Plant Archives Vol. 26, Supplement 1, 2026 pp. 2757-2762 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.369

FERMENTATION BEHAVIOUR OF MAHUA BLENDED CALENDULA WINE MUST IN RELATION TO RATE OF FERMENTATION, FERMENTATION EFFICIENCY AND ETHANOL PRODUCTION

Aishwarya R. Ingole[1*], Dalal S.R.[2], Gupta N.S.[1], Warade A.D.[3], Mane S.S.[4] and Mohammad Sajid[5]
[1]Department of Floriculture and Landscape Architecture, Dr. P.D.K.V., Akola, Maharashtra, India
[2]College of Agriculture, Dr. PDKV, Akola, Maharashtra, India
[3]Department of Horticulture, College of Agriculture, Dr. PDKV, Akola, Maharashtra, India
[4]Director of Research, Dr. PDKV, Akola, Maharashtra, India
[5]Department of Soil Science, College of Agriculture, Dr. P. D. K. V., Akola, Maharashtra, India
*Corresponding author E-mail: aishingole96@gmail.com
(Date of Receiving : 19-11-2025; Date of Acceptance : 20-01-2026)

ABSTRACT

The experiment on "Effect of levels of yeast and blending proportions in relation to rate of fermentation, fermentation efficiency and ethanol production" was carried out at PHT Laboratory, Horticulture Section, College of Agriculture, Dr. PDKV, Akola during the years 2022-23 and 2023-24. The experiment was laid out in FCRD with two factors, as factor 'A' constitutes levels of yeast (*Saccharomyces cerevisiae* var. ellipsoideus @ 20, 25, 30 ml/l) and factor B is blending proportions [(100: 00, 90:10, 80:20, 70:30, 60:40, (Calendula pulp: mahua pulp)]. with fifteen treatment combinations and replicated thrice. Yeast levels and blending proportions have significant effects on the fermentation behaviour of wine must. Significantly maximum rate of fermentation (1.34°Brix/24 hrs.), fermentation efficiency (92.30%) and ethanol (10.38%) content after fermentation of wine must were observed in treatment combination Y_3B_3 [Yeast (30 ml/l) +70:30 (Calendula pulp: Mahua pulp)]. From the findings it can be concluded that, mahua blended calendula wine prepared with by using *Saccharomyces cerevisiae* 30 ml/l and 70:30 proportion of Calendula and Mahua pulp, respectively showed better results as compared to other treatment combinations.

Keywords **:** Mahua blended calendula wine, yeast levels, blending proportions, fermentation behavior.

