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Effect of wood chips maturation on wild apricot fruit (*Prunus armeniaca* L.) mead

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Abstract
Honey fermented alcoholic drink is called as mead. The present study was conducted to prepare functionally enriched mead by ameliorate the wild apricot fruit pulp with honey. TSS content of the wild apricot must was raised by addition of honey to 22°B, 24°B and 26°B. Wild apricot mead prepared from initial TSS 26ºB found to containe more reducing sugars, TSS, total esters, higher alcohols and ethanol content. After completion of fermentation, mead was matured to six months with wood chips of *Quercus*, *Bombax* and *Acacia* and evaluated for various functional properties. All the three wood chips treated wines were higher in total phenols, total esters, total caroteniods and low in titratable acidity and ethanol content than the control. *Quercus* treated wine was rated superior to others due to higher total esters, total phenols and reduced acidity. *Acacia* treated wine reduced the quantity of higher alcohols, whereas, *Bombax* was found highest in higher alcohols. The change in the concentration of these components during maturation improved the flavour of all the wines treated with wood chips. Out of three wood chips, *Quercus* treated wine was preferred to by the judges, followed by *Bombax* and then *Acacia*.

Keywords: Wild apricot; mead; wood chips; maturation; TSS

Introduction
Honey is used from time immemorial to prepare the alcoholic drink called ‘mead’. The English word ‘mead’ was derived from old English *medu* or perhaps from the Sanskrit word *madhu*. Honey was also added for the preparation of fruit mead in fruits like apple, plum and pear (Kime and Lee, 1987; Joshi *et al*., 1990) [25, 14, 20]. Fruit mead preparation was found similar to that of fruit wines (Molanar *et al*., 1980) [27]. The earliest archaeological evidence for the production of mead dates to around 7000 BC in China where a Pottery vessel containing a mixture of mead, rice and other fruits along with organic compounds of fermentation was being produced (McGovern *et al*., 2004) [26]. Honey is known for its excellent effect on digestion and metabolism (Ioyrish, 1974). Light honey is preferred to make mead as compare to the dark honey. It is necessary to add enough acid and tannins to the must, as it contains neither of it (Filipello and Marsh, 1934) [8]. On the other hand wild apricot (*Prunus armeniaca* L.) is commonly found growing wild at cold desert region of Tibet, southern part of China and northern India and rich in functional and nutritional properties (Sharma, 2000; Parmar and Sharma, 1992; Sharma, 1994) [32, 29, 33]. But the fruits are highly perishable, and is dried or converted into hard liquor (Parmar and Kaushal, 1982) [28] which lacks in nutrients and also found to have high in methanol content. The fruits can be employed for the production of various alcoholic beverages, even having high acidity (Joshi *et al.*, 1991) [19]. Further, there is no report on wild apricot mead and its maturation with wood chips. Therefore, attempts have been made in present study to see the effect of maturation wood chips (*Quercus*, *Acacia* and *Bombax*) on functional properties of wild apricot mead.

Materials and Methods
Raw materials
The fruits of wild apricot were procured from Kinnaur Dist. of Himachal Pradesh. Wild apricot was converted into pulp. To prepare pulp, 10 per cent water was added before cooking the fruit. The cooked fruits were passed through a pulper to remove skin and stones. Honey was purchased from the Department of Entomology of the Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (INDIA) for the preparation of wild apricot mead. The pectin esterase enzyme used in the studies was manufactured by M/S Triton Chemicals, Mysore, India under the brand name “Pectinol”. Woods of different trees viz. *Quercus*,

Bombax and *Acacia* were collected from the Forest area of University field for the mead maturation. Chips were made of 5×2 cm (l × b) and 0.5 cm thickness and were oven dried at 65ºC, till the constant weight was achieved.

Yeast culture: The yeast culture viz. *Saccharomyces cerevisiae* var. *ellipsoideus*, (UCD 595) used in the study was originally obtained from Department of Enology and Viticulture, California, Davis, USA. It was maintained on yeast malt extract agar (YMEA) medium and re-cultured after every three months or whenever needed from the stock yeast culture.

Activation of yeast culture: Culture of *Saccharomyces cerevisiae* var. *ellipsoideus*, (UCD 595) was made for the preparation of wild apricot mead. The wild apricot pulp was heated to boiling point followed by cooling. The sterilized pulp was diluted in 1:2 ratios (Abrol and Joshi, 2011) which was inoculated with yeast from the slant.

