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EFFECT OF SUGAR SOURCES AND BLENDING PROPORTIONS ON FERMENTATION BEHAVIOUR AND ETHANOL PRODUCTION OF BEETROOT BLENDED WATERMELON WINE

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ABSTRACT

An investigation on "Effect of sugar sources and blending proportions on fermentation behaviour and ethanol production of beetroot blended watermelon wine" was carried out at Post Harvest Technology Laboratory, Section of Horticulture, College of Agriculture, Dr. PDKV, Akola during the years 2022-23 and 2023-24. The experiment was laid out in Factorial Completely Randomized Design with three different sugar sources (Cane sugar, Honey, Jaggery) and four different blending proportions [70:30, 80:20, 90:10 and 100:00 (Watermelon pulp: Beetroot juice)] with twelve treatment combinations and replicated thrice. Different sugar sources and blending proportions significantly influenced the fermentation behaviour of the must. Significantly maximum rate of fermentation (1.23°Brix/24 hrs.), fermentation efficiency (99.57%), ethanol content (9.64%) and minimum TSS (8.69 °Brix) after fermentation of must were recorded in treatment combination S_2B_2 [Honey+80:20 (Watermelon pulp: Beetroot juice)]. From the results it can be concluded that, beetroot blended watermelon wine prepared with Honey+80:20 (Watermelon pulp: Beetroot juice) exhibited superior fermentation performance as compared to other treatment combinations.
Keywords **:** Beetroot blended watermelon wine, sugar sources, blending proportions, fermentation behaviour.

Introduction

Wine is an alcoholic beverage produced from the fermentation of different fruits, vegetables and flowers by using yeast. Several vegetables such as beetroot, watermelon, carrot, pumpkin and tomato have gained attention for wine production due to their natural sugars, bioactive compounds and distinctive sensory attributes. Blending is an important technological approach in wine making used to improve colour, aroma, astringency, body and overall taste of the final product. Low grade product would be upgraded to product of superior quality by blending of two or more different types of food entities having desired attributes. The goal of blending wine is to add more complexity to the flavor and texture of a wine. Sugars play a vital role in wine fermentation as they serve as the main substrate for yeast metabolism, being converted into alcohol and carbon dioxide and also contribute to the perceived sweetness of the wine. The type of sugar source and blending proportion significantly influence fermentation behaviour, ethanol production and sensory quality of wines. Understanding the effects of sugar sources and blending proportions on the fermentation behaviour of vegetable wine must is essential for achieving consistent quality. In view of this, the present study was undertaken to evaluate the fermentation behaviour of beetroot blended watermelon wine.

Material and Methods

An investigation was conducted during the year 2022-23 and 2023-24 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 consisted of three sugar sources i.e. Cane sugar, Honey and Jaggery. And second factor consisted of four blending proportions 70:30, 80:20, 90:10 and 100:00 (Watermelon pulp: Beetroot juice) and TSS of must was maintained 24°Brix. The experiment was conducted over two consecutive years and pooled data from two years were expressed in this article. Fully matured watermelon fruits and beetroot were procured from the local market of Akola, (Maharashtra) during the month of February 2023 and 2024. The fermentation behaviour of the must was evaluated using standard analytical procedures both before fermentation and after completion of the fermentation process. The ethanol content was analyzed by standard procedure reported by FSSAI (2015). Total soluble solids were 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 beetroot blended watermelon wine is shown diagrammatically in Fig. 1.