Introduction

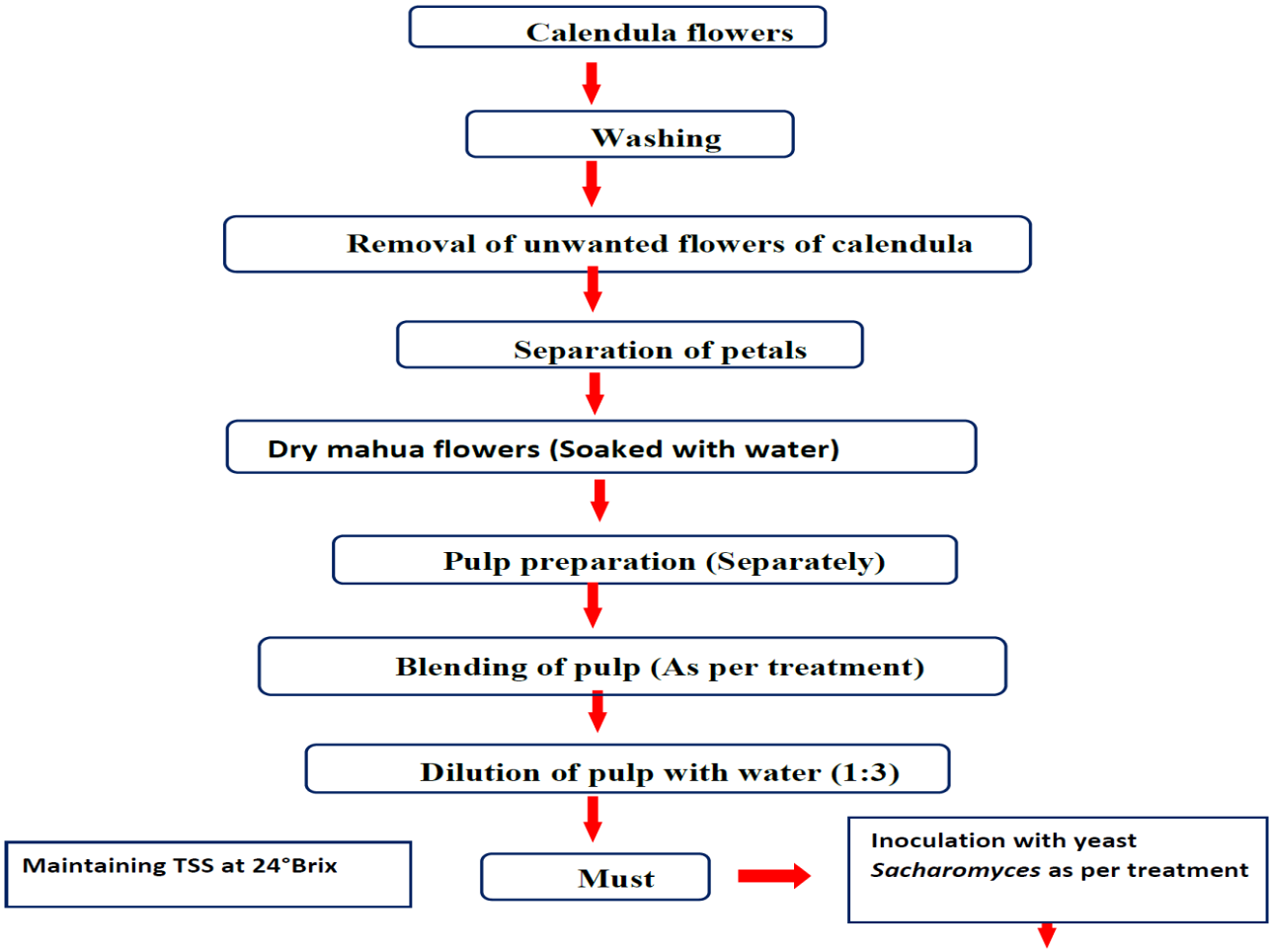
Wine has been an important part of human culture and history in many societies for a long time. It has traditionally been associated with religious rituals, celebrations, festivals and social gatherings. Over the centuries, wine production and consumption have influenced the traditions and lifestyles of people around the world. Traditionally, wine has been produced from grapes and other fruits; however, increasing interest in value addition and utilization of underexploited floral resources has encouraged the development of flower wines. Flowers such as calendula, rose, hibiscus and mahua are rich in bioactive compounds including phenolics, flavonoids, carotenoids, vitamins and essential oils, which contribute to their medicinal and antioxidant properties. 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. The goal of blending wine is to add more complexity to the flavor and texture of a wine. Sugars are the main source of perceived sweetness in wine also used as food for the yeast and turned into carbon dioxide and alcohol. Understanding the fermentation behaviour of flower wines is essential for achieving consistent product quality and desirable sensory attributes. Studying the underlying fermentation mechanisms helps in improving fermentation efficiency, enhancing aroma

development and preserving the characteristic floral qualities of the wine. In view of these considerations, the present experiment was undertaken to investigate the fermentation behaviour of rose petal wine.

Material and Methods

The laboratory experiment 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 FCRD with two factors, as factor 'A' constitutes levels of yeast (*Saccharomyces cerevisiae* var. ellipsoideus @ 20, 25, 30 ml/l) and factor B is blending proportions [(100: 00, 90:10, 80:20, 70:30, 60:40, (Calendula pulp: mahua pulp)]. with fifteen treatment combinations and replicated thrice and TSS was maintained 24°Brix in wine must. The experiment was conducted over two years and pooled data from two years were expressed in this article. Fully opened calendula (*Calendula offcinalis*) flowers were harvested from Floriculture Unit, Department of Floriculture and Landscape Architecture, Dr. PDKV, Akola. Fully ripened and well dried mahua flowers were procured from local market of Akola. The fermentation behaviour of wine 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). 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 mahua blended calendula wine is shown diagrammatically in Fig. 1.

