

RESEARCH PAPER

Physico-chemical and Sensory Quality Characteristics of Mandarin (*Citrus reticulata* Blanco.) Wine as Affected by Initial TSS and Sulphur Dioxide Concentration of the Must

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ABSTRACT

An Attempt was made to prepare wine from mandarin fruit juice using commercial yeast powder and by adjusting the initial TSS of the must at 20, 24, 28 and 32° Brix and SO₂ concentration at 100 and 200 ppm. The must having 32° Brix and 100 ppm SO₂ had the maximum fermentation rate (1.90). The physico-chemical and sensory quality of wine differed with various treatments. During maturation period, the TSS, acidity and phenol content of the wine decreased while alcohol content increased. After 3 months of maturation period, the wine prepared from the 'must' having an initial TSS of 24° Brix and 100 ppm SO₂ was found superior with respect to biochemical attributes having 6.67 per cent TSS, 8.89 per cent ethanol and the maximum overall sensory score (7.89/9.00).

Keywords: Mandarin, wine, ethanol, yeast, sensory quality, fermentation, maturation

Citrus is an important group of fruits belonging to family Rutaceae and include limes/ lemons, oranges, mandarins, tangerines, clementines, satsumas, etc. Citrus fruits, fresh as well as their juice are popular worldwide due to excellent flavour and nutritional value. Citrus fruits are cultivated in tropical and subtropical regions of the world, especially in USA, Brazil and China (Ladaniya, 2008). In India citrus occupies third position among fruits after mango and banana, covering an area of 1055 thousand ha with an annual production of 127.46 lakh metric tonnes (Anon, 2017). Among various citrus species, mandarins, limes/ lemons and sweet oranges are cultivated the most in India occupying 41, 25 and 20 per cent of the total area, respectively (Anon, 2017). Mandarins occupy an area of 428 thousand ha with annual production of 51.01 lakh metric tonnes in the

country (Anon, 2017). It is commercially cultivated in the specific regions of the country like 'Nagpur' mandarin in central India, 'Khasi' mandarin in north-eastern regions and 'Coorg' mandarin in southern parts of the country.

Mandarin fruit is refreshing and nutritional due to its sweet: acid taste, vitamin 'C' and minerals (Ca, P & Fe) content and appealing colour (Ladaniya, 2008). However, due to the presence of bitter glucocides 'Naringine' and 'limonine' the juice turns bitter soon after its extraction from fruits when it comes into contact with air. This limits the processing potential of mandarin in to juices and other beverages (Chen *et al.* 2010). As a result of that large quantity of fruits that are not utilized goes waste due to lack of processing possibilities. Hence, production of wine from mandarin fruits is an available alternative which

will minimize seasonal glut, associated post harvest losses and price fluctuation in the market.

Fruit wines are undistilled fruit based fermented beverages made from grapes and other fruits by alcoholic fermentation of their juice under controlled conditions by yeast (*Saccharomyces cerevisiae*), subsequent ageing (maturation) and clarification (Joshi, 1997).

A typical wine contains ethyl alcohol, sugars, organic acids, tannins, aldehydes, esters, amino acids, minerals, vitamins, pigments and flavouring compounds (Amerine *et al.* 1980). Alcohol, a macro-nutrient present in wine acts as a energy source and provide calories for all the essential biological activities in human cells (Bisson *et al.* 1995). Different studies have shown the beneficial effects of wine consumption due to presence of phenolic substances and alcohol in it which protects the human body from attack of free radicals and increase the high density lipid (HDL) level in the body (Joshi *et al.* 1997; Joshi *et al.* 2011; Joshi *et al.* 2012).

Very limited work has been reported on utilization of mandarin fruits, particularly the 'Nagpur' mandarins grown in Rajasthan. Therefore, the present experiment was conducted to investigate the feasibility of production of wine from mandarin fruits and to evaluate the same.

MATERIALS AND METHODS

Raw material

The mandarin fruits of 'Nagpur' variety were procured from local farmer of Jhalawar (Rajasthan). Table sugar was used to raise the TSS of the 'must' prior to fermentation. Commercial dry yeast powder (lyophilized) of strain *Saccharomyces cerevisiae bayanus* (Trade name Lalwin EC1118) and yeast protector (Trade name Goferm® Protect) for rehydration step of dry yeast were procured from Zytex Biotech Pvt. Ltd., Mumbai.

Rehydration of yeast

The dry yeast powder was rehydrated as per the

directions of the manufacturer. To 50 ml of sterile water (temperature 40°C), 10 g yeast protector was added and dissolved by stirring. When the temperature came down to 35°C, 10 g of dry yeast powder was added and let it rest for 20 min for rehydration.

