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Fermentation behaviour of palash must in relation to days required for fermentation, rate of fermentation, fermentation efficiency and ethanol production

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Abstract

The study "Effect of different levels of dilution and TSS on fermentation behavior of must in relation to days required for fermentation, rate of fermentation, fermentation efficiency and ethanol production" was conducted in 2024-2025 and 2025-2026 at the PHT Laboratory, Section of Horticulture, College of Agriculture, Dr. PDKV, Akola. The experiment was set up in a Factorial Completely Randomized Design with two factors: factor "A" represents various dilution levels [1:3, 1:4, 1:5 and 1:6 (palash pulp: water dilution ratio)] and factor "B" represents various TSS levels (20°Brix, 22°Brix, 24°Brix and 26°Brix) with sixteen treatment combinations and three replication. The fermentation behavior of must was significantly impacted by varying dilution and TSS levels. Treatment combination D₁T₁ (dilution of pulp with water in a 1:3 ratio + 20°Brix TSS) had the lowest number of days needed for fermentation (12.140), treatment combination D₁T₃ (dilution of pulp with water in a 1:3 ratio + 24 °Brix TSS) had the highest rate of fermentation (1.190°Brix/24 hours), and treatment combination D₁T₄ (dilution of pulp with water in a 1:3 ratio + 26 °Brix TSS). However, it was found that the palash wine's fermentation efficiency was not significant after fermentation.

Keywords: Palash wine, dilution levels, TSS levels, rate of fermentation, fermentation efficiency, ethanol

Introduction

Since thousands of years ago, yeast has been used to ferment grapes, berries, apples, and other fruits and flowers to create wine, a "alcoholic beverage". It has been taken extensively throughout from ancient times under the names Madeira, Sula, etc. It may have positive impacts on human health, particularly because it contains resveratrol and polyphenols. Alcoholic beverages fall into three main categories: wines, spirits and beers. With its floral flavors and smells, flower wines have become a distinctive category of drinks. In addition to being a crucial dietary supplement, it is regarded as a safe and healthful beverage. Flower wines are produced by fermenting extracts from a range of flowers, such as lavender, hibiscus, rose, calendula and mahua, as opposed to traditional grape wines. Since the dawn of civilization, people have added wine to food, making it the first alcoholic beverage ever manufactured.

Many flowers are edible and are commonly used to add flavor, scent, and aesthetic appeal to dishes and drinks, such as salads. A country's economy can be strengthened and production costs can be decreased by using easily available, locally sourced raw resources for food and beverage production. Palash (*Butea monosperma* Lamk. Taub.) is a member of the Fabaceae family—also referred to as "dhak" or "palas," "Flame of forest," Khakara, Chichara, Bastard teak, and Bengal Kino—has been utilized medicinally. The palash plant is well-known for both its decorative and therapeutic uses. It has been extensively utilized to treat a wide range of illnesses in the old Indian medical systems of "Ayurveda," "Unani," and "Homeopathic" medicine and it is now a cynosure of contemporary medicine. Tonic, astringent, aphrodisiac, and diuretic properties are among its uses (Kumar *et al.* 2013) [9]. Flowers are astringent, diuretic, depurative, tonic, and helpful in treating liver or hepatic conditions (Yadav *et al.* 2020) [14]. Butein and butrin make up the flower's main components. Butin, isobutrin, palasitrin, sulfurin, coreopsin and isocoreopsin,

chalcones and aurones are other recognized ingredients. Additionally, the structures of two other glycosides, monospermoside and isomonospermoside, were found. According to Dubey *et al.* (2010) ^[4], the bright color of flowers is caused by chalcones and aurones. Antidiarrheal, anticancer, anti-convulsant, antidiabetic, anti-inflammatory, anti-free radical scavenging, antitumor, anti-toxicity, hepatoprotective, antidopaminergic, antihepatoprotective, anti-inplantation, and liver disorder are among the pharmacological activities found in *Butea monosperma* flowers (Pooja and Nisha, 2023) ^[12].