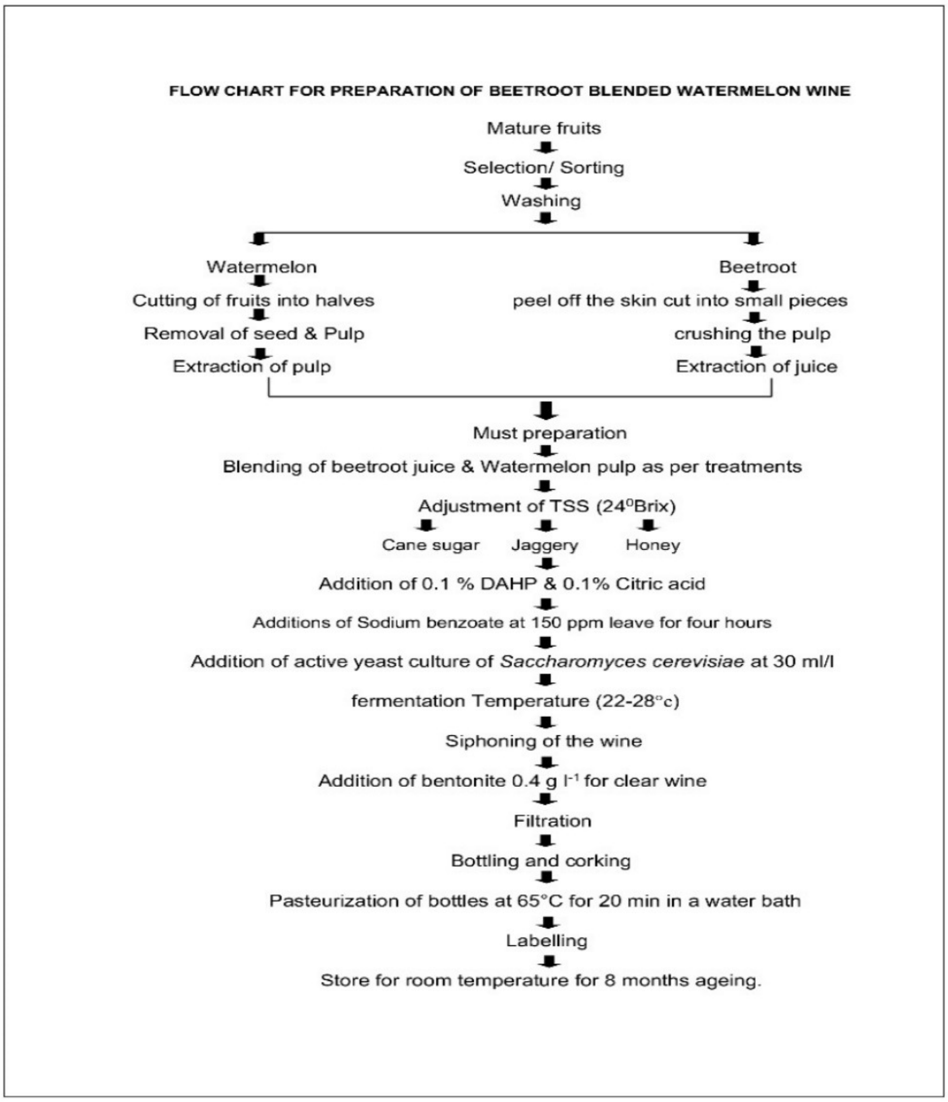

Fig. 1: Procedure for preparation of beetroot blended watermelon wine

Results and Discussion

Rate of fermentation

The data revealed that different sugar sources exerted a significant influence on the rate of fermentation. Significantly maximum rate of fermentation (1.13 °Brix /24 hrs) was recorded in treatment S2 (Honey). While, minimum rate of fermentation (0.97 °Brix/24 hrs.) was recoded in treatment S3 (Jaggery). With respect to blending proportions, significantly maximum rate of fermentation was recorded in treatment B2- 80:20 (Watermelon pulp: Beetroot juice) i.e. 1.14 °Brix /24 hrs. Whereas, minimum rate of fermentation (1.00 °Brix /24 hrs.) was noted in treatment B4-100:00 (Watermelon pulp: Beetroot juice). The interaction effect of sugar sources and blending proportions was also significant, significantly maximum rate of fermentation (1.23 °Brix/24hrs) was observed in treatment combination S2B2. While, significantly minimum rate of fermentation (0.93 °Brix/24hrs) was recorded with the treatment combination S3B4.

After completion of fermentation, the highest rate of fermentation in must observed in treatment combination S2B2 [Honey + 80:20 (Watermelon pulp: Beetroot juice)] which was attributed due to availability of more sugar content than that of other treatments which attributed to the higher fermentability of must. Similar findings were reported by Gorivale *et al.* (2024) in mahua blended rose wine, Minh *et al.* (2019) in gooseberry wine fermentation. Similarly, Sevda and Rodrigues (2011) in guava wine observed that higher the sugar content higher will be the fermentation rate.