Preparation of must: For conducting the experiment, the pulp stored with 2000 ppm KMS was heated to make it free from SO_2 and then diluted in the ratio of 1:2 with water. To the diluted pulp, 0.1% diamonium hydrogen phosphate (DAHP) as nitrogen source and 0.5% pectinase enzyme for clarification were added. The TSS of diluted wild apricot was raised with to 22°B, 24°B and 26°B as per the treatments. The respective must were inoculated with 5% of activated culture of *Saccharomyces cerevisiae* var. *ellipsoideus.* The fermentation of each treatment was carried out in 10 lt capacity narrow mouth glass carboys, filled up to 75% of their capacity.

Fermentation: Fermentation for all the treatments (22 °B, 24 °B and 26 °B) for mead was carried over at room temperature (22-25 °C). When a stable TSS was reached, the fermentation was considered completed. Air locks were fitted in the mouth of glass carboys near the end of fermentation.

Wood chips maturation

The experiment was laid out to determine, the effect of different wood chips on wild apricot mead maturation. Wild apricot mead of different initial TSS were filled in 200ml bottles. To each bottle, 1 g wood chips was added. Maturation was carried out for 6 months.

Functional properties Analysis

Total soluble solids (TSS) were measured using an Erma hand refractometer (0 to 32 ºB) and the results were expressed as degree Brix (ºB). The readings were corrected by incorporating the appropriate correction factor for temperature variation (AOAC, 1980) [1]. Titratable acidity was estimated by titrating a known aliquot of the sample against N/10 NaOH solution using phenolphthalein as an indicator. The titratable acidity was calculated and expressed as per cent malic acid (AOAC, 1980) [1]. The total phenols content in different mead were determined by Folin Ciocalteu calorimetric procedure given by Singleton and Rossi (1965) [36]. ELTOp-3030 pH meter was used to measure pH. The total and reducing sugars of fruit and mead were estimated by Lane and Eynon volumetric method (AOAC, 1980) [1] by titrating the sample against Fehlings solutions.

Quality of ethanol in mead was estimated by spectrophotometric method (Caputi et.al., 1968), whereas, higher alcohols in mead was estimated by the method given by Guymon and Nakagiri (1952) [11].

Statistical analysis

Statistical analysis of the quantitative data of chemical parameters obtained from the experiments was done by Completely Randomized Design (CRD) Factorial (Cochran and Cox, 1963).

Results

Effect of different wood chips treatment and maturation time on TSS is represented in figure 1. The treatment of wines with wood chips was found to be non-significant on TSS. In consistence with increase in sugar concentration, an increase in TSS was observed and was found in the range of 8.18 to 8.53 ºB. Similarly as seen in TSS, wood chips treated wines didn't showed much change for reducing sugars content. With the increase in initial TSS, significant increase in reducing sugars was observed. The highest (0.478%) reducing sugars content was found in the wine made from initial TSS level of 26 ºB and lowest (0.367%) in wine having initial TSS 22ºB. The highest total sugar (1.302%) was recorded in wild apricot wine having initial TSS 26ºB and lowest (1.072%) in *Acacia* chips treated wine (Figure 2). There was significant increase in total sugars concentration with respect to increment in TSS. The highest total sugars content was recorded in wine made from 26 ºB (1.263%) and lowest (1.123%) in 22 ºB.

The titratable acidity and pH is interlinked with each other and are important parameter of wine quality, both these were affected by wood chips maturation and increase in TSS concentration by addition of sweetening agent in wild apricot must (Figure 3). Out of three wood chips used for maturation of wild apricot wine, the highest acidity (0.780% as MA) was reported in Control wine followed by wine treated with *Acacia*, *Bombax* and *Quercus*, respectively. Wild apricot wine having initial TSS 26 ºB was found to be higher in titratable acidity (0.809%) whereas, 22 ºB wild apricot wine recorded lower titratable acidity (0.708%). The results for pH revealed that the wine treated with *Acacia* and *Bombax* found to have same pH 3.161, while of *Quercus* matured wine found to have 3.167 pH. Mean of 26 ºB TSS level was found to be statistically at par with wine from 24ºB as initial TSS, while that of 22ºB wild apricots wine was significantly different from these wines.

All the three wood chips treated wines had reduced level of ethanol compared to control (Figure 4). Wine treated with *Quercus* recorded the lowest ethanol content (10.43%) while the highest (10.51%) was in control. There were significant differences in the ethanol content of wines prepared with different sugar concentration i.e. 22, 24 and 26 ºB. The highest (11.14%) ethanol content was found in the wine made from initial TSS level of 26ºB and lowest (9.63%) in 22 ºB.

