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Fermentation behaviour of rose petal must in relation to rate of fermentation, fermentation efficiency and Ethanol production

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Abstract
The experiment "Effect of levels of yeast and TSS on fermentation behaviour of rose petal must in relation to rate of fermentation, fermentation efficiency and ethanol production" was carried out at PHT Laboratory, Section of Horticulture, College of Agriculture, Dr. PDKV, Akola during the years 2020-21 and 2021-22. The experiment was laid out in FCRD with two factors, as factor 'A' constitutes levels of yeast (*Saccharomyces cerevisiae* var. ellipsoideus @ 15, 20 and 25 ml/l) and factor 'B' constitutes levels of TSS (24, 26, 28 and 30°Brix) with twelve treatment combinations and replicated thrice. Different levels of yeast and TSS exerted significant effects on the fermentation behaviour of rose petal must. Significantly maximum rate of fermentation (1.31°Brix/24 hrs.) was observed in treatment combination Y_3T_2 (*Saccharomyces cerevisiae* inoculum of 25 ml/l + 26 °Brix TSS). Whereas, significantly maximum fermentation efficiency (91.79%) and ethanol (9.48%) after fermentation of must were observed in treatment combination Y_1T_1 (*Saccharomyces cerevisiae* inoculum of 15 ml/l + 24 °Brix TSS). From the findings it can be concluded that, rose petal wine prepared with *Saccharomyces cerevisiae* inoculum @ 15 ml/l + 24 °Brix TSS showed better results as compared to other treatment combinations.

Keywords: Rose petal wine, yeast levels, TSS levels, fermentation behaviour

Introduction
Flower wines have emerged as a unique category of beverages, offering a distinct sensory experience with floral aromas and flavours. Unlike traditional grape wines, flower wines are produced by fermenting the extracts derived from various flowers, such as rose, calendula, mahua, elderflower, lavender and hibiscus. The wine-making science is called oenology. Wine is an alcoholic beverage made from juices/pulp by fermentative action of microbes either impulsively or seeding by a specific strain mostly belonging to yeast species. Yeast plays a crucial role in fermentation, converting sugars into alcohol and carbon dioxide. However, the presence of different yeast strains and varying yeast levels in flower extracts can significantly impact fermentation behaviour. Similarly, the TSS levels, representing the amount of soluble solids like sugars and organic compounds in the flower extracts can influence the fermentation process. Understanding the fermentation behaviour of flower wines is crucial for achieving consistency in production and ensuring the optimal sensory experience for consumers. By exploring the underlying mechanisms, these techniques are essential to improve the fermentation process, enhance aroma development and maintain desirable floral characteristics. With these points of view, an experiment has been undertaken to ascertain the fermentation behaviour of rose petal wine.

Material and Methods
The laboratory experiment was conducted during the year 2020-21 and 2021-22 at PHT laboratory, Horticulture Section, College of Agriculture, Dr. PDKV, Akola, Maharashtra. The experiment was laid out in a Factorial Completely Randomized Design (FCRD) with three replications and twelve treatment combinations. First factor comprising of three levels of *Saccharomyces cerevisiae* var. ellipsoideus inoculum of 15, 20 and 25 ml/l. And second factor comprising of four levels of total soluble solids 24, 26, 28 and 30°Brix. The experiment was conducted over two years and pooled data from twos years were expressed in this article.
Fully open *Rosa damascena* (Damask rose/Desi roses) were procured during November 2020-21 and 2021-22 from the local market of Nagpur. The fermentation behaviour of rose must have been analyzed before the fermentation process and after completion of the fermentation

process by different standard procedures. The ethanol content was analyzed by standard procedure reported by FSSAI (2015) [1]. Total soluble solids was determined with the help of a digital refractometer, rate of fermentation was calculated by taking readings of Initial TSS – Final TSS) / Time. While fermentation efficiency was calculated by (Actual Alcohol Produced / Theoretical Alcohol Produced X 100. Whereas, Theoretical alcohol = Sugar used X 0.64 and sugar used = Initial TSS – Final TSS. The entire process of preparation of rose petal wine is shown diagrammatically in Fig. 1.

