0.094	0.127	0.126	0.058
CD (5%)		0.282	0.227	0.210	0.249	0.410	0.275	0.209	0.206	0.192	0.321	0.309	0.280	0.376	0.375	0.173

Table 3: Effect of sugar sources and blending ratios on taste of blended pomegranate-mahua wine during storage

Treatments		Fresh			2 months			4 months			6 months			8 months		
		2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean
Individual effect of sugar sources and blending ratios on blended pomegranate- mahua wine																
A ₁		7.63	7.58	7.60	7.94	7.92	7.93	8.33	8.26	8.29	8.74	8.69	8.71	9.00	8.97	8.98
A ₂		6.51	6.44	6.48	7.06	6.92	6.99	7.40	7.19	7.29	7.70	7.71	7.71	8.18	8.14	8.16
F-test		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B ₁		7.05	6.95	7.00	7.53	7.45	7.49	7.86	7.76	7.81	8.16	8.18	8.17	8.65	8.58	8.61
B ₂		7.20	7.17	7.18	7.68	7.52	7.60	8.05	7.73	7.89	8.36	8.28	8.35	8.76	8.64	8.72
B ₃		6.91	7.00	6.87	7.35	7.35	7.34	7.66	7.65	7.61	8.13	8.11	8.10	8.45	8.48	8.42
B ₄		7.15	7.16	7.15	7.56	7.51	7.54	7.80	7.93	7.77	8.30	8.35	7.55	8.57	8.68	8.61
B ₅		7.05	6.83	7.02	7.40	7.33	7.37	7.95	7.55	7.80	8.16	8.08	8.14	8.53	8.40	8.50
F-test		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effect of sugar sources and blending ratios on pomegranate- mahua wine																
T ₁	A ₁ B ₁	7.56 ^{ab}	7.47 ^a	7.51 ^{ab}	7.93 ^{ab}	7.83 ^{ab}	7.88 ^{bc}	8.26 ^{ab}	8.23 ^{ab}	8.25 ^{ab}	8.60 ^b	8.56 ^b	8.58 ^b	8.93 ^b	8.90 ^b	8.91 ^b