With the increase in initial TSS level of the wine, there was a significant increase in higher alcohols content from 123.6 to 153.6 mg/l. Figure 5 shows an inconsistent increase in higher alcohols was observed with increment in TSS content from 22 to 26ºB. Effect of wood chips treatment on total esters was found to be significant. Compared to the control, all the wood chips treated wine had more quantity of the total esters content. The highest total esters were recorded in *Bombax* treated wine (147.3 mg/L) and lowest in control (139.0 mg/L) wine. There was a significant increase in total esters content in the wines prepared from must with different initial TSS i.e. 22, 24, 26ºB. The highest quantity of total esters (148.0 mg/l) was found in the wine made from initial TSS of 26ºB and

lowest (140.6 mg/l) in wine with 22 ºB. Compared to the control wine, the total phenols were found higher in wood chips treated wines. However, among the wood chips treated wines, *Quercus* treated wine recorded the highest (251.5 mg/l) total phenols followed by *Bombax* (247.8 mg/l) and *Acacia* (245.8 mg/l), whereas, total phenols were lowest in the control wine (238.0 mg/l). With the increase in sugar level, the quantity of total phenols was found to be increased from 227.7 to 262.0 mg/l.

Discussion

Precipitation of soluble solids during interaction of various components might have resulted in a decreased TSS during maturation (Joshi and Sharma, 1993; Joshi *et al.*, 1999) [18, 22]. The highest reduction TSS in *Acacia* may be due to precipitation and interaction of different components contributed by the chips of this wood. Similar, results have been reported in peach wine also (Joshi *et al.*, 2005). Although not appreciable, a small increase in reducing sugars in wood chips treated wine could be attributed to the absorption of sugar from the wood chips into the wine (Wilker and Gallander, 1988). Higher reducing sugars content in wine of 26ºB is apparently due to higher initial sugar concentration in the must. The increasing trend of reducing sugars is apparently the results of hydrolysis of non- reducing sugar into reducing sugar during maturation (Amerine *et al*., 1980) [2]. It is significant from taste quality of wine and is one of the desirable effects of maturation of wine. Similar results have been reported in wild apricot wine and peach wine (Joshi *et al*., 1990; Joshi and Shah, 1998) [14, 20, 17].

Decrease in total sugars might be due to the Maillard's reaction resulting in non-enzymatic browning due to reaction of sugar with amino acid during maturation (Zoecklein *et al.*, 1995) [40]. Similar results have been reported for total sugars for strawberry wine, plum low alcoholic wine (Sharma *et al.*, 2009; Gill *et al.*, 2009) [35, 10]. With respect to the decrease in total sugars content a similar trend on maturation of peach wine with wood chips of *Quercus*, *Bombax* and *Albizia* was observed (Joshi and Shah, 1998) [17].

The reduction in titratable acidity was found in all the wines. The possible reason for the decrease in acidity could be the precipitation of different acids in terms of their respective salts (Amerine *et al*., 1980) [2]. The decrease in titratable acidity is desirable in wines from more acidic fruits during maturation as it increases the palatability of wine (Joshi *et al*., 1999; Joshi and Pandey, 1999) [22, 15]. It was also observed that increase in pH is corresponding to the decrease in acidity. As there is inverse relationship between pH and acidity. Similar results have been reported in strawberry wine (Sharma and Joshi, 2004) [34].

Decrease in ethanol content during maturation is apparently the results of interaction between alcohols and acids to form esters (Amerine *et al.*, 1980; Zoecklein *et al.*, 1995) [2, 40]. It is desirable as total ester formation results in higher fruity flavour. The difference in alcohol content due to increase in sugar content and could be correlated. As honey contains other than fermentable sugar, hence produces lower amount of alcohol (Qureshi and Tamhane, 1986) [31].

The quantity of higher alcohols, irrespective of treatment, in general is quite low than the threshold value of 420mg/l (Amerine *et al.*, 1980) [2], above which these alcohol produce hang over (Fowles, 1989) [9]. Since in wild apricot fermentation nitrogen source was added, therefore, the level of higher alcohols was curtailed to a significantly lower level, which is quite desirable. Lower quantity of higher alcohols in wine of TSS 22, 24 and 26ºB could apparently related with fermentation behaviour of higher sugar content, where the substrates are diverted towards metabolite other than ethanol (Zoecklein *et al.*, 1995) [40]. Between wood chips, the difference for higher alcohol could be attributed to hydrolysis of various wooden components during maturation which might have altered the higher alcohols content. Further the increase in higher alcohols may be the result of transamination of amino acid, decarboxylation and reduction of particular keto acids (Wondra and Berovic, 2001) [39]