Preparation and maturation of wine

Juice was extracted from ripe mandarin fruits by using screw type juice extractor. The TSS of the juice was adjusted to 20, 24, 28 and 32° B by adding cane sugar. SO₂ was added @ 100 and 200 ppm by adding calculated quantity of potassium metabisulphite to have 8 different treatments. Then rehydrated yeast culture was added to each treatment @ 2.25ml per 1.5 l of must contained in 2.0 l conical flasks. The must was allowed to ferment with air lock assembly 'on', to create anaerobic condition. After the fermentation was completed 'racking' was done 3 times to get clear wine. It was done by siphoning 'off' of wine leaving the settled mass of 'lees' and transferring the clear wine into another clean container. The wine was then pasteurized and bottled and left for maturation at 10°C for a period of 3 months.

Physico-chemical and sensory analysis

Wines from different treatment combinations were analyzed for various physico-chemical parameters during fermentation and maturation while sensory analysis was done only after maturation of 3 months. TSS (° Brix) was determined using digital refractometer (Atago, Japan) after correcting the readings for temperature variation. The rate of fermentation was estimated on the basis of decrease in TSS per day. Titrable acidity was measured by the method of AOAC (1980) and the results were expressed as per cent citric acid. Ethanol content was estimated by potassium dichromate method (Caputy *et al.* 1968), while total phenol content was determined by Folin Ciocalteu procedure (Ranganna 1986). Sensory analysis was done by a panel of 7 semi-trained judges who gave score for various parameters like colour, appearance, body, aroma, taste, astringency, and overall acceptability on a 9 point hedonic scale (Amerine *et al.* 1965).

Statistical analysis

The experiment was laid out in factorial CRD and the significance of variance was analyzed using F test given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Physico-chemical characteristics of fresh fruits of mandarin

The physico-chemical characteristics of fresh mandarin fruits is given in table 1.

Table 1: Physico-chemical characteristics of fresh fruits of mandarin

Particulars	Value
Average fruit weight (g)	105
Juice (%)	44
TSS (°Brix)	12
Acidity (% citric acid)	0.43
pH	3.7
Ascorbic acid (mg/ 100ml)	35
Total phenol (mg/ 100ml)	112

Physico-chemical analysis of wine

The results on the rate of fermentation (Fig. 1) show that the highest rate of fermentation (1.90) was recorded in mandarin must having initial TSS 32° B and 100 ppm SO₂ while minimum (1.15) was observed in that of initial TSS 20° B and 200 ppm SO₂. This could be due to faster yeast activity and hence, faster fermentation in the must having higher sugar concentration and inhibition of yeast cells due to higher SO₂ levels (Bozoglu *et al.* 2015).

As expected, highest TSS content (9.30°B) was recorded in wine having initial TSS of 32°B and 100 ppm SO₂ while minimum TSS (5.40°B) was in that made from must having initial TSS of 20°B and 100 ppm SO₂ (Table 1). After maturation of wine for 3 months, the TSS content of wines slightly decreased in all the treatments, highest (8.93°B) being in the must having initial TSS of 32°B and 200 ppm SO₂. The decrease in TSS content during the period of maturation of

wine may be due to precipitation of soluble solids during interaction of various components (Holegar *et al.* 2016; Beera *et al.* 2013). Maximum titrable acidity (0.72%) was found in the wine prepared from must having 20°B and 200 ppm SO₂ while minimum acidity was recorded in that prepared from must having 28°B and 100 ppm SO₂. During maturation, the acidity got slightly decreased in all the treatments which may be due to precipitation of various acids into their respective salts (Amerine *et al.* 1980; Joshi *et al.* 2012). Ethanol content was in accordance with the fermentation behaviour of the respective musts. The highest ethanol content (10.20%) was recorded in the wine made from the must having initial TSS of 28°B and 100 ppm SO₂ which was at par with that of 32°B and 100 ppm SO₂ (10.06 %). After completion of maturation period of 3 months, it was observed that the alcohol content in all the wines increased slightly which could be due to conversion of sugars into alcohol due to slow secondary fermentation (Shukla *et al.* 1991). The ethanol content of mandarin wine indicated that the wine fall in the category of table wine.

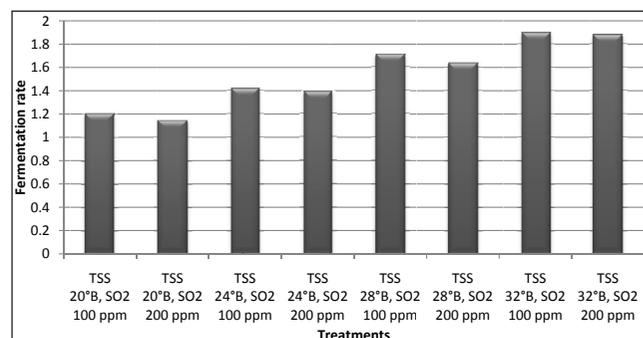


Fig. 1: Fermentation rate of mandarin must as influenced by initial TSS and SO₂ concentration

Further, the phenol content did not differ significantly among mandarin wine prepared from different treatment combinations. The total phenol varied from 85.10 to 90.77 mg/ 100 ml which got slightly decreased during the maturation. The reduction in total phenol content during maturation might be due to susceptibility of phenolic constituents to degradation, condensation and polymerization and subsequent precipitation as complexes with pectates,

