

Preparation of plum wine with reduced alcohol content: Effect of must treatment and blending with sand pear juice on physico-chemical and sensory quality

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Plum (*Prunus salicina* L.) with attractive colour and flavour, but highly perishable fruit is grown all-over the world including India, holds promise to prepare wine. Attempt to optimize a technique for preparation of low alcoholic plum wine was made. Fruit of Santa rosa plum cultivar were used to produce wine by different methods, viz. conventional method (T₁), must ameliorated with honey (T₂), removal of alcohol from wine by distillation (T₃), inoculation with *Schizosaccharomyces pombe* to reduce the acidity followed by fermentation with *Saccharomyces cerevisiae* (T₄) and inoculation with *Schizosaccharomyces pombe* (T₅) only for deacidifying the must. A comparison of RF (Rate of fermentation) revealed that the must fermented by conventional method (T₁) had the highest RF (0.97) while that of T₅ recorded the lowest RF value. Must ameliorated with honey compared well with the cane sugar based on different parameters of wines examined. On the basis of physico-chemical characteristics, all the treatments except that with *Schizosaccharomyces pombe* in the pulp (T₅) can successfully be used for wine preparation with better physico-chemical characteristics. Blending of base wines with different proportions of sand pear juice showed that blending at 20 % and 30 % of pear juice not only reduced the alcohol content but also made the blend acceptable with respect to sensory qualities.

Keywords: Plum, *Prunus salicina*, 'Santa rosa', Plum wine, *Saccharomyces*, *Schizosaccharomyces*, Sand pear, Alcohol, Deacidification.

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Introduction

Plum (*Prunus salicina* L.) is an important and widely cultivated temperate fruit crop having attractive colour and flavour. In India, it is predominantly grown in Himachal Pradesh, Jammu and Kashmir and Uttarakhand and also to some extent in Nilgiri hills of South India¹. It is a highly perishable fruit with a shelf-life of 3-4 days at ambient temperature and 1-2 weeks in the cold storage. It can be utilized for the preparation of jams, jellies, etc. but to accommodate the large quantities of the fruit produced during the glut periods, alternate methods are required for its diversified utilization. Production of alcoholic beverages from this fruit is a profitable alternative. It has proved its potential for preparation of alcoholic beverages including wine and vermouth²⁻⁶. Wine has a long association with human artistic cultural and religious activities⁶⁻⁷ and is considered as nutritious, safe and healthy drink, besides an important adjunct to the diet unlike distilled liquor⁸.

Consumers are now recognizing the health benefit of consumption of low alcoholic beverages⁹. Focus on production techniques for manufacturing low or reduced alcoholic beverages is being made over the last 15 to 20 years to satisfy the consumer demand for healthier alcoholic products, reduced excise duty ultimately results in better wine sales. Changes in legal blood alcohol limits for driving and increased awareness amongst consumers, about the adverse health effects of excessive alcohol intake, have resulted in decreased wine consumption in traditional market segments^{10, 11}. However, the production and sale of reduced alcohol wine, and the lowering of ethanol concentration in wines greater than acceptable for a specific wine style, poses a number of technical and marketing challenges¹². To make a wine of acceptable quality, several approaches have been made including the use of malic acid utilizing yeast (*Schizosaccharomyces pombe*), dilution with water or blending with low acid juices^{3-4, 6}. So, to make wine with low or no alcoholic wine, the available options are to remove the alcohol produced during fermentation, blend with unfermented juice and ferment with

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Schizosaccharomyces pombe to reduce acid then, blend. Besides, the sugar used to ameliorate the must for fermentation to produce wine with desirable alcoholic content has profound influence on the quality of wine¹³, therefore, effect of honey for amelioration to produce plum wine was also studied. As only a limited work on low alcoholic wine from grapes and absolutely, no work on low or no alcohol plum wine, has been reported at all therefore, investigation on production of low or no alcoholic plum wine of acceptable quality with a reasonable cost were undertaken. The results obtained using several approaches as out-lined earlier, to make plum wine, are reported here.

