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Effect of sugar sources and blended must on physico-chemical and sensory evaluation of Nagpur mandarin wine

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Abstract
An investigation on "Effect of different sugar sources and blended must on physico-chemical and sensory evaluation of Nagpur mandarin wine" was conducted at Post-Harvest Technology Laboratory, Department of Fruit Science, Dr. PDKV, Akola during the academic year 2017-18 with the objectives of to study the chemical changes and sensory qualities of blended wine prepared from Nagpur mandarin and to find out the suitable combinations of sugar sources and blended wine prepared from Nagpur mandarin. The experiment was carried out with three sugar sources (Cane sugar, Jaggery and Honey) and Nagpur mandarin juice was blended with coloured grape and pomegranate juices in different proportion and framed in Factorial Completely Randomized Design with fifteenth treatments and three replications. The wine of each bottle was transferred into 200 ml fresh sterile glass bottles and sealed air-tight with crown caps, keeping 0.7 cm head-space. The sealed wine bottles were subjected for pasteurization in water bath at 65 °C for 20 minutes. After cooling, the wine bottles were labeled with respective treatment name and left for storage of 3 months. From the finding it was observed that, there was decrease in ethyl alcohol, total sugar and ascorbic acid content of Nagpur mandarin wine irrespective of storage period. Whereas, reducing sugar content of Nagpur mandarin wine increased with the advancement of storage period of 3 months. Maximum ethyl alcohol and ascorbic acid and minimum total sugar and reducing sugar was observed when Nagpur mandarin wine prepared with Honey as sugar source and blended with mandarin juice and coloured grape juice with 80:20 ratio. Similarly, the Nagpur mandarin wine prepared with Honey as sugar source and blended with mandarin juice and coloured grape juice with 80:20 ratio secured the highest score for colour, flavour, taste, appearance, astringency and overall acceptability as compared to other treatment.

Keywords: Nagpur mandarin, wine, sugar sources, blending, physico-chemical and sensory evaluation

Introduction
Citrus is one of the leading fruit crops of the world and adaptable to wide range of soil, terrain, planting and cultural arrangements. It is widely grown in most areas with suitable climates tropical, subtropical and borderline subtropical and temperate (Kahn *et al.*, 2001) [13]. The citrus growing state in India are Maharashtra, Madhya Pradesh, Andhra Pradesh, Telgana, Punjab, Karnataka, Orissa, Bihar, Haryana, Assam, Tamil Nadu, Gujarat, etc. The area, production and productivity of citrus in India during 2018-19 was 1003 thousand ha and 12546 thousand MT and 12.0 MT/ha, respectively (Anon, 2019) [2].

Nagpur santra is the only cultivar of mandarin grown in Vidarbha for last 200 years, on around 100.7 thousand ha area. Cultivation of Nagpur mandarin is mostly concentrated in Amravati, Nagpur, Wardha, Yaotmal, Akola, Washim and Buldana districts of Vidarbha region, which comprises of about 75 per cent area under mandarin cultivation in Maharashtra.

Citrus fruit juices in general and mandarin juices in particular have a poor shelf-life and face problems of post-harvest losses. Mandarin can be consume fresh or processed for preparation of juice concentrate, crush, squash, syrup, jam, marmalade, etc. Apart from these products, mandarin can also be utilized for preparation of wine, which can be a potential value addition step to this fruit crop. A typical wine contains ethyl alcohol, sugars, acids, higher alcohol, tannins, aldehydes, esters, amino-acid, minerals, vitamins, anthocyanin and minor constituents like flavouring compounds, etc. (Amerine *et al.*, 1980) [3, 4]. The utilization of Nagpur mandarin for preparation of wine can solve the problems of market surplus and related spoilage, apart from development of a new type of wine.

Material and Methods

Fruits of Nagpur mandarin, coloured grape and pomegranate were obtained from Local Fruit Market, Akola. The well mature, healthy fruits were carefully graded and brought to the laboratory for further experimentation. The selected fruits were thoroughly washed with clean tap water to remove dirt and dust particles adhered to the pericarp of the fruits (Singh and Kumar, 1995) [15]. The yeast strain of *Saccharomyces cerevisiae* var. *ellipsoideus* was used for the present study.