FLOW SHEET OF PREPARATION OF MAHUA BLENDED CALENDULA WINE



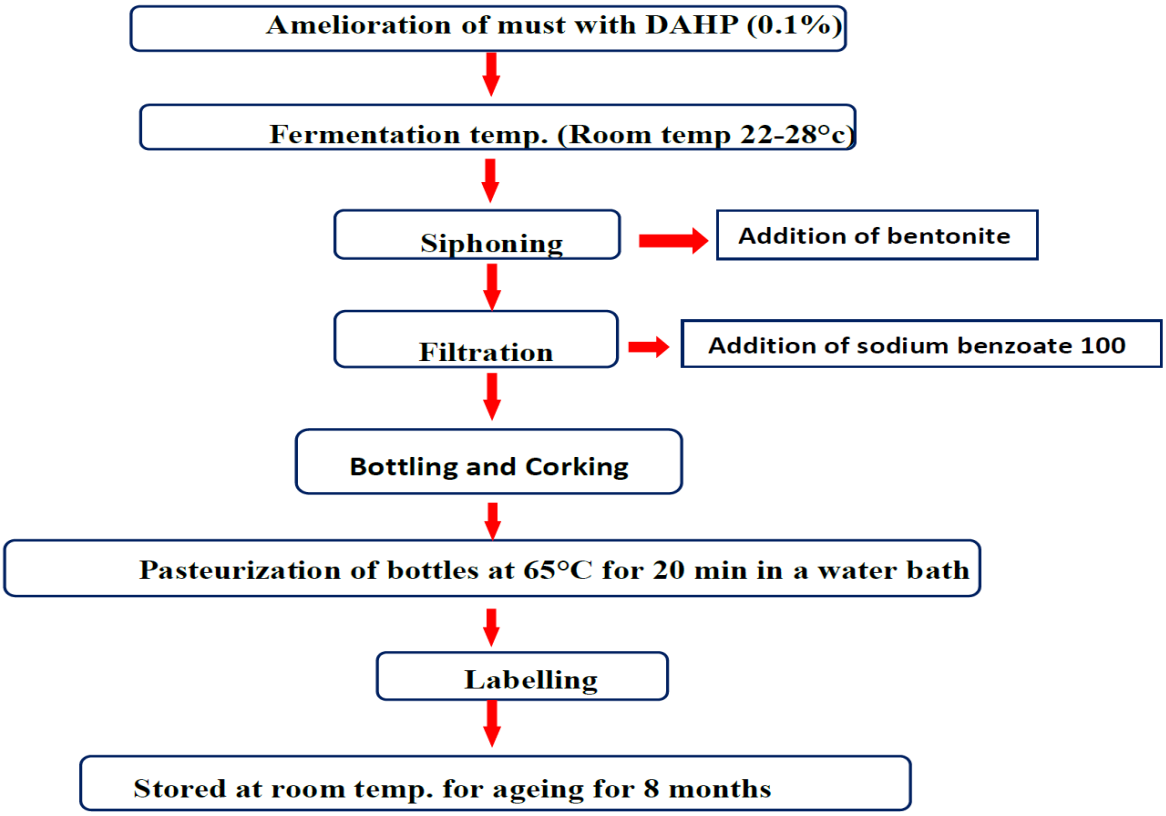


Fig. 1 : Process of preparation of mahua blended calendula wine

Results and Discussion

Effect of levels of yeast

The data with respect to the levels of yeast is presented in Table 1. it is revealed that, maximum rate of fermentation (1.19 °Brix /24 hrs.), fermentation efficiency (92.74%) and ethanol content after fermentation (10.23%) were observed in treatment Y_3 [Yeast (30 ml/l)]. There was no evidence of ethanol content in any treatment before fermentation.