T ₂	A ₁ B ₂	7.76 ^a	7.73 ^a	7.75 ^a	8.06 ^a	8.00 ^{ab}	8.03 ^{ab}	8.43 ^a	8.26 ^{ab}	8.35 ^a	9.03 ^a	8.96 ^a	9.00 ^a	9.16 ^a	9.13 ^a	9.15 ^a
T ₃	A ₁ B ₃	7.33 ^b	7.30 ^a	7.31 ^b	7.73 ^b	7.70 ^b	7.71 ^c	8.13 ^b	7.96 ^b	8.05 ^c	8.46 ^b	8.43 ^b	8.45 ^b	8.86 ^b	8.83 ^b	8.85 ^b
T ₄	A ₁ B ₄	7.86 ^a	7.77 ^a	7.81 ^a	8.13 ^a	8.16 ^a	8.15 ^a	8.50 ^a	8.60 ^a	8.55 ^a	9.02 ^a	9.04 ^a	9.03 ^a	9.18 ^a	9.16 ^a	9.17 ^a
T ₅	A ₁ B ₅	7.63 ^{ab}	7.64 ^a	7.63 ^{ab}	7.86 ^b	7.93 ^{ab}	7.90 ^{bc}	8.33 ^{ab}	8.23 ^{ab}	8.28 ^b	8.60 ^b	8.46 ^b	8.53 ^b	8.86 ^b	8.83 ^b	8.85 ^b
T ₆	A ₂ B ₁	6.53 ^c	6.43 ^b	6.48 ^c	7.13 ^{cd}	7.06 ^c	7.10 ^d	7.60 ^c	7.26 ^c	7.43 ^d	7.73 ^{cd}	7.80 ^c	7.76 ^c	8.36 ^c	8.26 ^c	8.31 ^c
T ₇	A ₂ B ₂	6.63 ^c	6.50 ^b	6.56 ^c	7.30 ^c	6.96 ^c	7.13 ^d	7.33 ^d	7.23 ^c	7.28 ^e	7.56 ^d	7.60 ^c	7.58 ^d	8.36 ^c	8.23 ^c	8.30 ^c
T ₈	A ₂ B ₃	6.50 ^c	6.36 ^b	6.43 ^c	7.06 ^d	7.00 ^c	7.03 ^{de}	7.20 ^d	7.13 ^c	7.17 ^e	7.86 ^c	7.80 ^c	7.83 ^c	8.20 ^{cd}	8.13 ^{cd}	8.16 ^{cd}
T ₉	A ₂ B ₄	6.43 ^c	6.56 ^b	6.50 ^c	7.00 ^{de}	6.86 ^c	6.93 ^{ef}	7.30 ^c	7.26 ^c	7.28 ^e	7.56 ^d	7.66 ^c	7.61 ^d	7.96 ^e	8.13 ^{cd}	8.05 ^{de}
T ₁₀	A ₂ B ₅	6.46 ^c	6.36 ^b	6.41 ^c	6.83 ^e	6.73 ^c	6.78 ^f	7.25 ^c	7.06 ^c	7.15 ^e	7.66 ^d	7.70 ^c	7.68 ^{cd}	8.03 ^{de}	7.96 ^d	8.00 ^e
SEm±		0.088	0.100	0.084	0.061	0.077	0.054	0.072	0.128	0.065	0.083	0.082	0.070	0.076	0.081	0.066
CD (5%)		0.262	0.297	0.250	0.181	0.228	0.161	0.214	0.379	0.194	0.247	0.245	0.207	0.227	0.242	0.196