Preparation and storage of wine

The juice of selected fruits of Nagpur mandarin, coloured grape and pomegranate were extracted seperatly with the help of screw type juice extractor and then strained through muscline cloth to separate seeds and fiber. The above extracted juices were used for the preparation of blended must. Initially, the mandarin juice was measured in different reagent bottles and then different blending (Factor 'B') was given as per the treatment details. The TSS of blended juice was raised by addition of sugar sources *viz*., cane sugar, jaggery and honey at 24 ^{o}Brix. Sodium benzoate was added to the juice at the rate of 150 ppm to inhibit the wild yeast and other spoilage microorganism and leave for four hours. After four hours the must was supplemented with 0.1% diammonium hydrogen phosphate (DAHP). Then an active yeast culture was added to each treatment at the rate of 5% to the Reagent Bottles Containing must of different treatment. The must was allowed to ferment with air lock assembly 'on' to create anaerobic condition. An experiment was conducted in Factorial Completely Randomized Design comprise fifteenth different treatments and replicated thrice.

After completion of fermentation, the yeast and other material settled down at the bottom of the reagent bottle leaving clear wine as supernatant. The supernatant wine was then siphoned off to new sterilized bottles using a rubber tubing to separate the lees. After siphoning, the wine was clarified with the aid of 0.4 g l^{-1} bentonite to recover wine of crystal clear quality finish. The wine was clarified by decantation for two times after a sedimentation period of 7 days each in order to get clear wine. Then the wine of each bottle was transferred into 200 ml fresh sterile glass bottles and sealed air-tight with crown caps, keeping 0.7 cm head-space. The sealed wine bottles were subjected for pasteurization in water bath at 65 °C for 20 minutes. After cooling, the wine bottles were labeled with respective treatment name and left for storage of 3 months.

Physico-chemical and sensory evaluation

Wines from different treatment combinations were analyzed for various physico- chemical parameters and sensory evaluation at fresh and 3 months. The ethyl alcohol content of wine samples was estimated pycnometer method (FSSAI, 2015) [7]. The total sugar and reducing sugar was estimated by the spectrophotometer method reported by Sadasivam and Manickam (1997) [19]. Ascorbic acid content was estimated by using 2,6-dichlorophenol indophenols dye as reported by Ranganna (1986) [18]. Sensory analysis was done by 5 trained panelist who gave score for various parameters like colour, flavour, taste, appearance, astringency and overall acceptability on a 9 point hedonic scale.

Statistical analysis

The data collected on various observations, during the course of investigation were statistically analyzed by Factorial Completely Randomized Design as suggested by Panse and Sukhatme (1985) [17].

Results and Discussion

Physico-chemical analysis of wine

The data related to physico-chemical characteristics of Nagpur mandarin wine at fresh and 3 months of storage are presented in Table 1. It is evident from the statistical analysis of the data that with advancement in storage period, a slight decrease was observed in all the parameters except reducing sugar.

Ethyl alcohol

Significantly maximum ethyl alcohol content (11.85 and 11.79%) was observed in treatment combination S_3B_2 (Honey blend with 80:20- mandarin juice: coloured grape juice) for fresh and 3 months aged Nagpur mandarin wine, respectively. Whereas, the treatment combination S_2B_5 (Jaggery with 100% mandarin juice) was observed minimum ethyl alcohol content (10.39 and 10.39%) for fresh and 3 months, respectively. A decrease in ethyl alcohol content during storage is apparently the result of interaction between alcohols and acids to form esters (Amerine *et al.,* 1980 and Zoecklein *et al.,* 1995) [3, 4, 23]. It is desirable as total ester formation results in higher fruity flavour in wine. The results obtained in the present investigation are in close agreement with the findings of Sharma and Joshi (2003) [22] in strawberry wine, Ghan Shyam (2009) in wild apricot sugar base wine and mead, Joshi *et al.* (2012) in jamun wine and Kumar *et al*., (2016) [14] in custard apple wine.

Total Sugar

Significantly minimum total sugar for fresh and 3 months aged Nagpur mandarin wine was reported as 4.36 and 4.29%, respectively in treatment combination S_3B_2 (Honey with 80:20- mandarin juice: coloured grape juice). Whereas, maximum total sugar content for fresh and 3 months aged Nagpur mandarin wine was reported as 5.73 and 5.68%, respectively in treatment combination S_2B_5 (Jaggery with 100% mandarin juice). The decrease in total sugar of Nagpur mandarin wine during storage period might be to the Maillard's reaction resulting non-enzymatic browning due to reaction of sugar with amino acids (Zoecklein *et al.,* 1995) [23]. The result mentioned above are in conformity with the findings of Chauhan *et al.* (2016) [5] in bael vermouth, Kumar *et al.* (2016) [14] in custard apple wine, Dhomane (2017) [6] in pumpkin wine.