Increase in total esters during maturation is attributed to the phenomenon of aging (Amerine *et al*., 1980) [2]. Esters in general, have fruity and floral impact, characteristics that are important in sensory properties of wine. The amount of total esters in various wines ranged between 200 to 400 mg/l (Jackson, 2004; Amerine *et al*., 1980) [13, 2]. Wine esters are formed as a result of reaction between acetate and ethanol as well as other higher alcohols. Wines esters also arise from ethanol by reaction with straight chain fatty acid precursors (Zoecklein *et al.*, 1995; Joshi and Sandhu, 2000) [40, 16, 24]. Oxidation of ethanol into acetic acid and their interaction and the subsequent increase in the ester content of wine during maturation might have contributed to the increase of total esters (Castino *et al.*, 1993) [6]. Similar increase in total esters was observed by Joshi and Shah (1998) [17]. Increase in esters content of wine during maturation is desirable from sensory quality point of view.

Results indicated that during maturation, a significant decrease in total phenols or tannins took place. There was also a decrease in phenol concentration during storage of wines of various wood chips treatments. Among the interactions, there were significant differences. Decrease in phenol concentration might be due to the susceptibility of phenolic constituents to degradation, condensation and polymerization, and subsequent precipitation (Beridze, 1948; Somers, 1987). During ageing, tannin levels in wines decreased as a result of oxidation and precipitation with proteins (Zoecklein *et al.*, 1995) [40]. The decrease in total phenols is desirable as after their polymerization, palatability of the wine increases. But the range of total phenols found was higher than that reported for wood treated plum and apricot wines (Joshi *et al.*, 1994) [21]. The higher tannin contents in the wood treated wines than control attributable to extraction of both flavionoides and non-flavonoides phenolic compound from wood during maturation period (Quinn and Singleton, 1985; Wilker and Gallander, 1988; Deves, 1994; Joshi and Shah, 1998) [30, 38, 7, 17]. Among the pheolic acids examined only gallic acid increased among the wood treated wines and other phenols (protocatechuic acid, vanillic acid, Syringic acid and Ferulic acid) were found the same in the treated wines compared to the control wine during maturation (Wilker and Gallander, 1988; Joshi *et al*., 2000.) [16, 24]. Gallic acid levels may be related to hydrolysable tannins, as gallic acid is one of the hydrolytic products of ellagitannins, a type of hydrolysable tannin. Increase in gallic acid decreases the astringency (Quinn and Singleton, 1985) [30]. Similar decrease in total phenols were observed in pinotage wine during maturation with oak chips, but out of Gallic acid, Caftaric acid, Caffeic acid and Coutaric acid), gallic acid increased to 6 weeks of maturation then decreased (Beer *et al.*, 2008) [3].

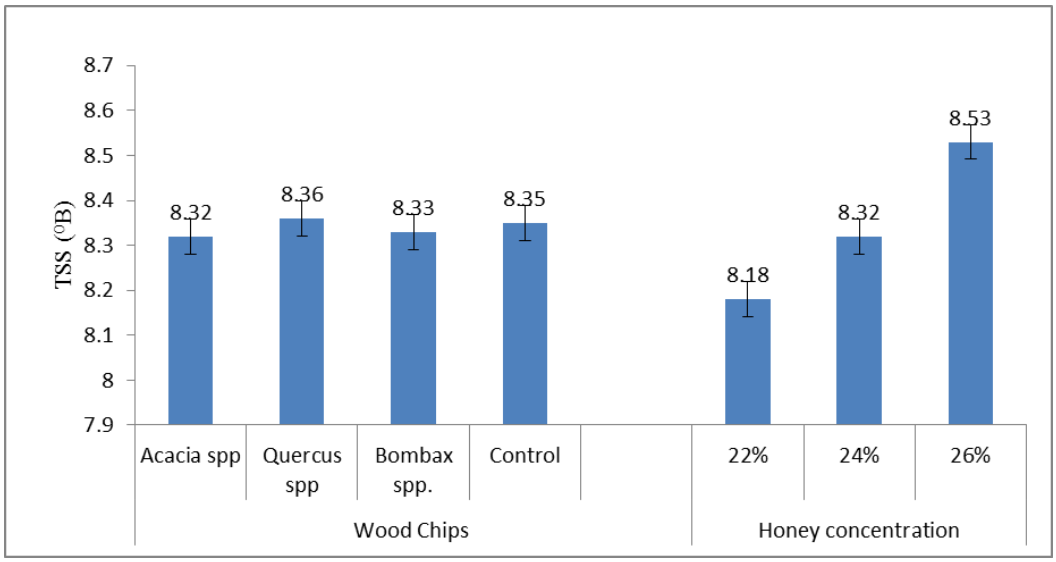

Fig 1: Effect of different wood chips maturation and honey concentration on TSS content of wild apricot mead