Table 4: Effect of sugar sources and blending ratios on flavour of blended pomegranate-mahua wine during storage

Treatments	Fresh			2 months			4 months			6 months			8 months			
	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	
Individual effect of sugar sources and blending ratios on pomegranate- mahua wine																
A ₁	7.42	7.26	7.34	7.58	7.48	7.53	8.02	8.00	8.01	8.36	8.32	8.08	8.67	8.63	8.65	
A ₂	5.57	5.44	5.51	6.40	6.4	6.40	6.93	6.98	6.95	7.50	7.41	7.45	8.22	7.96	8.09	
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
B ₁	6.40	6.33	6.36	6.75	6.81	6.78	7.55	7.43	7.49	7.85	7.76	7.80	8.38	8.26	8.32	
B ₂	6.65	6.51	6.58	7.12	7.10	7.10	7.58	7.56	7.57	7.93	7.93	7.27	8.53	8.30	8.41	
B ₃	6.21	6.11	6.16	6.90	6.77	6.83	7.27	7.36	7.31	7.91	7.80	7.85	8.35	8.21	8.28	
B ₄	6.76	6.61	6.69	7.27	7.15	7.20	7.67	7.76	7.71	8.05	7.95	8.00	8.63	8.53	8.58	
B ₅	6.45	6.18	6.31	6.93	6.87	6.90	7.32	7.33	7.32	7.91	7.90	7.90	8.33	8.18	8.25	
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Interaction effect of sugar sources and blending ratios on pomegranate- mahua wine																
T ₁	A ₁ B ₁	7.23 ^b	7.20 ^{ab}	7.21 ^{ab}	7.57 ^a	7.43 ^{ab}	7.50 ^a	8.00 ^{ab}	7.93 ^{bc}	7.96 ^{bc}	8.20 ^b	8.06 ^a	8.13 ^b	8.63 ^{bc}	8.40 ^{abc}	8.51 ^{bc}
T ₂	A ₁ B ₂	7.60 ^a	7.53 ^a	7.56 ^a	7.77 ^a	7.73 ^a	7.75 ^a	8.23 ^a	8.16 ^{ab}	8.20 ^{ab}	8.50 ^a	8.40 ^a	8.45 ^a	8.76 ^b	8.76 ^{ab}	8.76 ^{ab}
T ₃	A ₁ B ₃	7.13 ^b	6.96 ^b	7.05 ^b	7.23 ^b	7.13 ^b	7.18 ^a	7.83 ^b	7.80 ^{cd}	7.81 ^{cd}	8.30 ^{ab}	8.26 ^a	8.28 ^{ab}	8.36 ^d	8.36 ^{bc}	8.36 ^{cd}
T ₄	A ₁ B ₄	7.73 ^a	7.60 ^a	7.66 ^a	7.87 ^a	7.77 ^a	7.81 ^a	8.33 ^a	8.46 ^a	8.40 ^a	8.60 ^a	8.53 ^a	8.56 ^a	9.00 ^a	9.03 ^a	9.01 ^a
T ₅	A ₁ B ₅	7.40 ^{ab}	7.00 ^b	7.20 ^{ab}	7.47 ^{ab}	7.33 ^{ab}	7.40 ^a	7.70 ^b	7.66 ^d	7.68 ^d	8.20 ^b	8.36 ^a	8.28 ^{ab}	8.60 ^c	8.60 ^{ab}	8.60 ^{bc}
T ₆	A ₂ B ₁	5.56 ^{cd}	5.46 ^{cd}	5.51 ^{cd}	5.93 ^d	6.20 ^d	6.06 ^b	7.10 ^c	6.93 ^e	7.01 ^e	7.50 ^{cd}	7.46 ^b	7.48 ^c	8.13 ^{ef}	8.13 ^{cd}	8.13 ^{de}
T ₇	A ₂ B ₂	5.70 ^c	5.50 ^{cd}	5.60 ^{cd}	6.47 ^c	6.47 ^{cd}	6.46 ^b	6.93 ^d	6.96 ^e	6.95 ^e	7.36 ^d	7.46 ^b	7.41 ^c	8.30 ^{de}	7.83 ^d	8.07 ^{de}
T ₈	A ₂ B ₃	5.30 ^d	5.26 ^d	5.28 ^d	6.57 ^c	6.40 ^{cd}	6.48 ^b	6.70 ^e	6.93 ^e	6.81 ^e	7.53 ^{cd}	7.33 ^b	7.43 ^c	8.06 ^f	7.76 ^d	7.91 ^e
T ₉	A ₂ B ₄	5.80 ^c	5.63 ^c	5.71 ^c	6.67 ^c	6.53 ^c	6.60 ^b	7.00 ^{cd}	7.06 ^e	7.03 ^e	7.50 ^{cd}	7.36 ^b	7.43 ^c	8.26 ^{de}	8.03 ^{cd}	8.15 ^{de}
T ₁₀	A ₂ B ₅	5.50 ^{cd}	5.36 ^d	5.43 ^d	6.40 ^c	6.40 ^{cd}	6.40 ^b	6.93 ^d	7.00 ^e	6.96 ^e	7.62 ^c	7.43 ^b	7.52 ^c	8.33 ^{de}	8.06 ^{cd}	8.19 ^{de}
SEm±		0.116	0.118	0.095	0.210	0.202	0.197	0.096	0.101	0.082	0.079	0.112	0.074	0.070	0.164	0.098
CD (5%)		0.344	0.351	0.284	0.623	0.600	0.586	0.286	0.299	0.245	0.236	0.332	0.220	0.209	0.487	0.290