Reducing sugar

Significantly minimum reducing sugar content (2.00 and 2.10%) was observed in treatment combination S_3B_2 (Honey with 80:20- mandarin juice: coloured grape juice) for fresh and 3 months aged Nagpur mandarin wine, respectively. Whereas, maximum reducing sugar content (2.77 and 2.82%) was observed in treatment combination S_2B_5 (Jaggery with 100% mandarin juice) for fresh and 3 months aged Nagpur mandarin wine, respectively. The increasing trend of reducing sugar is apparently the results of hydrolysis of non- reducing sugar into reducing sugar during maturation (Amerine and Ough, 1980) [3, 4]. It is significant from taste quality of wine and is one of the desirable effects of maturation of wine. The result mentioned above was in conformity with the findings of Joshi *et al.* (2014a) [11] in mandarin orange wine, Joshi *et al.* (2014b) [10] in blended plum wine, Joshi *et al.* (2012) [12] in

jamun wine, Munde (2018) [16] in pumpkin wine and Sima (2019) [19] in mahua wine.

Ascorbic acid

Significantly maximum ascorbic acid content (37.49 and 37.42 mg 100 ml^{-1}) was observed in treatment combination S_3B_2 (Honey blended with 80:20- mandarin juice: coloured grape juice) for fresh and 3 months aged Nagpur mandarin wine, respectively. Whereas, minimum ascorbic acid content (34.45 and 34.39 mg 100 ml^{-1}) was observed in treatment combination S_2B_5 (Jaggery with 100% mandarin juice) for fresh and 3 months aged Nagpur mandarin wine, respectively. The decreasing trend in ascorbic acid content of Nagpur mandarin wine during aging period might be due to the fact that several compound in wine related to the ascorbic acid breakdown due to heat by fluctuation in temperature or due to oxidation of ascorbic acid present in the wine during racking (Akubor *et al.*, 2003) [1]. The result mentioned above are in conformity with the findings of Kuntal (2018) [15] in jamun wine, Garg *et al.* (2014) [8] in bael wine, Dhomane (2017) [6] and Sima (2019) [20] in mahua wine.

Table 1: Interaction effect of sugar sources and blended must on ethyl alcohol, total sugar, reducing sugar and ascorbic acid of Nagpur mandarin wine during storage

Treatments	Ethyl alcohol (%)		Total sugar (%)		Reducing sugar (%)		Ascorbic acid (mg 100 ml^{-1})	
	Fresh	3 Months	Fresh	3 Months	Fresh	3 Months	Fresh	3 Months
S_1B_1	11.26	11.23	4.77	4.71	2.30	2.36	37.04	37.00
S_1B_2	11.59	11.51	4.68	4.63	2.24	2.33	37.36	37.30
S_1B_3	10.92	10.87	4.95	4.88	2.43	2.47	35.94	35.90
S_1B_4	10.64	10.70	5.26	5.20	2.53	2.58	36.26	36.21
S_1B_5	10.59	10.53	5.65	5.60	2.74	2.79	34.73	34.70
S_2B_1	11.43	11.40	5.03	4.96	2.47	2.51	37.30	37.27
S_2B_2	11.26	11.26	5.18	5.11	2.57	2.61	37.33	37.21
S_2B_3	10.81	10.78	5.33	5.27	2.56	2.62	35.40	35.23
S_2B_4	10.51	10.50	5.42	5.37	2.62	2.69	35.60	35.55
S_2B_5	10.39	10.39	5.73	5.68	2.77	2.82	34.45	34.39
S_3B_1	11.59	11.54	4.64	4.57	2.22	2.22	37.38	37.33
S_3B_2	11.85	11.79	4.36	4.29	2.00	2.10	37.49	37.42
S_3B_3	11.37	11.34	5.13	5.08	2.53	2.58	36.50	36.43
S_3B_4	11.12	11.09	5.21	5.15	2.50	2.54	36.77	36.66
S_3B_5	10.45	10.56	5.55	5.50	2.69	2.73	35.06	34.98
F Test	Sig	Sig	Sig	Sig	Sig	Sig	Sig	Sig
SE(m)±	0.034	0.032	0.015	0.015	0.016	0.014	0.024	0.025
CD at 5%	0.097	0.093	0.043	0.044	0.046	0.041	0.070	0.072