Material and Methods

Raw materials

Plum fruits of 'Santa Rosa' cultivar employed in the present study were procured from Dr. Y. S. Parmar University of Horticulture and Forestry orchard (Department of Fruit Science) of the university. They were converted into pulp by adding 10 % water to the fruits before cooking which were passed through a pulper to remove skin and stones. The pulp was cold stored at a temperature of 7 °C, till further use. Pear juice for blending with plum base wine was extracted from the fresh sand pear fruit procured from the market. The fruits were grated, the juice was extracted by a basket press, filled-in 650 mL bottles and sucrose, the common sugar and honey needed for amelioration of must were procured from the local market and the Department of Entomology of the University, respectively. The pectin esterase enzyme 'pectinol' was procured from M/S Triton Chemicals, Mysore, India.

Preparation of wine

Yeast culture

The two yeast cultures, viz. *Schizosaccharomyces pombe* strain no. UCD-592 and *Saccharomyces cerevisiae* var. *ellipsoideus*, (UCD 595) were obtained from Indian Institute of Horticulture Research, Bangalore. These were maintained on yeast malt extract agar medium and re-cultured after every three months or whenever needed from the stock yeast culture.

Activation of yeast culture

Liquid culture of *Schizosaccharomyces pombe* yeast and *Saccharomyces cerevisiae* were prepared by inoculating a loop of the yeast cells from the slant into

100 mL sterilized yeast extract malt broth. The cultures so prepared were further transferred to 500 mL flask containing plum must having TSS of 15 °B. After incubation for 48 h at 25±2 °C, the culture was ready for inoculation into the must.

Preparation of must

The experiment was conducted with the objective to select the best treatment for preparation of base wine using stored plum must. The treatments were: T₁ -Conventional method and amelioration with sucrose (Plum pulp diluted 1:1 with water, DAHP @ 0.1 %, pectinol @ 0.3 % and culture of *S. cerevisiae*), T₂ - Amelioration with honey to raise the TSS (Plum pulp diluted 1:1 with water, DAHP @ 0.1 % , Pectinol @ 0.3 % and culture of *S. cerevisiae*), T₃- Amelioration with sucrose and removal of alcohol by distillation (Plum pulp diluted 1:1 with water, DAHP @ 0.1 %, Pectinol @ 0.3 % and culture of *S. cerevisiae*), T₄ – Amelioration with sucrose fermented with (*Schizosaccharomyces pombe* to reduce the acidity followed by *Saccharomyces cerevisiae*) and T₅–Without sucrose and water (inoculation with *Schizosaccharomyces pombe* to reduce the acidity). In all the treatments, TSS was raised to 24 ° Brix by ameliorating the musts with sugar syrup and honey. No TSS was raised in the fermentation conducted with *Schizosaccharomyces pombe* to deacidify the must. The conical flasks were filled with must up to 75 % of their capacity.

Fermentation

To initiate the fermentation at a temperature of 25 ± 1°C, addition of liquid culture of *Schizosaccharomyces pombe* in treatment T₄ and T₅ was made at a rate of 5 %, while *Saccharomyces cerevisiae* was added at the same rate in treatments T₁, T₂ and T₃. The fermentation of treatment T₅ did not ferment to completeness so was discarded for the blending purpose. After the completion of fermentation of other four treatments, the wine prepared was siphoned and the clarified wine was stored in glass bottles for preparation of low alcoholic plum wine. The details of treatments and entire process of plum wine making is shown in Fig. 1.

Preparation of wine with low alcoholic content

The plum base wine was blended with different proportions of sand pear juice at the rate of 10, 20, 30, 40 and 50 per cent to reduce the acid/alcohol content of the plum base wine. These blends were evaluated for physico-chemical and sensory characteristics.