Table 5: Effect of sugar sources and blending ratios on viscosity of blended pomegranate-mahua wine during storage

Treatments	Fresh			2 months			4 months			6 months			8 months			
	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	
Individual effect of sugar sources and blending ratios on pomegranate- mahua wine																
A ₁	6.40	6.36	6.38	6.74	6.70	6.72	7.38	7.48	7.43	7.99	8.03	7.78	8.35	8.34	8.34	
A ₂	5.44	5.36	5.40	6.34	6.29	6.31	6.64	6.67	6.66	7.36	7.32	7.34	7.58	7.58	7.58	
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
B ₁	5.85	5.75	5.80	6.45	6.46	6.45	6.90	6.97	6.92	7.56	7.58	7.54	7.93	7.93	7.93	
B ₂	6.03	5.90	5.96	6.61	6.51	6.56	7.01	7.08	7.05	7.73	7.70	7.54	8.02	8.00	8.03	
B ₃	5.69	5.73	5.71	6.20	6.25	6.22	6.88	6.88	6.89	7.50	7.52	7.51	7.80	7.78	7.79	
B ₄	6.08	5.98	6.03	6.90	6.83	6.86	7.21	7.32	7.26	7.86	7.87	7.87	8.12	8.05	8.08	
B ₅	5.96	5.94	5.95	6.53	6.41	6.47	7.06	7.15	7.10	7.73	7.73	7.73	7.98	8.03	8.01	
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	
Interaction effect of sugar sources and blending ratios on pomegranate- mahua wine																
T ₁	A ₁ B ₁	6.26 ^b	6.20 ^{bc}	6.23 ^{bc}	6.66 ^{bc}	6.73 ^b	6.70 ^{bc}	7.16 ^c	7.10 ^c	7.13 ^c	7.80 ^{ab}	7.83 ^{ab}	7.82 ^{bc}	8.20 ^b	8.20 ^b	8.20 ^b
T ₂	A ₁ B ₂	6.50 ^{ab}	6.40 ^{ab}	6.45 ^{ab}	6.93 ^{bc}	6.80 ^b	6.86 ^b	7.56 ^a	7.67 ^{ab}	7.61 ^a	8.13 ^a	8.07 ^{ab}	8.10 ^{ab}	8.43 ^{ab}	8.40 ^{ab}	8.42 ^{ab}
T ₃	A ₁ B ₃	6.10 ^b	6.16 ^c	6.13 ^c	6.70 ^{bc}	6.53 ^{bc}	6.61 ^c	7.20 ^{bc}	7.30 ^{bc}	7.25 ^{bc}	7.73 ^b	7.77 ^b	7.75 ^c	8.20 ^b	8.13 ^b	8.17 ^b
T ₄	A ₁ B ₄	6.73 ^a	6.63 ^a	6.68 ^a	7.26 ^a	7.26 ^a	7.26 ^a	7.60 ^a	7.83 ^a	7.71 ^a	8.26 ^a	8.37 ^a	8.32 ^a	8.57 ^a	8.60 ^a	8.58 ^a
T ₅	A ₁ B ₅	6.40 ^{ab}	6.40 ^{ab}	6.40 ^{ab}	6.13 ^d	6.16 ^d	6.15 ^e	7.40 ^{ab}	7.53 ^{abc}	7.46 ^{ab}	8.03 ^a	8.13 ^{ab}	8.08 ^{ab}	8.37 ^{ab}	8.37 ^{ab}	8.37 ^{ab}
T ₆	A ₂ B ₁	5.43 ^c	5.31 ^e	5.37 ^d	6.36 ^d	6.30 ^d	6.33 ^e	6.63 ^{de}	6.67 ^d	6.65 ^{de}	7.40 ^c	7.27 ^c	7.33 ^e	7.67 ^c	7.67 ^c	7.67 ^c
T ₇	A ₂ B ₂	5.56 ^c	5.40 ^{de}	5.48 ^d	6.30 ^d	6.23 ^d	6.26 ^{de}	6.56 ^{ef}	6.63 ^d	6.60 ^e	7.33 ^c	7.33 ^c	7.33 ^{de}	7.60 ^c	7.70 ^c	7.65 ^c
T ₈	A ₂ B ₃	5.29 ^c	5.30 ^e	5.29 ^d	6.23 ^d	6.20 ^{cd}	6.21 ^{de}	6.46 ^f	6.50 ^d	6.48 ^e	7.20 ^c	7.33 ^c	7.26 ^{de}	7.40 ^c	7.43 ^d	7.42 ^c
T ₉	A ₂ B ₄	5.43 ^c	5.34 ^{de}	5.38 ^d	6.53 ^c	6.40 ^{cd}	6.46 ^{cd}	6.83 ^d	6.80 ^d	6.81 ^d	7.46 ^c	7.37 ^c	7.42 ^d	7.67 ^c	7.40 ^d	7.53 ^c
T ₁₀	A ₂ B ₅	5.52 ^c	5.48 ^d	5.50 ^d	6.26 ^d	6.33 ^{cd}	6.30 ^{de}	6.73 ^{de}	6.77 ^d	6.75 ^d	7.43 ^c	7.33 ^c	7.38 ^d	7.60 ^c	7.70 ^c	7.65 ^c
SEm±	0.098	0.098	0.082	0.080	0.094	0.089	0.078	0.086	0.093	0.078	0.102	0.127	0.098	0.083	0.087	
CD (5%)	0.292	0.292	0.245	0.238	0.279	0.264	0.233	0.256	0.276	0.232	0.303	0.376	0.274	0.248	0.260	