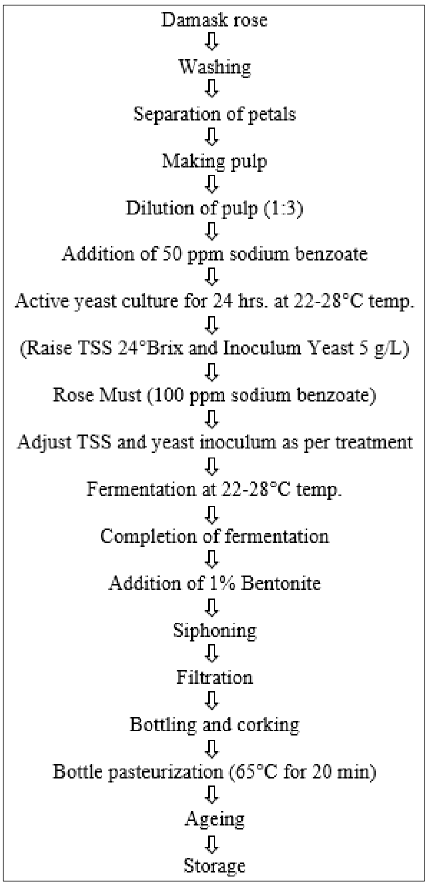

Fig 1: Procedure for preparation of rose petal wine

Results and Discussion

Rate of fermentation: The data with respect to effect of levels of yeast, significantly maximum rate of fermentation i.e. 1.27 °Brix /24 hrs. was observed in treatment Y_3 (25 ml/lit.). However, a minimum rate of fermentation (1.16 °Brix /24 hrs.) was observed in treatment Y_1 (15 ml/lit.). In terms of the effect of levels of TSS, significantly maximum rate of fermentation was observed in treatment T_4 (30 °Brix.) i.e. 1.25 °Brix /24 hrs. However, a minimum rate of fermentation i.e. 1.15 °Brix /24 hrs. was observed in treatment T_1 (24 °Brix). Significantly maximum rate of fermentation due to interaction effect of yeast and TSS was observed in treatment combination Y_3T_2 (1.31 °Brix/24hrs.). However, significantly minimum rate of fermentation was recorded with the treatment combination Y_1T_1 (1.07 °Brix/24hrs).

After completion of fermentation, the highest rate of fermentation in must observed in higher inoculum concentration (25 ml/l) having higher TSS (30°Brix) which was attributed due to the highest initial sugar content than that of other treatments which attributed to the higher ferment ability of must because of more availability of sugar. Similar findings were reported by Minh *et al.* (2019) [4] in gooseberry wine fermentation. Similarly, Sevda and Rodrigues (2011) [6] in guava wine observed higher the inoculum size higher will be the fermentation rate.

Fermentation efficiency

Significantly maximum fermentation efficiency (79.07%) due to levels of yeast was recorded in treatment Y_1 (15 ml/l.). However, a minimum fermentation efficiency (78.59%) was recorded in treatment Y_3 (25 ml/l). In terms of the effect of levels of TSS, significantly maximum fermentation efficiency (91.62%) was recorded in treatment T_1 (24 °Brix). However, it was minimum (67.63%) in treatment T_4 (30 °Brix). Due to interaction effect of yeast and TSS levels significantly maximum fermentation efficiency was observed in treatment combination Y_1T_1 (91.79%). However, minimum fermentation efficiency was recorded in treatment combination Y_3T_4 (67.00%).

The results showed that, when the concentration of yeast was increased, yeast cells converted more sugar to alcohol. However, at the higher inoculum concentration yeast cells did not grow well because of the limited nutrient and were not able to convert more sugar into it. The results obtained was agreed with the report of Satav and Pethe (2017) [5] who studied wine production from banana, Kumar *et al.* (2011) [3] in custard apple wine.

Ethanol

Ethanol content was not observed in any treatment combination in must before fermentation. While must after fermentation, maximum ethanol content (9.16%) was observed in treatment Y_1 (15 ml/l) which was significantly superior than rest of all treatments. However significantly minimum ethanol content (9.00%) was observed in treatment Y_3 (25 ml/l). In terms of the effect of levels of TSS, maximum ethanol content (9.38%) was observed in treatment T_1 (24º Brix) which was significantly superior than rest of all the treatments. However, minimum ethanol content (8.80%) was observed in treatment T_4 (30º Brix). Due to interaction effect of yeast and TSS levels maximum ethanol content (9.48%) was recorded in treatment combination Y_1T_1 (15 ml/l inoculum and TSS 24 °Brix) which was significantly superior than rest of all treatments. However, significantly minimum ethanol content (8.69%) was recorded with the treatment combination Y_3T_4. The interaction effect of yeast and TSS levels, the maximum ethanol content (9.48%) was observed in treatment combination Y_1T_1 which was significantly superior than rest of all treatment combinations. However, significantly minimum ethanol content (8.69%) was recorded with the treatment combination Y_3T_4.