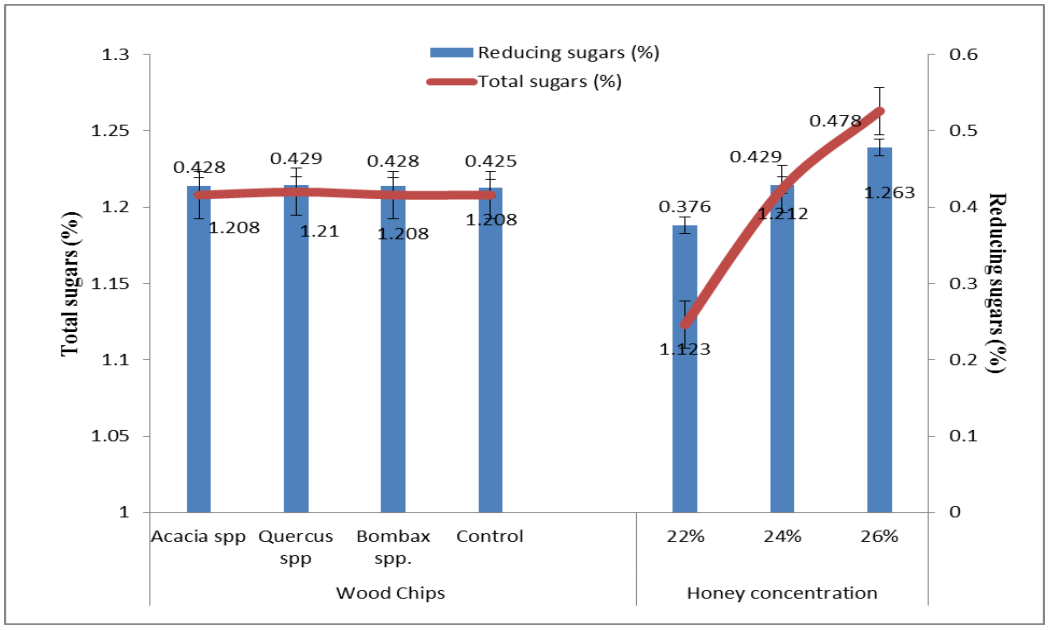

Fig 2: Effect of different wood chips maturation and honey concentration on Reducing sugars and Total sugars content of wild apricot mead

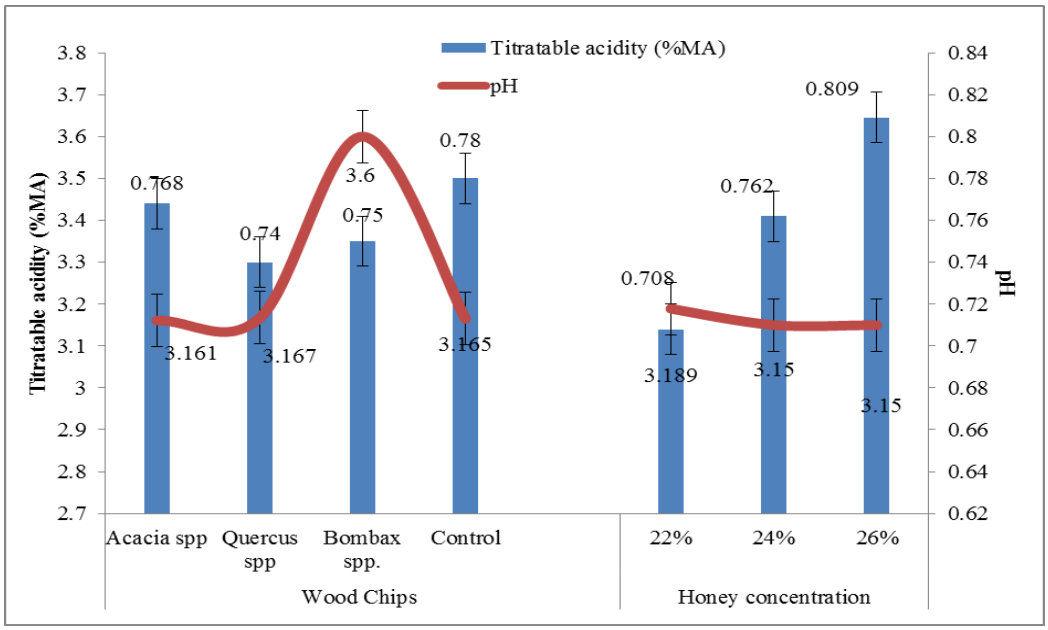

Fig 3: Effect of different wood chips maturation and honey concentration on Titratable acidity and pH of wild apricot mead