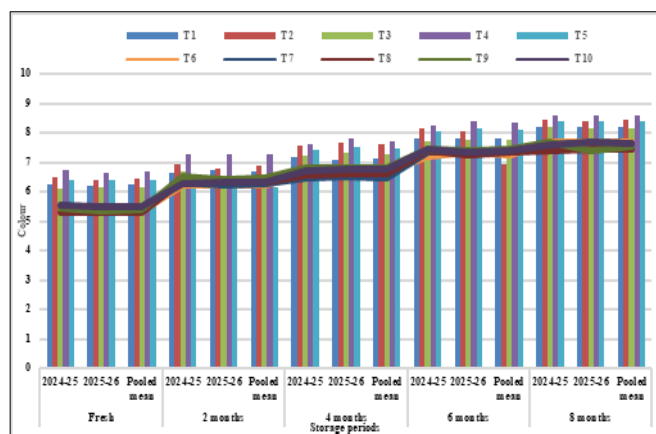
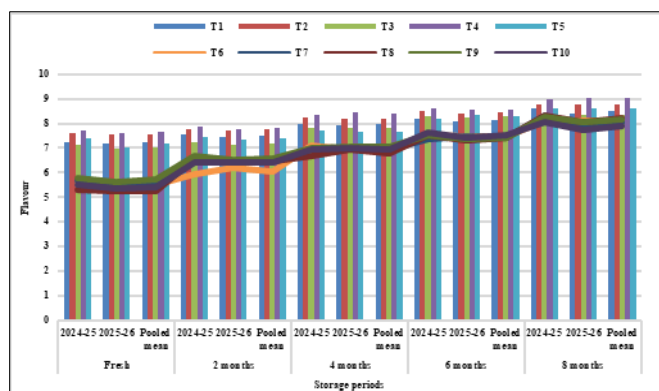
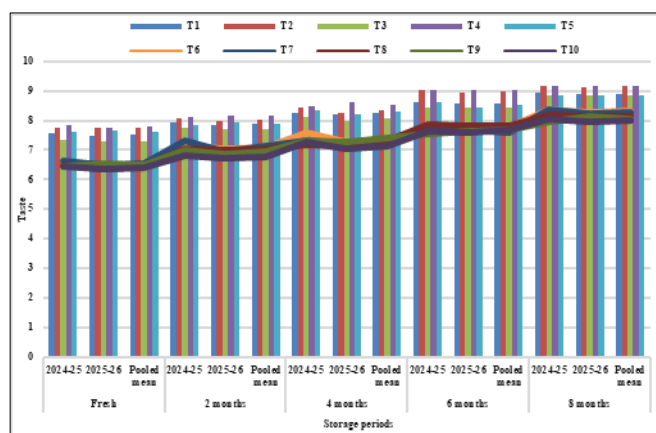
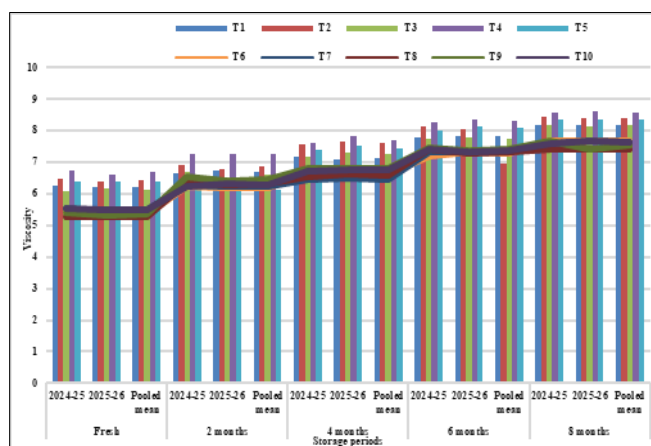
Table 6: Effect of sugar sources and blending ratios on overall acceptability of blended pomegranate-mahua wine during storage

Treatments	Fresh			2 months			4 months			6 months			8 months		
	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean	2024-25	2025-26	Pooled mean
Individual effect of sugar sources and blending ratios on pomegranate- mahua wine															
A ₁	6.85	6.80	6.82	7.45	7.46	7.46	8.02	8.02	8.02	8.02	8.04	7.78	8.59	8.63	8.61
A ₂	6.18	6.20	6.19	6.73	6.70	6.72	7.34	7.32	7.33	7.34	7.32	7.33	8.07	8.02	8.04
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
B ₁	6.43	6.33	6.38	6.98	6.95	6.96	7.65	7.65	7.65	7.65	7.60	7.625	8.25	8.21	8.23
B ₂	6.53	6.47	6.50	7.15	7.10	7.13	7.73	7.73	7.73	7.73	7.80	7.16	8.40	8.43	8.42