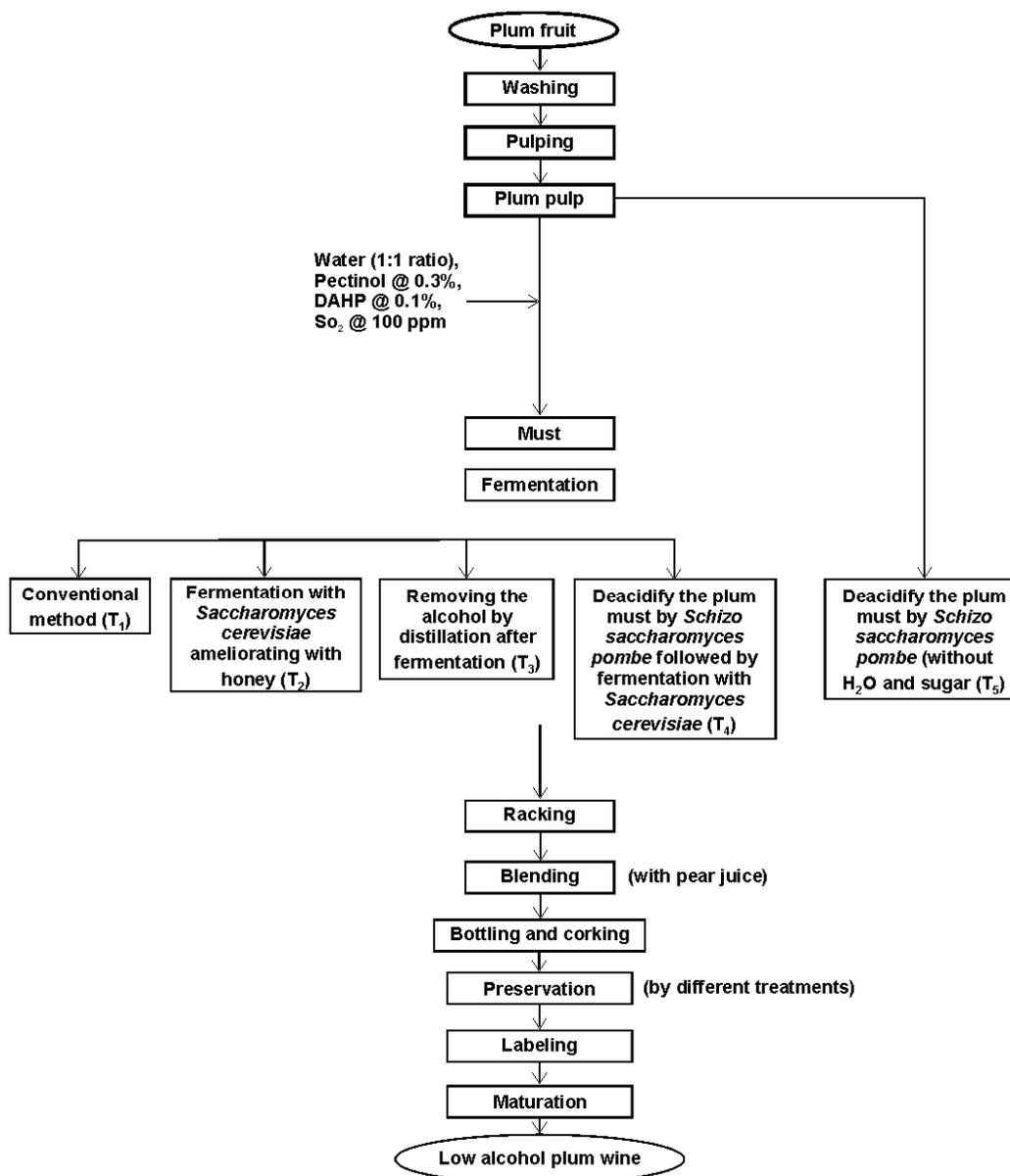


Fig. 1—Flow sheet of preparation of low alcohol plum wine of various treatments

Physico-chemical analysis

During fermentation, the musts were monitored for fall °B to determine the rate of fermentation (RF) of different treatments. Plum wines of different treatments were analyzed for TSS, reducing and total sugars, titratable acidity, pH and ethanol. Total soluble solids (TSS) were measured using an Erma hand refractometer (0 to 32 °B) and results were expressed as degree Brix (°B). The readings were corrected by incorporating the appropriate correction factor for temperature variation¹⁴. The total and reducing sugars were estimated by Lane and Eynon volumetric method by titrating against Fehlings solutions¹⁴. Titratable

acidity was estimated by titrating a known aliquot of the sample against N/10 NaOH solution using phenolphthalein as an indicator. The total titratable acidity was calculated and expressed as per cent malic acid¹⁴. pH was taken with ELTOT-3030 pH meter. Prior to pH measurement, the instrument was standardized with the buffer solutions of pH 4 and 7. Ethanol content was determined by spectrophotometric method¹⁵.