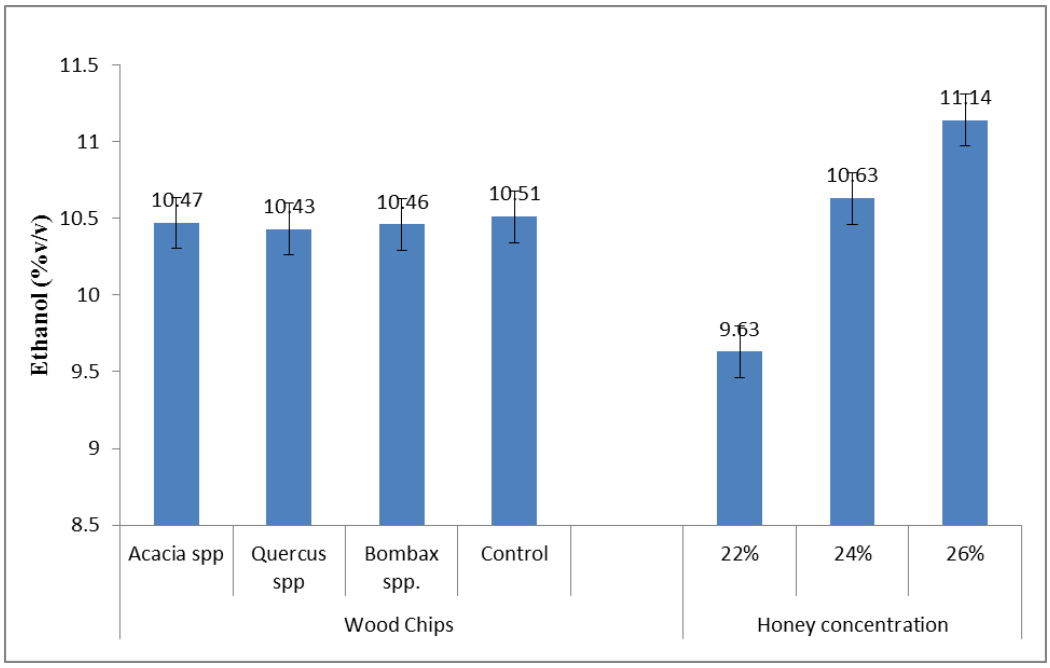

Fig 4: Effect of different wood chips maturation and honey concentration on ethanol content of wild apricot mead