B ₃	6.30	6.32	6.31	6.93	6.95	6.94	7.47	7.50	7.48	7.56	7.54	7.55	8.12	8.07	8.09
B ₄	6.77	6.80	6.78	7.32	7.32	7.32	7.85	7.85	7.85	7.85	7.85	7.85	8.52	8.52	8.52
B ₅	6.55	6.58	6.57	7.08	7.12	7.10	7.70	7.63	7.67	7.70	7.68	7.69	8.38	8.40	8.39
F-test	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction effect of sugar sources and blending ratios on pomegranate- mahua wine															
T ₁	6.73 ^b	6.57 ^{bcd}	6.65 ^{bc}	7.27 ^{bc}	7.30 ^c	7.28 ^c	7.93 ^{bc}	7.87 ^{bc}	7.90 ^{bc}	7.93 ^{bc}	7.87 ^b	7.90 ^{bc}	8.37 ^{bc}	8.37 ^c	8.37 ^{bc}
T ₂	6.87 ^b	6.77 ^{bc}	6.82 ^b	7.60 ^a	7.53 ^b	7.57 ^b	8.13 ^{ab}	8.17 ^{ab}	8.15 ^{ab}	8.13 ^{ab}	8.23 ^a	8.18 ^{ab}	8.63 ^b	8.77 ^b	8.70 ^b
T ₃	6.57 ^c	6.53 ^{cd}	6.55 ^c	7.20 ^c	7.30 ^c	7.25 ^c	7.87 ^c	7.83 ^c	7.85 ^c	7.87 ^c	7.87 ^b	7.87 ^c	8.30 ^{cd}	8.27 ^{cd}	8.28 ^{cd}
T ₄	7.23 ^a	7.27 ^a	7.25 ^a	7.80 ^a	7.83 ^a	7.82 ^a	8.30 ^a	8.37 ^a	8.33 ^a	8.30 ^a	8.33 ^a	8.32 ^a	9.07 ^a	9.10 ^a	9.08 ^a
T ₅	6.87 ^b	6.87 ^b	6.87 ^b	7.40 ^{ab}	7.37 ^{bc}	7.38 ^{bc}	7.87 ^c	7.90 ^{bc}	7.88 ^{bc}	7.87 ^c	7.90 ^b	7.88 ^c	8.60 ^b	8.67 ^b	8.63 ^b
T ₆	6.13 ^{ef}	6.10 ^f	6.12 ^e	6.70 ^d	6.60 ^e	6.65 ^e	7.37 ^{de}	7.43 ^d	7.40 ^{de}	7.37 ^{de}	7.33 ^d	7.35 ^e	8.13 ^{de}	8.07 ^e	8.10 ^{de}
T ₇	6.20 ^{de}	6.17 ^{ef}	6.18 ^{de}	6.70 ^d	6.67 ^{de}	6.68 ^e	7.33 ^e	7.30 ^d	7.32 ^e	7.33 ^e	7.37 ^{cd}	7.35 ^e	8.17 ^{de}	8.10 ^{de}	8.13 ^{de}
T ₈	6.03 ^f	6.10 ^f	6.07 ^e	6.67 ^d	6.60 ^e	6.63 ^e	7.07 ^f	7.17 ^d	7.12 ^f	7.07 ^f	7.10 ^e	7.08 ^f	7.93 ^e	7.87 ^f	7.90 ^e
T ₉	6.30 ^d	6.33 ^d	6.32 ^d	6.83 ^d	6.80 ^d	6.82 ^d	7.40 ^{de}	7.33 ^d	7.37 ^{de}	7.40 ^{de}	7.37 ^{cd}	7.38 ^{de}	7.97 ^e	7.93 ^f	7.95 ^e
T ₁₀	6.23 ^{de}	6.30 ^{de}	6.27 ^d	6.77 ^d	6.87 ^d	6.82 ^d	7.53 ^d	7.37 ^d	7.45 ^d	7.53 ^d	7.47 ^c	7.50 ^d	8.17 ^{de}	8.13 ^{cd}	8.15 ^{de}
SEm±	0.069	0.092	0.071	0.084	0.082	0.075	0.068	0.083	0.069	0.068	0.063	0.056	0.092	0.091	0.085
CD (5%)	0.206	0.272	0.210	0.249	0.243	0.223	0.201	0.247	0.204	0.201	0.188	0.168	0.272	0.271	0.254