From the above result, it is apparent that ethanol content in lower levels of inoculum and TSS was highest and thereafter it is less in higher levels from this it can be concluded that rose petal must inoculated with 15 ml/l and maintaining the TSS at 24 °Brix converted more sugars to alcohol, while at higher concentration yeast was not able to utilize more sugar for conversion. Thus it could be said that the optimum levels of inoculum for *Saccharomyces cerevisiae* 15 ml/l and TSS 24 °Brix for rose petal wine production. The present findings conformed with research work carried out by Sevada and Rodrigues (2011) [6]. Similarly, Yadav *et al.* (2009) [7] in mahua wine fermentation and Hunbin *et al.* (2017) [2] in white rose wine fermentation.

Table 1: Effect of levels of yeast and TSS on rate of fermentation, fermentation efficiency and ethanol of rose petal must.

	ROF (ºBrix/24 hrs.)	FE (%)	Ethanol (%)	
Factors	**Yeast Levels**			
Factor A			**MBF**	**MAF**
Y_1 (15 ml/l)	1.16	79.07	ND	9.16
Y_2 (20 ml/l)	1.21	79.05	ND	9.08
Y_3 (25 ml/l)	1.27	78.59	ND	9.00
F Test	Sig.	Sig.	-	Sig.
SE(m)±	0.012	0.080	-	0.004
CD at 5%	0.036	0.234	-	0.013
Factor B	**TSS Levels**			
T_1 (24ºB)	1.15	91.62	ND	9.38
T_2 (26ºB)	1.22	82.35	ND	9.22
T_3 (28ºB)	1.23	73.99	ND	8.91
T_4 (30ºB)	1.25	67.63	ND	8.80
F Test	Sig.	Sig.	-	Sig.
SE(m)±	0.014	0.093	-	0.005
CD at 5%	0.041	0.270	-	0.015

Table 2: Interaction Effect of yeast and TSS levels on rate of fermentation, fermentation efficiency and ethanol of rose petal must.

Interactions (YXT)	ROF (ºBrix/24 hrs.)	FE (%)	Ethanol (%)	
			MBF	**MAF**
Y_1T_1	1.07	91.79	ND	9.48
Y_1T_2	1.15	82.98	ND	9.35
Y_1T_3	1.17	73.56	ND	8.93
Y_1T_4	1.25	67.95	ND	8.89
Y_2T_1	1.16	91.64	ND	9.35
Y_2T_2	1.21	82.53	ND	9.22
Y_2T_3	1.22	74.06	ND	8.92
Y_2T_4	1.25	67.96	ND	1.25
Y_3T_1	1.22	91.45	ND	9.33
Y_3T_2	1.31	81.55	ND	9.10
Y_3T_3	1.29	74.36	ND	8.87
Y_3T_4	1.24	67.00	ND	8.69
F Test	Sig.	Sig.	-	Sig.
SE(m)±	0.024	0.160	-	0.009
CD at 5%	0.071	0.468	-	0.025

ROF= Rate of fermentation, FE= Fermentation efficiency and ND= Not detected

Conclusion

From the results, it is concluded that the rose petal wine prepared with different levels of yeast inoculum and different levels of TSS had a positive effect on the rate of fermentation, fermentation efficiency and alcohol production of the rose petal wine. There is an interplay between yeast levels and TSS levels in rose petal wine fermentation. Optimal fermentation performance is achieved when there is a balance between yeast population and available sugar content. Finding the right yeast-to-TSS ratio is crucial to ensure a complete and efficient fermentation process. Thus, along with other fermentation techniques, it's crucial to maintain TSS of must at 24° Brix and inoculate yeast at a concentration of 25 ml/l while making rose petal wine.

Future scope

The findings of this study will be extremely valuable in doing further research on this particular feature of rose petal wine. It will also assist in reducing major rose flower losses that occur during the handling chain. There has been very little research done in the region, and there is little scientific information accessible on the demand for rose products, which is likely to expand in the future.

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