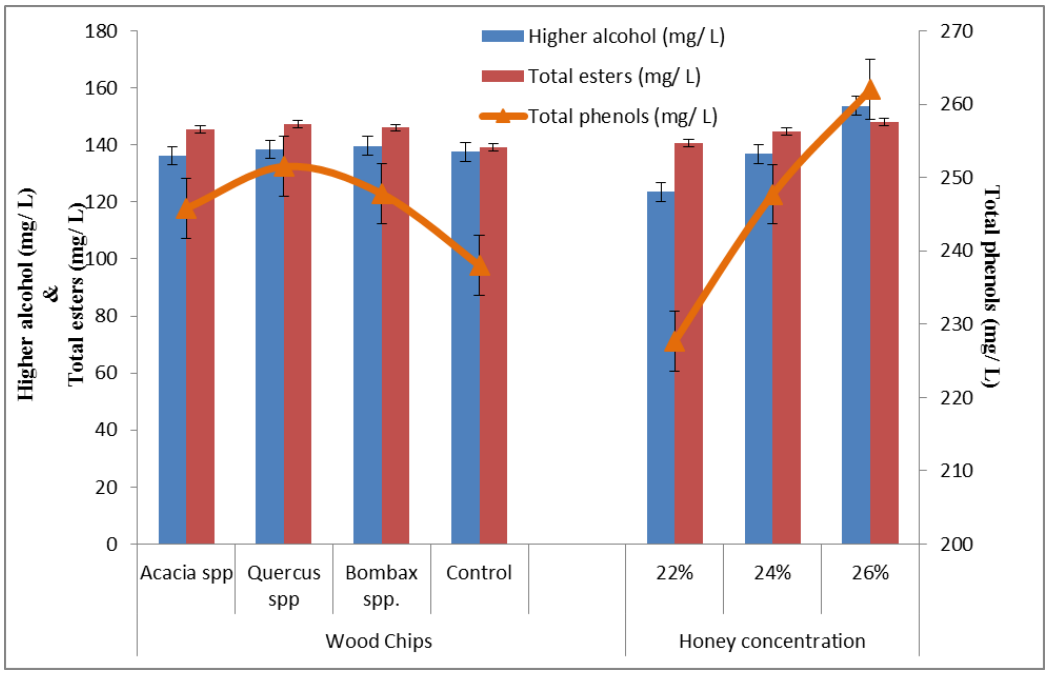

Fig 5: Effect of different wood chips maturation and honey concentration on higher alcohols, total esters and total phenols of wild apricot mead

Conclusion

Wild apricot mead is prepared by raising the TSS of "must" to 22, 24 and 26 °B by using honey and after completion of fermentation these are further matured with three different wood chips i.e. *Quercus*, *Bombax* and *Acacia*. Mead having initial TSS 26 ºB contained more reducing sugar, TSS, total esters, higher alcohols and ethanol content than the others after six months of maturation. During maturation decrease in TSS, total sugar, titratable acidity, ethanol and total phenols took place however, reducing sugar pH, higher alcohols and total esters increased during maturation. All the three wood chips treated wines were higher in total phenols, total esters and low in titratable acidity and ethanol content than the control, whereas, there was no effect of wood chips treatment on reducing sugars, total sugars and volatile acidity. *Quercus* treated wine was rated superior to others due to higher total esters, total phenols and reduced acidity. It is evident from the results of present study that wood chips have positive impact on mead maturation. During maturation, wine become more pleasant and wood chips played a major role for increasing tannin and total esters content.

Reference

1. AOAC. Assocation of Official Analytical Chemists. Official Methods of Analysis. Hortwitz, W. (ed.), 13th ed. Washington, D.C, 1980, 1015.
2. Amerine MA, Berg HW, Kunkee RE, Qugh CS, Singleton VL, Webb AD. The Technology of Wine Making, 4th edn. AVI Publishing Co., Inc. Westport, CT, 1980.
3. Beer D, Joubert E, Marais J, Toit W du, Fourie B, Manley M. Characterisation of pinotage wine during maturation on different oak products. South African Journal of Enology and Viticulture. 2008; 29(1):39-49.