However, a minimum rate of fermentation (1.08 °Brix /24 hrs.), fermentation efficiency (91.31%) and ethanol content (10.13 %) were observed in treatment Y_1 [Yeast (20 ml/l)]. The results showed that, increasing yeast inoculum level significantly enhances fermentation rate, fermentation efficiency and ethanol content in wine. Higher yeast inoculum increases the number of metabolically active cell at the onset of fermentation, which directly accelerates sugar uptake and ensure faster and more complete fermentation. The results obtained was agreed with the report of Satav and Pethe (2017) in banana wine, Kumar *et al.* (2011) in custard apple wine. Similar findings were reported by Minh *et al.* (2019), in gooseberry wine fermentation, Boadre (2025) in hibiscus wine and Bhagwat (2023) in rose wine.

Table 1 : Effect levels of yeast on Rate of Fermentation, Fermentation efficiency and Ethanol content of calendula wine must

Factors	Rate of fermentation (°Brix/24 hrs.)			Fermentation efficiency (%)			Ethanol (%) Must After Fermentation		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Factor A	**Yeast levels (*Saccharomyces cerevisiae*)**								
Y_1 (20 ml/l)	1.09	1.07	1.08	91.29	91.32	91.31	10.14	10.12	10.13
Y_2 (25 ml/l)	1.17	1.14	1.16	91.67	91.60	91.63	10.22	10.19	10.21
Y_3 (30 ml/l)	1.21	1.17	1.19	91.76	91.73	91.74	10.24	10.22	10.23
F Test	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**
SE(m)±	**0.006**	**0.007**	**0.005**	**0.008**	**0.009**	**0.006**	**0.007**	**0.007**	**0.005**
CD at 5%	**0.017**	**0.019**	**0.015**	**0.024**	**0.025**	**0.017**	**0.019**	**0.020**	**0.013**

Effect of blending proportions

The data with respect to the blending proportions is presented in Table 2. it is revealed that, maximum rate of fermentation (1.25 °Brix /24 hrs.), fermentation efficiency (92.04%) and ethanol content after fermentation (10.31%) were observed in treatment B_3 [70:30 (Calendula pulp: Mahua pulp)].There was no evidence of ethanol content in any treatment before fermentation.

However, a minimum rate of fermentation (1.03 °Brix /24 hrs.), fermentation efficiency (90.98%) and ethanol content (10.04 %) were observed in treatment B_0 [100:00 (Calendula pulp: Mahua pulp)]. The superior rate of fermentation, fermentation efficiency and ethanol content observed in wine must having 70:30 (Calendula pulp: Mahua pulp) blending proportion can be attributed to the optimized balance between sugar and nutrient availability. The present findings conformed with research work carried out by Sevada and Rodrigues (2011) in guava. Similarly, Hunbin *et al*. (2017) in white rose wine, Tiwari *et al*. (2017) in hibiscus wine, Gujar *et al*. (2023) in hibiscus wine, Kadage (2021) in blended mandarin must, Bodare (2025) in hibiscus wine and Gorivale (2025) in mahua blended rose wine.

Table 2 : Effect blending proportions on Rate of fermentation, Fermentation efficiency and Ethanol content of calendula wine must

Factors	Rate of fermentation (°Brix/24 hrs.)			Fermentation efficiency (%)			Ethanol (%) Must After Fermentation		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Factor B	**Blending proportion (Calendula pulp: Mahua pulp)**								
B_0 (100:00)	1.03	1.02	1.03	90.92	91.05	90.98	10.03	10.04	10.03
B_1 (90:10)	1.09	1.07	1.08	91.31	91.18	91.24	10.10	10.11	10.10
B_2 (80:20)	1.21	1.18	1.19	91.86	91.82	91.84	10.25	10.26	10.25
B_3 (70:30)	1.27	1.24	1.25	92.05	92.07	92.06	10.30	10.31	10.30
B_4 (60:40)	1.16	1.14	1.15	91.74	91.62	91.68	10.21	10.22	10.21
F Test	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**
SE(m)±	**0.007**	**0.009**	**0.007**	**0.011**	**0.011**	**0.007**	**0.009**	**0.006**	**0.009**
CD at 5%	**0.022**	**0.025**	**0.019**	**0.031**	**0.033**	**0.021**	**0.026**	**0.017**	**0.026**

Interaction effect

The data in respect of interaction effect of levels of yeast and blending proportions on rate of fermentation, fermentation efficiency and ethanol content of wine must is presented in Table 3. Significantly maximum rate of fermentation (1.34 °Brix/24hrs.), fermentation efficiency (93.30%) and ethanol content (10.38%) were observed in treatment combination Y_3B_3 [Yeast (30 ml/l) +70:30 (Calendula pulp: Mahua pulp)].