Sensory analysis

For sensory evaluation, chilled and coded samples were served to the judges who were asked to evaluate

sensory characteristics of various samples of plum wine on a prescribed performance². Each sample was evaluated for overall acceptability on hedonic scale or composite scores using various quality attributes, viz. colour and appearance, aroma and bouquet, volatile acidity, total acidity, sweetness, body, flavour, bitterness, astringency and overall impression.

Statistical analysis

Statistical analysis of the quantitative data of chemical parameters obtained from the two experiments was carried out by Completely Randomized Design (CRD). The statistical analysis of the data obtained from sensory evaluation of the matured low alcohol plum wine was done by Randomized Block Design (RBD)¹⁶.

Results and Discussion

Fermentability of musts of different treatment

The results clearly show that the T₃ must recorded the highest reduction in TSS (7.5 °B), followed by T₁ and T₂ (7.6 and 7.6 °B), whereas the minimum reduction in TSS was given by T₅ must (12.4 °B). A comparison of RF revealed that the must fermented by conventional method had the highest RF (0.97) while that of T₅ recorded the lowest RF the value due to the thick pulpy nature of the must and fermentation did not proceed further to completion so the treatment was discontinued for further study. The initial higher decrease in TSS during fermentation is attributed to availability of higher sugar and low alcohol content in the medium. With increase in fermentation time, however, the ethanol content of the must increased exerting thereby, inhibitory effect on the fermentability¹⁷⁻¹⁹ due to

inhibition of yeast growth and activity. The trend of ethanol increase or TSS decrease during fermentation discussed earlier, was similar to the fermentation of any fruit to make a wine^{2, 19-21}.

Physico-chemical characteristics of plum wine

Physico-chemical characteristics (Table 1) of plum wine revealed that the TSS of wines of different methods ranged between 7.5 and 12.4°B and the wide variation in TSS is apparently related to the difference in fermentability of the must as discussed earlier. The finding showed that the wine prepared by the conventional method had the lowest decrease in TSS (7.6°B) and accordingly, had the highest ethanol (11.36 % v/v). Thus, the fermentation was completed to almost dryness. But the must (T₅) with 12.4°B failed to complete the fermentation apparently due to the fact that no dilution in the pulp was made and the yeast failed to multiply and conduct fermentation consequently, could not utilize the sugar present in the pulp to any extent due to anaerobic environment failed to multiply and conduct fermentation. Total sugars in different wines ranged between 0.84 to 7.30 % (Table 1) while the reducing sugars were found in between 0.31 to 4.30 %. A reference to the literature showed that reducing sugars in the wines such as that of plum and apricot after complete fermentation was in the same range as observed earlier²²⁻²³. Titratable acidity of different wines ranged between 0.9 to 1.6 %. The highest acidity (1.6%) was recorded in T₅ treatment because *Schizosaccharomyces pombe* did metabolize some acid in this treatment but pulpiness of the treatments hindered the further action of yeast to make low acid juice. It was the lowest (0.9 %) in T₄

Table 1—Effect of treatment on physico-chemical characteristics of plum wine

Treatments	RF (% TSS reduction /24 h	TSS (°Brix)	Total sugars (%)	Reducing sugars (%)	Titratable acidity (% malic acid)	pH	Ethanol (% V/V)
T ₁ (Conventional method i.e. using <i>Saccharomyces cerevisiae</i>)	0.96	7.6	1.25	0.32	1.0	3.25	11.36
T ₂ (Using <i>Saccharomyces cerevisiae</i> , ameliorated with honey)	0.96	7.6	1.24	0.32	1.1	3.22	11.22
T ₃ (Conventional method followed by distillation for removal of alcohol)	0.97	7.5	1.20	0.31	1.2	3.20	1.70
T ₄ (De-acidification with <i>Schizosaccharomyces pombe</i> , followed by fermentation with <i>Saccharomyces cerevisiae</i>)	0.92	8.4	0.84	0.10	0.9	3.24	11.24
T ₅ (De-acidification of plum pulp without dilution and amelioration with sugar)	0.43	12.4	7.30	4.30	1.6	2.74	1.03

treatment because *Schizosaccharomyces pombe* metabolized the malic acid to ethanol and carbon dioxide³ and reduced the acidity. The pH of different wines ranged between 2.74 to 3.25 and was in accordance with the acidity of the respective treatments.