Material and Methods

The study was carried out in the Post Harvest Technology laboratory, Horticulture Section, College of Agriculture, Dr. PDKV, Akola, Maharashtra, in the years 2024-2025 and 2025-2026. A Factorial Completely Randomized Design (FCRD) with three replications and sixteen treatment combinations was used to set up the experiment. The first element consists of four dilution levels (1:3, 1:4, 1:5, and 1:6) (palash pulp: water dilution ratio), whereas the second

factor is made up of various TSS levels (20, 22, 24, and 26°Brix). The experiment was carried out over a two-year period, and this article expressed the combined data from those two years. Palash flowers were collected from the Barshitakli woodland region in March 2024-2025 and 2025-2026. Prior to fermentation and following the fermentation process, the fermentation behavior of palash must have been examined using several conventional techniques. Several standard protocols have been used to examine the fermentation behavior of must both prior to and following the fermentation process. According to FSSAI (2015) ^[5], a conventional approach was used to evaluate the ethanol content. A digital refractometer was used to measure total soluble solids, and data of (Initial TSS-Final TSS)/Time were used to compute the rate of fermentation. However, the formula for calculating fermentation efficiency was (Actual Alcohol Produced/Theoretical Alcohol Produced x 100). In contrast, sugar consumed = Initial TSS-Final TSS and theoretical alcohol = Sugar used x 0.64.