Table 2: Physico-chemical characteristics of mandarin wine before and after maturation

Treatments (Initial TSS and SO ₂ Conc. Of the must)	Before maturation				After maturation			
	TSS (°Brix)	Acidity (%)	Ethanol (%)	Phenol (mg/100 ml)	TSS (°Brix)	Acidity (%)	Ethanol (%)	Phenol (mg/100 ml)
TSS 20° B; 100 ppm SO ₂	5.40	0.69	7.63	87.50	5.07	0.61	8.39	87.23
TSS 20° B; 200 ppm SO ₂	6.10	0.72	7.86	90.77	5.93	0.65	8.29	87.60
TSS 24° B; 100 ppm SO ₂	6.93	0.66	8.66	86.93	6.47	0.59	8.89	85.33
TSS 24° B; 200 ppm SO ₂	7.20	0.71	8.13	85.33	6.93	0.63	8.58	83.43
TSS 28° B; 100 ppm SO ₂	7.47	0.53	10.20	86.77	7.07	0.51	10.39	85.30
TSS 28° B; 200 ppm SO ₂	8.17	0.66	9.76	85.10	7.87	0.58	10.03	84.50
TSS 32° B; 100 ppm SO ₂	9.13	0.69	10.06	85.73	8.67	0.62	11.10	84.57
TSS 32° B; 200 ppm SO ₂	9.30	0.63	9.03	85.50	8.93	0.54	10.31	84.00
S.Em ±	0.12	0.02	0.19	0.60	0.08	0.02	0.15	1.43
C.D. at 5 %	NS	0.06	0.59	NS	0.24	0.07	NS	NS

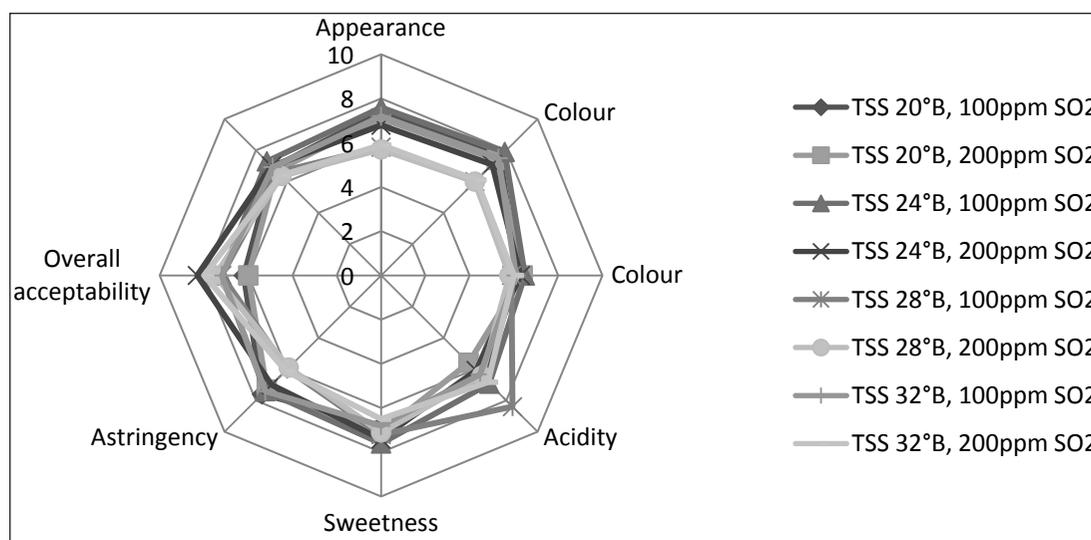


Fig. 2: Comparison of the sensory evaluation of mandarin wine as influenced by initial TSS and SO₂ concentration of the must

acids and other compounds leading to reduction in astringency (Somers 1987).

Sensory evaluation of wine

The wine prepared from mandarin must was evaluated for different sensory attributes viz. Appearance, colour, aroma, acidity, sweetness, body/mouth feel, astringency and overall acceptability. All the wines recorded an overall score of more than 5.5/

9.00, so they all were found acceptable. However, the wine prepared from mandarin must having initial TSS of 24°B and 100 ppm SO₂ was found to be the best with respect to appearance (7.60/9.00), colour (7.90/ 9.00), aroma (6.50/ 9.00), sweetness (7.60/ 9.00), astringency (8.30/ 9.00) and overall acceptability (7.30/ 9.00). These results are in line with the findings of Joshi *et al.* (2012); Joshi *et al.* (2014) and Patharkar *et al.* (2017).

CONCLUSION

There is a potential for making wine from mandarin fruits grown in central India and Jhalawar district of Rajasthan. Since the TSS content of the juice ranges between 10-12° Brix, it is recommended to add cane sugar to have suitable alcohol content in the final wine. The results of the present investigation indicated that the wine prepared from mandarin juice having an initial TSS of 24° Brix and 100 ppm SO₂, fermentation caused by *Saccharomyces cerevisiae* and matured for 3 months had the highest overall sensory score of 7.30/9.00 and having 8.89 per cent ethanol content.

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