However, significantly minimum rate of fermentation (1.02 °Brix/24hrs.), fermentation efficiency (90.79%) and ethanol content (10.01 %%) were recorded with the treatment combination Y_1B_0 [Yeast (20 ml/l) +100:00 (Calendula pulp: Mahua pulp)]. From the above result it can be concluded that, must having 70:30 (Calendula pulp : Mahua pulp) inoculated with Yeast at 30 ml/l by maintaining the TSS at 24 °Brix by using a sugar source converted more sugars to alcohol. Because, high sugar content present in must was as a good substrate for yeast fermentation to produce alcohol. The present findings conformed with research work carried out by Sevada and Rodrigues (2011) in guava. Similarly, Hunbin *et al*. (2017) in white rose wine, Tiwari *et al*. (2017) in hibiscus wine, Gujar *et al*. (2023) in hibiscus wine, Bhagwat (2024) in rose petal wine production, Bodare (2025) in hibiscus wine and Gorivale (2025) in mahua blended rose wine.

Table 3 : Effect levels of yeast and blending proportions on Rate of fermentation, Fermentation efficiency and Ethanol content of calendula wine must

Interactions (YXB)	Interaction								
	Rate of Fermentation (°Brix/24 hrs.)			Fermentation efficiency (%)			Ethanol (%) Must After Fermentation		
	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Y_1B_0	1.02	1.02	1.02	90.76	90.82	90.79	10.02	10.00	10.01
Y_1B_1	1.07	1.04	1.06	91.23	91.13	91.18	10.10	10.08	10.09
Y_1B_2	1.11	1.10	1.10	91.47	91.54	91.51	10.19	10.18	10.19
Y_1B_3	1.15	1.11	1.13	91.65	91.73	92.69	10.22	10.21	10.22

Y_1B_4	1.10	1.09	1.10	91.36	91.35	91.36	10.16	10.15	10.15
Y_2B_0	1.03	1.02	1.03	90.95	91.01	90.98	10.05	10.03	10.04
Y_2B_1	1.09	1.06	1.07	91.34	91.15	91.25	10.13	10.10	10.11
Y_2B_2	1.23	1.21	1.22	91.96	91.94	92.95	10.30	10.28	10.29
Y_2B_3	1.31	1.28	1.30	92.25	92.14	92.19	10.36	10.33	10.35
Y_2B_4	1.18	1.14	1.16	91.84	91.74	91.79	10.25	10.23	10.24
Y_3B_0	1.05	1.03	1.04	91.05	91.32	91.18	10.08	10.05	10.07
Y_3B_1	1.13	1.11	1.12	91.35	91.25	91.30	10.15	10.12	10.14
Y_3B_2	1.29	1.23	1.26	92.14	91.96	92.05	10.33	10.30	10.32
Y_3B_3	1.35	1.32	1.34	92.26	92.34	92.30	10.38	10.37	10.38
Y_3B_4	1.21	1.18	1.20	92.02	91.76	92.89	10.27	10.25	10.26
F Test	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**	**Sig**
SE(m)±	**0.013**	**0.015**	**0.011**	**0.019**	**0.020**	**0.013**	**0.015**	**0.015**	**0.010**
CD at 5%	**0.037**	**0.043**	**0.033**	**0.054**	**0.057**	**0.037**	**0.042**	**0.045**	**0.030**

Conclusion

From the results, it is concluded that the mahua blended calendula wine prepared with different levels of yeast and blending proportions had a positive effect on the rate of fermentation, fermentation efficiency and ethanol production of the mahua blended calendula wine. There is an interplay between yeast levels and blending proportions in mahua blended calendula wine fermentation. Optimal fermentation performance is achieved when there is a balance between yeast population and available sugar content. Finding the suitable yeast levels and blending ratio is crucial to ensure a complete and efficient fermentation process. Thus, along with other fermentation techniques, it's crucial to inoculate yeast at a concentration of 30 ml/l and selecting a blending proportion of 70:30 (Calendula pulp : Mahua pulp) while making mahua blended calendula wine.