4. Beridze GI. Vanodelie. Venegradartvo. 1948; 8(8):11
5. Caputi A, Ueda M, Brown J. Spectrophtometric determentaion of ethanol in wine. American Journal of Enology and Viticulture. 1968; 19:160-165.
6. Castino M, Crevero M, Ponzetto L. Some consideration on the use of barrels for aging of red wines. Enotecnico. 1993; 29(10):49-53.
7. Deves M. De mystifying oak. Australian and New Zealand Wine Industry Journal. 1994; 9(3):175-178.
8. Filipello F, Marsh GL. Honey wine. Journal Honey Wine. 1934; 14(40):42.
9. Fowles G. The complete home wine maker. *New Scientist.* 1989; 9:38-42.
10. Gill Amandeep. Evaluation of preservation methods of low alcoholic plum wine. Natural Product Radiance, 2009; 8(4):365-369.
11. Guymon JF, Nakagiri J. Methods for the determination of fusel oil. Proc. Am. Soc. Enol. 1952; 3(15):117-134.
12. Ioyrish N. Bees and people. Mir Puplisher, Moscow, 1974.
13. Jackson RS. 2nd ed. Wine Science; principles, practice and perception. Academic press, New York, 2004, 650.
14. Joshi VK, Bhutani VP. Evaluation of plum cultivars for wine preparation. In: International Horticulture Cong. held in Italy in Aug. 1990, 3336.
15. Joshi VK, Pandey A. In: Fruit Based Alcoholic Beverages, Biotechnology: Food Fermentation (Microbiology, Biochemistry and Technology), VK Joshi and A Pandey eds., Educational Publishers and distributors, New Delhi, India, 1999; II:719.
16. Joshi VK, Sandhu DK. Influence of ethanol concentration, addition of spices extract, and level of sweetness on physico-chemical characteristics and sensory quality of apple vermouth. Brazilian Archives of Biology and Technology. 2000; 43:537-545.
17. Joshi VK, Shah PK. Effect of wood treatment on chemical and sensory quality of peach wine during aging. Acta Alimentaria Budapest. 1998; 27(4):307-318.
18. Joshi VK, Sharma SK. Effect of method of must preparation and initial sugar levels on the quality of Apricot Wine. Journal of Science and Industrial Research. 1993; 39(4):255-257.
19. Joshi VK, Attri BL, Mahajan BVC. Production and evaluation of vermouth from plum fruits. Journal of Food Science and Technology. 1991; 28:138-141.
20. Joshi VK, Bhutani VP, Sharma RC. Effect of dilution and addition of Nitrogen source on chemical, mineral and sensory qualities of wild apricot wine. American Journal of Enology and Viticulture. 1990; 41(3):229-231.
21. Joshi VK, Mahajan BVC, Sharma KR. Treatment of fruit wines with wood chips- effect on physico-chemical and sensory qualities. Journal Tree Science. 1994, 27-36.
22. Joshi VK, Sandhu DK, Thakur NS. Fruit based alcoholic beverages. *In*: Biotechnology Food Fermentation, Joshi V K and Pandey Ashok eds. Asia tech Pub. House, New Delhi, 1999, 647-744.
23. Joshi VK, Shah PK, Kumar K. Evaluation of different peach cultivars for wine preparation. Journal Food Science and Technology. 2005; 42(1):83-89.
24. Joshi VK, Shah PK, Nath AK. The influence of addition of wood chips to peach wine on quantity and type of phenols. Acta Alimentaria, 2000; 37(312):23-26.
25. Kime RW, Lee CY. The use of honey in apple wine making. American Bee Journal. 1987, 270.
26. McGovern E Patrick, Zhang J, Tang J, Zhang Z, Gretchen R Hall, Moreau A Robert *et al*. Fermented beverages of pre- and proto-historic China Proceedings of the National Academy of Sciences. 2004; 101(51):17593-17598.
27. Molanar I Oura, Sumalainen H. Acta Alimentaria Academic Science. Hung. 1980; 9:35.
28. Parmar C, Kaushal MK. *Prunus armeniaca*. In: Wild Fruits. Kalyani Publishers, New Delhi, 1982, 66-69.
29. Parmar C, Sharma AK. Chulli: A wild apricot from Himalayan Cold Desert Region. Fruit Varieties Journal. 1992; 46(1):35-36.
30. Quinn KM, Singleton VL. Isolation and identification of elligitannin from white oak wood and an estimate of their roles in wines. American Journal of Enology and Viticulture. 1985; 36:148-155.
31. Qureshi N, Tamhane DV. Production of mead by immobilized cells of Hansenula anomala. Applied Microbiology and Biotechnology. 1986; 27:27-30.
32. Sharma JK. Morphological studies on apricot and its wild relatives. Journal Hill Research. 2000; 13(1):5-10.
33. Sharma SD. Variation in Local Apricots growing in Kinnaur of Himachal Pradesh (India). Varieties Journal. 1994; 48(4):225-228.
34. Sharma Somesh, Joshi VK. Flavour profiling of strawberry wine by quantitative descriptive analysis technique. Journal of Food Science and Technology. 2004; 41(1):22-26.
35. Sharma S, Joshi VK, Abrol G. An overview on Strawberry (*Fragaria* × *ananassa* (Weston) Duchesne ex Rozier) wine production technology, consumption, maturation and quality evaluation. Natural Product Radiance. 2009; 8(4):356-365.
36. Singleton VL, Rossi JA Jr. Colorimetry of total phenolics with phosphomolybadic phosphotungstic acid reagents. American Journal of Enology and Viticulture. 1965; 16:144-158.
37. Somers TC. Assessment of phenolic components in viticulture and oenology. *In*: Proceedings of Sixth Australian Wine Industry Technical Conference, Lee T *ed*. Adelaide Australia, Australian Industrial Publishers, 1987, 257-261.
38. Wilker KL, Gallander JF. Comparison of Seyval blanc wine aged in barrels and stainless steel tanks with oak chips. American Journal of Enology and Viticulture. 1998; 39:38-43
39. Wondra M, Berovi M. Analyses of aroma components of chardonnay wine fermented by different yeast strains. Food Technology and Biotechnology. 2001; 39(2):141-148.
40. Zoecklein BW, Fugelsang KC, Gump BH, Nury FS. Wine analysis and production. Chapman Hall, New York, 1995.