Flow sheet of preparation of Palash wine

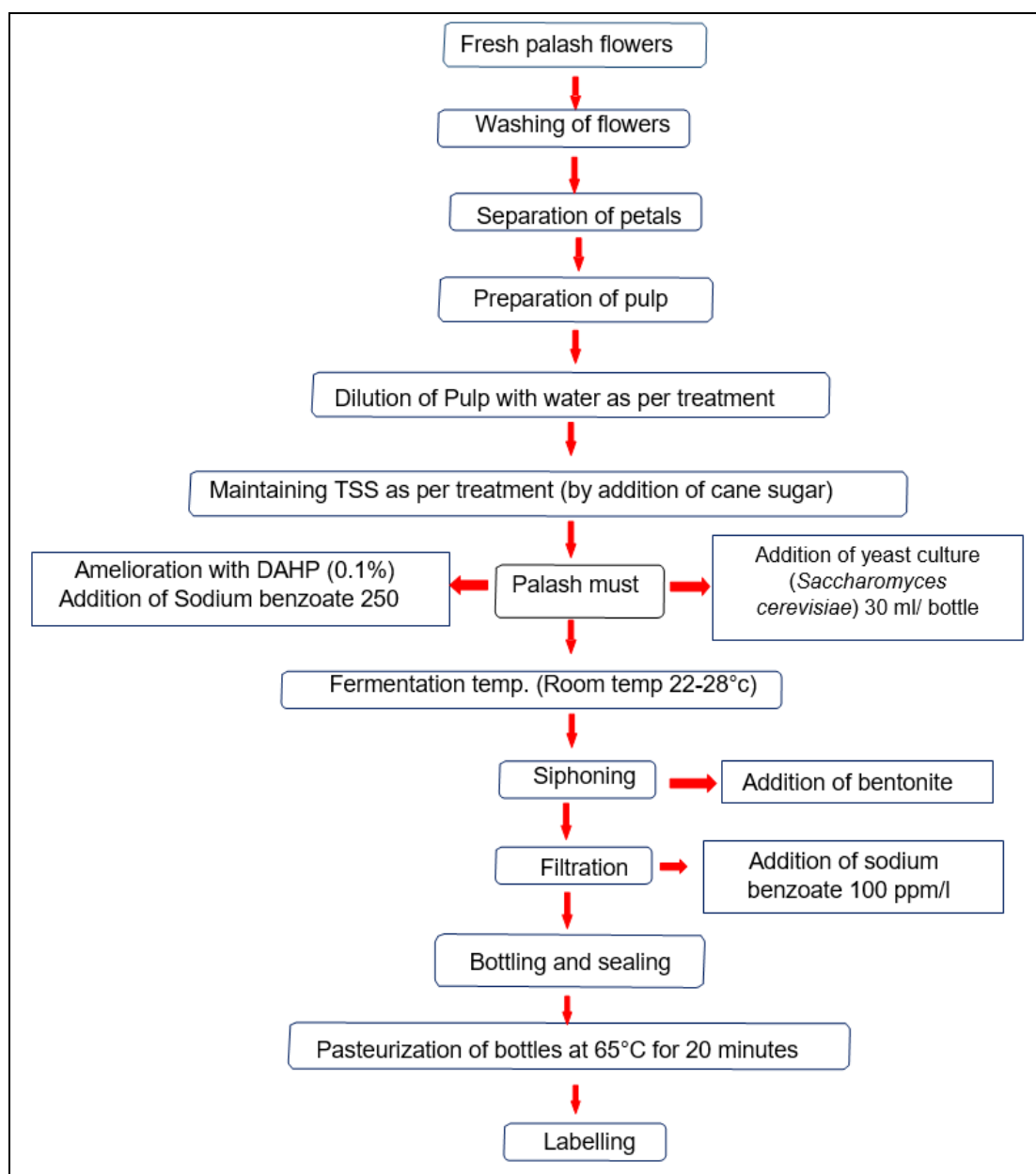


Fig 1: Procedure for preparation of palash wine

Results and Discussion

Days required for fermentation

The data regarding the effect of different levels of dilution and TSS showed the significant effect on days required for fermentation. Among the different dilution levels, treatment D₁ (1:3 dilution ratio) recorded a significantly shorter fermentation period (13.060 days), whereas treatment D₄ (1:6 dilution ratio) recorded a significantly longer fermentation period (13.483 days). With respect to different TSS levels, the minimum days required for fermentation (12.265 days) was observed in treatment T₁ (TSS 20°Brix), while the maximum fermentation period (14.755 days) was recorded in treatment T₄ (TSS 26°Brix). In the interaction effect, the minimum fermentation period (12.140 days) was observed in treatment combination D₁T₁ (1:3 dilution ratio + TSS 20°Brix), whereas the maximum fermentation period (15.060 days) was recorded in treatment combination D₄T₄ (1:6 dilution ratio + TSS 26°Brix). The early initiation and rapid progress of fermentation observed in the treatment combination of 1:3 dilution with 20°Brix may be attributed to the availability of an optimum concentration of fermentable sugars and nutrients, which favoured rapid growth and metabolic activity of *Saccharomyces cerevisiae*. Lower osmotic pressure at 20°Brix enhanced yeast viability and reduced the lag phase, resulting in faster sugar utilization and earlier CO₂ evolution. The present findings are in conformity with those of Matthew *et al.* (2007) [10]. Similar results were found in blended mandarin must by Kadge (2021) [8], rose must by Bhagwat (2023) [2], hibiscus must by Bodare (2025) [3] and mahua blended rose must by Gorivale (2024) [6].

Rate of fermentation

The data with respect to effect of different levels of dilution and TSS exhibited significant effect on rate of fermentation.

With respect to different dilution levels, treatment D₁ (pulp diluted with water in a 1:3 ratio) recorded a significantly higher rate of fermentation (1.147°Brix/24 hrs), whereas the lowest rate of fermentation (1.085°Brix/24 hrs) was observed in treatment D₄ (1:6 dilution ratio). With respect to different TSS levels, a significantly higher rate of fermentation (1.147°Brix/24 h) was recorded in treatment T₃ (TSS 24°Brix), while the lowest rate of fermentation (1.038°Brix/24 h) was observed in treatment T₁ (TSS 20°Brix). In the interaction effect, the maximum rate of fermentation (1.190°Brix/24 hrs) was observed in treatment combination D₁T₃ (1:3 dilution ratio + TSS 24°Brix), whereas the minimum rate of fermentation (1.020°Brix/24 hrs) was recorded in treatment combination D₄T₁ (1:6 dilution ratio + TSS 20°Brix). The superior fermentation observed at the 1:3 dilution ratio and 24°Brix TSS may be attributed to the establishment of a favorable physicochemical environment for yeast growth and metabolism. Moderate dilution reduces excessive osmotic pressure, acidity and phenolic inhibition while maintaining sufficient fermentable sugars and nutrients for efficient yeast activity. Consequently, yeast cells exhibit enhanced metabolic efficiency, resulting in rapid sugar utilization, improved ethanol production and superior wine quality. Similar findings were reported by Aarti *et al.* (2024) [1] in Bael wine, Minh *et al.* (2019) [11] in gooseberry wine fermentation. Whereas, Sevda and Rodrigues (2011) [13] in guava wine observed that higher the sugar content higher will be the fermentation rate.

Fermentation efficiency

With regard to the effect of different levels of dilution and TSS and for the interaction effect fermentation efficiency of must was found to be non-significant.

Table 1: Effect of different levels of dilution and TSS on days required for fermentation, rate of fermentation, fermentation efficiency and ethanol content of palash must.

Factors	Days required for fermentation	Rate of fermentation (°Brix/24 hrs.)	Fermentation efficiency (%)	Ethanol (%)	
				*MBF	*MAF
Factor A			Dilution levels		
D ₁ (1:3)	13.060	1.147	92.203	ND	8.880
D ₂ (1:4)	13.203	1.123	92.206	ND	8.768
D ₃ (1:5)	13.368	1.100	92.180	ND	8.680
D ₄ (1:6)	13.483	1.085	92.208	ND	8.643
'F' Test	Sig.	Sig.	NS	-	Sig.
SE (m)±	0.009	0.003	0.013	-	0.007
CD at 5%	0.025	0.009	-	-	0.022
Factor B			TSS levels		
T ₁ (20 °Brix)	12.265	1.038	92.207	ND	7.530
T ₂ (22 °Brix)	12.636	1.141	92.186	ND	8.498
T ₃ (24 °Brix)	13.448	1.147	92.193	ND	9.100
T ₄ (26 °Brix)	14.755	1.130	92.211	ND	9.843
'F' Test	Sig.	Sig.	NS	-	Sig.
SE (m)±	0.009	0.003	0.013	-	0.007
CD at 5%	0.025	0.009	-	-	0.022