There were significant differences for ethanol levels between the wines various treatments. The highest ethanol concentration was recorded in T₁ treatment (11.36 % v/v) which is attributed to the completeness of fermentation followed by T₂ and T₄ (11.25 and 11.24 % v/v). The lowest ethanol concentration was found in T₅ treatment (1.03 % v/v) because in this treatment where neither dilution nor amelioration with sugar was done, so there was less decrease in TSS and hence, less fermentation and ethanol, whereas, the second lowest ethanol content was found in T₃ treatment as ethanol produced was removed by the distillation to 1.70 % (v/v).

Blended plum wines

Physico-chemical characteristics

The perusal of data (Table 2) revealed that in general, with increase in initial blending proportions, the TSS increased in T₁ and C₅ wine. Amongst the treatments, the TSS were according to the initial TSS % of the wine. Further, the highest titratable acidity (0.91) of blended plum wine was recorded in T₃ treatment and minimum (0.79 %) in T₄ treatment, whereas among the concentrations, the maximum (0.99 %) and minimum (0.71 %) acidity were recorded in C₁ and C₅, respectively. On the other hand, the treatment combination T₃C₁ gave the highest (1.10 %) titratable acidity, whereas it was the lowest (0.64 %) in T₄C₅ (Table 3). The pH values of the various treatments and blends were according to their respective acidities. The data (Table 4) revealed that the reducing sugars of

Table 2—Effect of blending of plum wine of different treatments with pear juice on TSS (°B)

Treatments	C ₁	C ₂	C ₃	C ₄	C ₅	Mean
	10 % blend of pear juice	20 % blend of pear juice	30 % blend of pear juice	40 % blend of pear juice	50 % blend of pear juice	
T ₁ Conventional method i.e. using <i>Saccharomyces cerevisiae</i>	7.80	8.03	8.10	8.30	8.60	8.12
T ₂ Using <i>Saccharomyces cerevisiae</i> but ameliorated with honey	8.13	8.30	8.60	8.80	9.03	8.57
T ₃ Conventional method but followed by distillation for removal of alcohol	7.63	7.80	8.10	8.40	8.60	8.12
T ₄ De-acidification with <i>Schizosaccharomyces pombe</i> followed by fermentation with <i>Saccharomyces cerevisiae</i>	8.50	8.70	9.10	9.30	9.60	9.04
Mean	8.08	8.21	8.48	8.70	8.96	
CD P _≥ 0.05	T = 0.06	=	0.06	C = 0.06		
	TxC = 0.13	=	0.13			

Table 3—Effect of blending of plum wine of different treatments with pear juice on titratable acidity (%)

Treatments	C ₁	C ₂	C ₃	C ₄	C ₅	Mean
	10% blend of pear juice	20% blend of pear juice	30% blend of pear juice	40% blend of pear juice	50% blend of pear juice	
T ₁ Conventional method i.e. using <i>Saccharomyces cerevisiae</i>	0.94 (1.00)	0.90 (1.00)	0.84 (0.92)	0.74 (0.86)	0.70 (0.84)	0.82 (0.90)
T ₂ Using <i>Saccharomyces cerevisiae</i> but ameliorated with honey	1.00 (1.00)	0.94 (0.97)	0.90 (0.95)	0.80 (0.90)	0.70 (0.84)	0.87 (0.93)
T ₃ Conventional method but followed by distillation for removal of alcohol	1.10 (1.05)	0.92 (1.00)	0.90 (1.00)	0.84 (0.92)	0.79 (0.90)	0.91 (0.95)
T ₄ De-acidification with <i>Schizosaccharomyces pombe</i> followed by fermentation with <i>Saccharomyces cerevisiae</i>	0.90 (0.95)	0.87 (0.93)	0.80 (0.90)	0.74 (0.86)	0.64 (0.80)	0.79 (0.90)
Mean	0.99 (0.99)	0.91 (0.95)	0.86 (0.93)	0.78 (0.88)	0.71 (0.84)	
CD (P _≥ 0.05)	T = 0.002	=	0.002	C =	=	0.003
	TxC = 0.005	=	0.005			