Sensory evaluation

The data pertaining to sensory evaluation are presented in Table 2 (a) and (b). From the result it was revealed that, there was increase in sensory score among all the treatments during fresh to 3 months of storage period of Nagpur mandarin wine. The blended wine prepared from Nagpur mandarin evaluated for different sensory attributes *viz.*, colour, flavour, taste, appearance, astringency and overall acceptability. The scores were used to evaluate the overall quality of wine. The wine prepared from the Honey blended with 80:20- mandarin juice: coloured grape juice (S_3B_2) secured the highest score among the different treatment.

Table 2 (a): Effect of sugar sources and blended must on colour, flavour and taste score of Nagpur mandarin wine during storage

Treatments	Colour		Flavour		Taste	
	Fresh	3 months	Fresh	3 months	Fresh	3 months
S_1B_1	6.6	6.8	6.4	6.8	6.4	6.6
S_1B_2	6.8	7.2	6.4	6.6	6.8	6.8
S_1B_3	6.4	6.6	6.8	7.0	6.4	6.6
S_1B_4	6.6	7.2	6.6	6.8	7.0	6.8
S_1B_5	6.4	6.8	6.4	6.8	5.8	5.8
S_2B_1	7.0	7.2	7.0	7.2	6.2	6.2
S_2B_2	7.2	7.2	7.0	6.8	7.0	6.8
S_2B_3	7.0	7.4	6.4	7.0	6.8	6.8
S_2B_4	7.2	7.4	6.4	6.6	6.4	6.8
S_2B_5	6.8	7.0	6.2	6.4	6.0	6.4
S_3B_1	7.0	7.2	6.8	6.8	7.0	7.0
S_3B_2	7.4	7.6	7.4	7.6	7.2	7.4
S_3B_3	6.8	7.0	7.2	7.4	6.2	6.4
S_3B_4	6.6	7.2	6.8	6.8	6.4	6.6
S_3B_5	7.0	6.8	7.0	6.8	6.8	6.8

Table 2 (b): Effect of sugar sources and blended must on appearance, astringency and overall acceptability score of Nagpur mandarin wine during storage

Treatments	Appearance		Astringency		Overall acceptability	
	Fresh	3 months	Fresh	3 months	Fresh	3 months
S_1B_1	6.2	6.2	6.4	6.8	7.2	7.6
S_1B_2	6.2	6.4	6.4	6.6	7.4	7.4
S_1B_3	6.0	6.2	7.0	6.8	6.4	6.6
S_1B_4	6.2	6.2	6.6	6.8	7.0	7.4
S_1B_5	5.8	6.2	6.0	6.2	6.4	6.6
S_2B_1	6.4	6.6	7.0	7.2	7.0	7.4
S_2B_2	6.8	6.8	7.4	7.6	6.8	7.0
S_2B_3	6.4	7.0	7.2	7.4	6.4	6.8
S_2B_4	6.4	6.8	7.0	7.2	6.4	6.6
S_2B_5	6.2	6.4	6.4	6.6	6.2	6.2
S_3B_1	7.0	7.2	6.2	6.2	7.8	8.0
S_3B_2	7.6	7.8	7.2	7.4	8.0	8.2
S_3B_3	7.0	6.8	6.8	7.0	6.6	6.8
S_3B_4	6.8	6.8	7.0	6.8	6.4	6.8
S_3B_5	6.8	6.8	6.6	6.8	6.8	7.0

Conclusion

Among the different sugar sources Honey and blending ratios, 80:20 (mandarin juice: coloured grape juice) ratio was found superior regarding ethyl alcohol, total sugar, reducing sugar and ascorbic acid content at fresh and 3 months storage Nagpur mandarin wine. The Nagpur mandarin wine prepared with Honey as sugar source and blended with mandarin juice and coloured grape juice with 80:20 ratio secured the highest score for colour, flavour, taste, appearance, astringency and overall acceptability as compared to other treatment. From the overall assessment of results obtained, it can be concluded that the blending of mandarin and coloured grape juice in the ratio of 80:20 along with Honey as a sugar source was found suitable for preparation of Nagpur mandarin wine.

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