ND = Not Detected, MBF = Must Before Fermentation, MAF = Must After Fermentation

Ethanol production

The data with respect to ethanol content in must are presented in Table 3. Ethanol concentration was not detected in any of the must treatments prior to fermentation. After fermentation, with reference to the effect of different dilution levels, a significantly higher ethanol content (8.880%) was observed in treatment D₁ (pulp diluted with

water in a 1:3 ratio), whereas the minimum ethanol content (8.643%) was recorded in treatment D₄ (1:6 dilution ratio). Regarding the effect of different TSS levels, a significantly higher ethanol content (9.843%) was observed in treatment T₄ (TSS 26°Brix), while the minimum ethanol content (7.530%) was recorded in treatment T₁ (TSS 20°Brix).

Table 2: Interaction effect of different levels of dilution and TSS on days required for fermentation, rate of fermentation, fermentation efficiency and ethanol content of palash must.

Interactions (DXT)	Days required for fermentation	Rate of fermentation (°Brix/24 hrs.)	Fermentation efficiency (%)	Ethanol (%)	
				*MBF	*MAF
D ₁ T ₁	12.140	1.060	92.197	ND	7.630
D ₁ T ₂	12.520	1.170	92.207	ND	8.640
D ₁ T ₃	13.141	1.190	92.193	ND	9.240
D ₁ T ₄	14.440	1.170	92.217	ND	10.010
D ₂ T ₁	12.230	1.040	92.240	ND	7.550
D ₂ T ₂	12.642	1.141	92.227	ND	8.500
D ₂ T ₃	13.340	1.160	92.170	ND	9.120
D ₂ T ₄	14.600	1.150	92.187	ND	9.900
D ₃ T ₁	12.310	1.031	92.150	ND	7.490
D ₃ T ₂	12.650	1.130	92.160	ND	8.440
D ₃ T ₃	13.550	1.130	92.180	ND	9.050
D ₃ T ₄	14.920	1.109	92.230	ND	9.740
D ₄ T ₁	12.380	1.020	92.24	ND	7.450
D ₄ T ₂	12.730	1.122	92.150	ND	8.410
D ₄ T ₃	13.760	1.110	92.230	ND	8.990
D ₄ T ₄	15.060	1.090	92.210	ND	9.720
'F' Test	Sig.	Sig.	NS	-	Sig.
SE (m)±	0.018	0.006	0.027	-	0.015
CD at 5%	0.051	0.019	-	-	0.045

ND = Not Detected, MBF = Must Before Fermentation, MAF = Must After Fermentation

With respect to the interaction effect, the maximum ethanol content (10.010%) was observed in treatment combination D₁T₄ (1:3 dilution ratio + TSS 26°Brix), whereas the minimum ethanol content (7.450%) was recorded in treatment combination D₄T₁ (1:6 dilution ratio + TSS 20°Brix). The results mentioned above make it clear that producing high quality wine requires an increase in ethanol level during the maturation stage. Auto-oxidation of ethyl alcohol may be the cause of the increase in ethanol content as maturation time progresses Aarti *et al.* (2024) ^[1]. These findings are consistent with those of Joshi *et al.* (2016) ^[7], who investigated the impact of various factors (pulp dilution and DAHP) on the alcohol concentration of muskmelon wine.

Conclusion

The findings indicate that the palash wine made with various dilution and TSS levels had a favorable impact on the number of days needed for fermentation, the rate of fermentation and the amount of ethanol produced. TSS levels and dilution levels interact during the fermentation of palash wine. A balance between the available sugar content and the dilution ratio led to the best fermentation performance. To guarantee a thorough and effective fermentation process, it is essential to determine the proper dilution to TSS ratio.

Therefore, in addition to the other fermentation methods, it is essential to keep the must dilution at a 1:3 ratio and the must TSS at 24 °Brix for producing the palash flower wine.

Future scope

Further research on this specific aspect of palash flower wine will greatly benefit from the study's findings. Additionally, it will help lessen the substantial bloom loss. The need for palash products, which is expected to grow in the future, has not been thoroughly studied in the area and there is a shortage of scientific data available. Converting the flowers into a variety of value-added products is essential and could be one way to decrease palash flower losses.

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