Fermentation efficiency

Significantly maximum fermentation efficiency (98.31%) due to different sugar sources was recorded in treatment S2 (Honey). However, a minimum fermentation efficiency (95.87%) was recorded in treatment S3 (Jaggery). In terms of the effect of blending proportions, significantly maximum fermentation efficiency (98.48%) was recorded in treatment B2-80:20 (Watermelon pulp: Beetroot juice). However, it was minimum (96.64%) in treatment B4-100:00 (Watermelon pulp: Beetroot juice). Due to interaction effect of different sugar sources and blending proportions, significantly maximum fermentation efficiency was observed in treatment combination S2B2 (99.57%). However, minimum fermentation efficiency was recorded in treatment combination S3B4 (95.07%).

The results showed that, more availability of sugar increases the ethanol production because sugar molecules are readily available for the yeast to use it for fermentation to convert it into alcohol. The results obtained are in agreement with the report of Gorivale *et al.* (2024) in mahua blended rose wine, Satav and Pethe (2017) who studied wine production from banana, Kumar *et al.* (2011) in custard apple wine.

Total soluble solids

TSS of must was maintained 24°Brix using different sugar sources as per treatment before fermentation. While, significantly minimum TSS (8.76 °Brix) in must after fermentation was recorded in treatment S2 (Honey) which was significantly superior than rest of all treatments. Whereas, significantly maximum TSS (8.92 °Brix) was observed in treatment S3 (Jaggery). Regarding the influence of blending proportions, significantly minimum TSS (8.76°Brix) was recorded in treatment B2- 80:20 (Watermelon pulp: Beetroot juice) which was significantly superior than rest of all treatments. While, it was maximum (8.88 °Brix) recorded in treatment B4-100:00 (Watermelon pulp: Beetroot juice). Due to interaction effect of different sugar sources and blending proportions, significantly minimum TSS (8.69 °Brix) was recorded in treatment combination S2B2 [Honey + 80:20 (Watermelon pulp: Beetroot juice)] which was significantly superior than rest of all treatment combinations. While, significantly maximum TSS was recorded in treatment combination S3B4 [Jaggery+100:00 (Watermelon pulp: Beetroot juice)] i.e.8.96 °Brix.

From the above result it is apparent that, decrease in total soluble solids of must after fermentation differed significantly due to different sugar sources and blending proportions. Must with honey had faster reduction in TSS than that of other sugar sources used to ameliorate the must. It is attributed to easy availability of fermentable sugar to the yeast in must. These findings are in close agreement with the findings of Biri *et al.* (2015) in watermelon must, Lenkannavar *et al.* (2015) in pomegranate must, Kakade (2019) in bael must, Kadage (2021) in blended mandarin must and Gorivale (2025) in mahua blended rose must.

Ethanol

Ethanol content was not detected in any treatment combination in must before fermentation. While, in must after fermentation, maximum ethanol content

(9.50 %) due to different sugar sources was found in treatment S2 (Honey) which was significantly superior than rest of all treatments. However, significantly minimum ethanol content (9.12%) was found in treatment S3 (Jaggery). With respect to blending proportions, maximum ethanol content (9.48%) was recorded in treatment B2-80:20 (Watermelon pulp: Beetroot juice) which was significantly superior to all other treatments. However, minimum ethanol content (9.21%) was recorded in treatment B4-100:00 (Watermelon pulp : Beetroot juice). Due to interaction effect of different sugar sources and blending proportions maximum ethanol content (9.64%) was recorded in treatment combination S2B2 [Honey+80 :20 (Watermelon pulp : Beetroot juice)] which was significantly superior than rest of all treatment combinations. However, significantly minimum ethanol content (9.04%) was recorded with the treatment combination S3B4 [Jaggery+100:00 (Watermelon pulp: Beetroot juice)].