Table 4—Effect of blending of plum wine of different treatments with pear juice on reducing sugar (%)

Treatments	C ₁	C ₂	C ₃	C ₄	C ₅	Mean
	10 % blend of pear juice	20 % blend of pear juice	30 % blend of pear juice	40 % blend of pear juice	50 % blend of pear juice	
T ₁ Conventional method i.e. using <i>Saccharomyces cerevisiae</i>	0.94 (1.00)	1.10 (1.04)	1.30 (1.13)	2.90 (1.70)	3.14 (1.80)	1.87 (1.33)
T ₂ Using <i>Saccharomyces cerevisiae</i> but ameliorated with honey	0.52 (0.72)	0.71 (0.84)	1.05 (1.02)	1.21 (1.10)	2.23 (1.50)	1.14 (1.04)
T ₃ Conventional method but followed by distillation for removal of alcohol	0.69 (0.83)	0.72 (1.85)	0.83 (0.91)	1.81 (1.35)	2.97 (1.72)	1.40 (1.13)
T ₄ De-acidification with <i>Schizosaccharomyces pombe</i> followed by fermentation with <i>Saccharomyces cerevisiae</i>	0.40 (0.63)	0.81 (0.90)	1.24 (1.11)	1.86 (1.40)	2.26 (1.50)	1.32 (1.10)
Mean	0.64 (0.79)	0.83 (0.91)	1.10 (1.04)	1.95 (1.40)	2.65 (1.62)	
CD(P _≥ 0.05)	T =	0.0027	C =			0.0031
	TxC =	0.0061				

Table 5—Effect of blending of plum wine of different treatments with pear juice on total sugar (%)

Treatments	C ₁	C ₂	C ₃	C ₄	C ₅	Mean
	10 % blend of pear juice	20 % blend of pear juice	30 % blend of pear juice	40 % blend of pear juice	50 % blend of pear juice	
T ₁ Conventional method i.e. using <i>Saccharomyces cerevisiae</i>	2.26 (1.50)	2.94 (1.72)	3.52 (1.90)	4.21 (2.05)	5.03 (2.24)	3.60 (1.90)
T ₂ Using <i>Saccharomyces cerevisiae</i> but ameliorated with honey	1.63 (1.30)	2.73 (1.70)	3.12 (1.80)	3.40 (1.85)	4.46 (2.11)	3.10 (1.73)
T ₃ Conventional method but followed by distillation for removal of alcohol	1.52 (1.23)	1.90 (1.40)	2.75 (1.70)	3.15 (1.80)	4.27 (2.10)	2.72 (1.62)
T ₄ Deacidification with <i>Schizosaccharomyces pombe</i> followed by fermentation with <i>Saccharomyces cerevisiae</i>	1.28 (1.13)	2.82 (1.70)	3.40 (1.84)	3.92 (1.98)	4.09 (2.02)	3.10 (1.73)
Mean	1.67 (1.30)	2.60 (1.61)	3.20 (1.80)	3.67 (1.91)	4.50 (2.11)	
CDP _≥ 0.05	T =	0.0012	C =			0.0015
	TxC =	0.0026				

plum wine was the highest (1.87 %) in T₁ treatment and minimum (1.14 %) in T₂ treatment, whereas, among the concentrations, the maximum (2.65 %) and minimum (0.64 %) reducing sugar was recorded in C₅ and C₁, respectively. The scrutiny of the data (Table 5) showed that the total sugars of plum wine was the highest (3.60 %) in T₁ treatment and minimum (2.72 %) in T₃ treatment, whereas, among the concentrations, the maximum (4.50 %) and minimum (1.67 %) total sugars were recorded in C₅ and C₁, respectively. Further, the treatment combination T₁C₅ recorded the highest (5.03 %) total sugars, where it was found the lowest (1.28 %) in T₄C₁.