Table 7: Economics of blended pomegranate-mahua wine

Treatments		Total cost		Gross return		Net return		B:C ratio	
		2024-25	2025-26	2024-25	2025-26	2024-25	2025-26	2024-25	2025-26
T ₁	A ₁ B ₁	375.00	405.00	1497	1497	1122.00	1092.00	2.99	2.70
T ₂	A ₁ B ₂	349.50	379.50	1587	1617	1237.50	1237.50	3.54	3.26
T ₃	A ₁ B ₃	327.00	357.00	1557	1587	1230.00	1230.00	3.76	3.45
T ₄	A ₁ B ₄	304.50	334.50	2547	2697	2242.50	2362.50	7.36	7.06
T ₅	A ₁ B ₅	285.00	315.00	1557	1587	1272.00	1272.00	4.46	4.04
T ₆	A ₂ B ₁	417.00	447.00	1287	1317	870.00	870.00	2.09	1.95
T ₇	A ₂ B ₂	388.80	418.80	1377	1407	988.20	988.20	2.54	2.36
T ₈	A ₂ B ₃	364.20	394.20	1467	1347	1102.80	952.80	3.03	2.42
T ₉	A ₂ B ₄	339.60	369.60	1257	1287	917.40	917.40	2.70	2.48
T ₁₀	A ₂ B ₅	315.00	345.00	1347	1317	1032.00	972.00	3.28	2.82

**Fig 1:** Interaction effect of sugar sources and blending ratios on colour of blended pomegranate-mahua wine during storage**Fig 3:** Interaction effect of sugar sources and blending ratios on flavour of blended pomegranate- mahua wine during storage**Fig 2:** Interaction effect of sugar sources and blending ratio on taste of blended pomegranate- mahua wine during storage**Fig 4:** Interaction effect of sugar sources and blending ratios on viscosity of blended pomegranate- mahua wine during storage

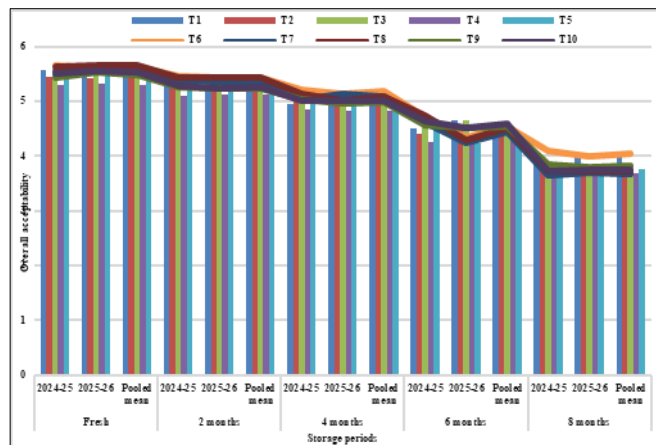


Fig 5: Interaction effect of sugar sources and blending ratios on overall acceptability of blended pomegranate- mahua wine during storage

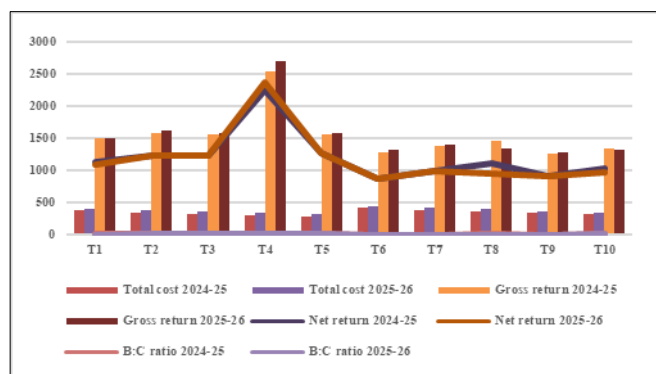


Fig 6: Economics of blended pomegranate-mahua wine during 2024-2025 and 2025-2026

Conclusion

The sensory parameter *i.e.* colour, taste, flavour, viscosity and overall acceptability of blended pomegranate-mahua wine were significantly influenced under the different treatment combinations and showed increasing trend with advancement of storage period. The blended wine prepared from the recipe T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)] recorded maximum organoleptic scores for all sensory parameters during both years of investigation. Furthermore, the minimum scores for colour, flavour, viscosity and overall acceptability were noticed under the treatment T₈ [Jaggery + Pomegranate juice (80%) + Mahua juice (20%)] while, the minimum taste scores was exhibited under the treatment T₉ [Jaggery + Pomegranate juice (70%) + Mahua juice (30%)] during both the year. The maximum benefit: cost ratio was recorded under the treatment T₄ [Cane sugar + Pomegranate juice (70%) + Mahua juice (30%)]. Furthermore, the minimum benefit: cost ratio was obtained under the treatment T₆ [Jaggery + Pomegranate juice (100%)], respectively under the present investigation.

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