From the results of the present study, it can be concluded that the must prepared with an 80:20 ratio of watermelon pulp to beetroot juice, adjusted to 24 °Brix and fermented using honey as the sugar source, exhibited higher conversion of sugars into alcohol. This enhanced alcohol production may be attributed to the presence of a high proportion of readily fermentable sugars in honey, which provides an efficient substrate for yeast activity during fermentation. The findings of the present investigation are in conformity with those reported by Sevada and Rodrigues (2011) and are further supported by the studies of Pratima *et al.* (2006) in kinnow must, Lenkannavar *et al.* (2015) in pomegranate must and Kadage (2021) in blended mandarin must and Gorivale *et al.* (2024) in mahua blended rose must.

Table 1: Effect of different sugar sources and blending proportions on rate of fermentation, fermentation efficiency, TSS and ethanol content of must.

Factors	ROF (°Brix/24 hrs.)	FE (%)	TSS °Brix		Ethanol (%)	
Factor A	**Sugar sources**					
			MBF	**MAF**	**MBF**	**MAF**
S_1 (Cane sugar)	1.10	98.31	24	8.80	ND	9.44
S_2 (Honey)	1.13	98.71	24	8.76	ND	9.50
S_3 (Jaggery)	0.97	95.87	24	8.92	ND	9.12
F Test	Sig	Sig	-	Sig	-	Sig
SE(m)±	0.004	0.031	-	0.003	-	0.005
CD at 5%	0.011	0.091	-	0.008	-	0.015
Factor B	**Blending proportions**					
B_1 (70:30)	1.04	97.40	24	8.85	ND	9.31
B_2 (80:20)	1.14	98.48	24	8.76	ND	9.48
B_3 (90:10)	1.09	98.00	24	8.81	ND	9.40
B_4 (100:00)	1.00	96.64	24	8.88	ND	9.21
F Test	Sig	Sig	-	Sig	-	Sig
SE(m)±	0.004	0.036	-	0.003	-	0.006
CD at 5%	0.013	0.105	-	0.010	-	0.018

ROF- Rate of fermentation, FE - Fermentation efficiency, MBF - Must before fermentation
MAF - Must after fermentation

Table 2: Interaction effect of different sugar sources and blending proportions on rate of fermentation, fermentation efficiency, TSS and ethanol content of must.

Interactions (SXB)	ROF (°Brix/24 hrs.)	FE (%)	TSS °Brix		Ethanol (%)	
			MBF	**MAF**	**MBF**	**MAF**
S1B1	1.06	98.03	24	8.82	ND	9.40
S1B2	1.19	99.23	24	8.73	ND	9.60
S1B3	1.13	98.85	24	8.78	ND	9.50
S1B4	1.03	97.14	24	8.86	ND	9.26
S2B1	1.09	98.51	24	8.80	ND	9.46
S2B2	1.23	99.57	24	8.69	ND	9.64
S2B3	1.15	99.06	24	8.74	ND	9.55

S2B4	1.04	97.70	24	8.83	ND	9.33
S3B1	0.95	95.67	24	8.93	ND	9.09
S3B2	1.01	96.62	24	8.88	ND	9.20
S3B3	0.98	96.09	24	8.91	ND	9.15
S3B4	0.93	95.08	24	8.96	ND	9.04
F Test	Sig	Sig	-	Sig	-	Sig
SE(m)±	0.008	0.062	-	0.006	-	0.011
CD at 5%	0.022	0.182	-	0.017	-	0.031

ROF - Rate of fermentation, FE - Fermentation efficiency, ND= Not detected
MBF - Must before fermentation and MAF - Must after fermentation

Conclusion

The results of the present study indicate that the use of different sugar sources and blending proportions significantly influenced the fermentation behaviour of beetroot blended watermelon wine, particularly with respect to fermentation rate, fermentation efficiency, total soluble solids (TSS) and ethanol production. Among the treatments evaluated, maintaining the must at 24°Brix using honey as the sugar source in combination with an 80:20 ratio of watermelon pulp to beetroot juice proved most effective in enhancing fermentation performance and ethanol production. Therefore, optimization of sugar source and blending proportion is critical for the production of beetroot blended watermelon wine with improved fermentation efficiency and quality.

Future Scope

The findings of this study will be extremely valuable to assist in reducing post-harvest losses of vegetables that occur during the handling chain. There is a need to emphasize the health benefits of watermelon and beetroot. Setting up a small-scale wine-making sector in rural locations will provide jobs and enhance the indigenous population's living conditions.

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