From these findings, it is quite evident that with the increase in concentration of juice in the blended wine there was an increase in TSS, reducing and total sugars. It is on the expected lines. The reduction in titratable acidity and alcohol concentration was also observed with the increase in blending proportions of juice apparently due to dilution with sand pear juice that had lower acidity than the plum wine. Similar findings had been observed earlier²⁴ in the preparation of apple cider, where blending of apple wine was made with different proportions of juice.

The colour of plum wine was scored the highest (7.70) in T₂, whereas, among the concentrations the

Table 6—Effect of blending of plum wine of different treatments with pear juice on overall acceptability

Treatments	C ₁	C ₂	C ₃	C ₄	C ₅	Mean
	10 % blend of pear juice	20 % blend of pear juice	30 % blend of pear juice	40 % blend of pear juice	50 % blend of pear juice	
T ₁ Conventional method i.e. using <i>Saccharomyces cerevisiae</i>	6.70	7.33	7.33	7.00	6.60	7.00
T ₂ Using <i>Saccharomyces cerevisiae</i> but ameliorated with honey	7.20	7.83	7.33	8.20	6.70	7.43
T ₃ Conventional method but followed by distillation for removal of alcohol	6.70	6.70	6.50	6.20	6.20	6.43
T ₄ Deacidification with <i>Schizosaccharomyces pombe</i> followed by fermentation with <i>Saccharomyces cerevisiae</i>	7.00	8.00	7.83	7.00	6.20	7.20
Mean	6.90	7.50	7.25	7.10	6.40	
CD _{0.05}	T	=	0.25	C	=	0.28
	TxC	=	0.56			

maximum score (7.73) was recorded in C₁. Further, the treatment combination T₂C₄ recorded the highest score (8.50) for colour. The perusal of the data showed that the scores for the taste of plum wine was recorded the highest (7.26) in T₄, whereas, among the concentrations the maximum (7.33) was recorded in C₂. The treatment combination T₄C₅ recorded the highest (7.83) score for taste and was therefore, adjudged to be the best. The highest score (7.24) for flavour of plum wine was recorded (7.26) in T₄, whereas, among the concentrations, the maximum (7.24) was recorded in C₁. Furthermore, the treatment combination T₄C₁ recorded the highest score (8.03) for flavour and was adjudged to be the best. The data (Table 6) revealed that the overall acceptability of plum wine was the highest (7.43) in T₂ treatment and minimum (6.43) in T₃ treatment whereas, among the concentrations, the maximum (7.50) and minimum (6.40) overall acceptability was recorded in C₂ and C₅, respectively. Further, the treatment combination T₂C₄ recorded the highest score (8.20) for overall acceptability and was adjudged to be the best.

In brief, it is clear from the results obtained by sensory evaluation that in the blend of 10 % juice, taste was not altered much and the acidity remained quite high, the product was not acceptable. But due to the less percentage of juice, its colour/appearance was quite appealing and thus, was adjudged the best (higher score) for this parameter whereas, in the blends of 30 and 40 % of pear juice, astringency was not high and was quite sweet in taste and was more of

juicy style than wine. Accordingly, it was also not liked much, whereas, with higher proportions of juice, the wine lost its colour and appearance and became viscous. Thus, wines with 20 and 30 % juice were adjudged better on the basis of colour, flavour, taste and overall acceptability. Apparently, the appropriate content of juice has influenced the sensory quality of the blended wine, the addition of lower quantity (10 %) gave the wine of unacceptable acid, sugar blend while higher than 30 % blend gave oversweet wine, hence unacceptable. Thus, a blending ratio of 20 and 30 % of juice was adjudged to be the best.

Conclusion

Conventional method of plum preparation gave the highest RF. Amelioration with honey and cane sugar showed similarity in fermentation in terms of TSS, titratable acidity, pH and ethanol production. Plum wine prepared by fermentation with *Schizosaccharomyces pombe* and *Saccharomyces cerevisiae* and blended with 20 % pear juice to reduce the alcohol concentration proved to be the best wine on the basis of physico-chemical and sensory characteristics.

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