Future Scope

The findings of the present study are expected to be highly valuable in minimizing post-harvest losses of flowers occurring at various stages of the handling and processing chain. Greater emphasis on the nutritional and health benefits of calendula and mahua flowers may enhance their utilization in value-added products such as flower-based wines. The establishment of small-scale wine-making units in rural areas can generate employment opportunities and improve the socio-economic status of the indigenous population. Furthermore, effective utilization of the underexploited mahua flower can contribute significantly to improving nutrition, livelihood security, and economic stability of tribal farmers.

Acknowledgement

I extend my sincere thanks to my research guide Dr. S. R. Dalal and to my advisory committee members for giving me proper guidance throughout the course of study.

References

Bhagwat, S. R., Dalal, S. R., Gupta, N. S., Nagre, P. K., Mane, S. S., & Lahariya, G. S. (2023). Fermentation behaviour of rose petal must in relation to rate of fermentation, fermentation efficiency and ethanol production. *The Pharma Innovation Journal*, **12**(5), 4478–4480.

Bodare, R. B. (2025). *Studies on preparation of hibiscus wine* (Unpublished M.Sc. (Horticulture) thesis). Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

Gorivale, A. A. (2025). *Preparation of mahua blended rose wine* (Unpublished Ph.D. (Horticulture) thesis). Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

Gujar, S., Todkar, A., & Mergal, S. (2023). Preparation of wine from dried shoe flower (*Hibiscus rosa-sinensis*) and damask rose (*Rosa damascena*) petals. *Journal of Emerging Technologies Research*, **10**(2), 173–180.

Food Safety and Standards Authority of India (FSSAI). (2015). *Manual of methods of analysis of foods: Alcoholic beverages* (Lab Manual No. 13, pp. 3–4). Ministry of Health and Family Welfare, Government of India, New Delhi.

Hunbin, S., Jieun, H., Kyun, H. L., Yun, B. K., & Han, N. S. (2017). Enhancing the antioxidant activities of wines by addition of white rose extract. *Journal of Microbiology and Biotechnology*, **27**(9), 1602–1608.

Kadage, N. R., Patil, S. R., & Sonkamble, A. M. (2021). Effect of sugar sources and blended must on physico-chemical and sensory evaluation of Nagpur mandarin wine. *Journal of Pharmacognosy and Phytochemistry*, **10**(1), 2706–2710.

Kumar, V., Goud, P. V., Babu, J. D., & Reddy, R. S. (2011). Preparation and evaluation of custard apple wine: Effect of dilution of pulp on physico-chemical and sensory quality characteristics. *International Journal of Food and Fermentation Technology*, **1**(2), 247–253.

Minh, N. P., Khai, H. Q., Loan, N. T., & Duc, L. V. (2019). Some variables affecting gooseberry (*Phyllanthus acidus*) wine fermentation. *Journal of Pharmaceutical Sciences and Research*, **11**(5), 1703–1709.

Satav, P. D., & Pethe, A. S. (2017). Production and optimization of wine from banana fruits. *International Journal of Pharma and Bio Sciences*, **8**(2), 790–794.

Sevda, S. B., & Rodrigues, L. (2011). Fermentative behavior of *Saccharomyces* strains during guava (*Psidium guajava* L.) must fermentation and optimization of guava wine production. *Journal of Food Processing and Technology*, **2**(118), 1–6.

Tiwari, S., Shukla, S., & Kishor, K. (2017). Production, optimization, characterization and evaluation of antimicrobial activities in *Hibiscus rosa-sinensis* wine. *Journal of Pharmacognosy and Phytochemistry*, **6**, 19–26.

Yadav, P., Garage, N., & Diwedi, D. H. (2009). Standardization of pretreatment conditions for mahua wine preparation. *Journal of Ecofriendly Agriculture*, **4**(1), 88–92.