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Research Paper

Effect of Addition of Herbal Extract and Maturation on Apple Wine

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Abstract

Preparation of wine from surplus apple fruits can reduces postharvest losses besides source of income. Apple wine using different sources of sugars i.e. honey, sugar, molasses and jaggary to raise the TSS of must to 24°B was prepared as per routine procedure. To impart medicinal value, spices and herb extract of hops, menth, anola, ginger and garlic @5% each was added to the must. The apparent effect of addition of extract was to delay the fermentation, not to stop it. Physico-chemical characteristics of apple wine before and after 6 months of maturation showed that the addition of extract did not affect the quality of wine adversely. From the sensory quality point of view, extract treated honey based, concentrate based or concentrate + apple juice based wines were superior to the control apple wine in most of the sensory qualities. The highest score was awarded to honey + herbs and spices extract (5%) based wine. Addition of extract increased the aldehyde, esters and total phenols which are expected to contribute the antimicrobial and antioxidant activities of the wine. The changes during maturation were desirable and in general, were the same as found in any wine. During maturation, reducing sugars, total esters, titrable acidity, ethanol and volatile acidity increased significantly while total phenols deseased but there was no effect on TSS and no significant decrease in total sugars and higher alcohols took place.

Keywords: Apple wine, different sources of sugars, herbs and spices extract, *Saccharomyces cerevisiae* var. *ellipsoideus.*

Apple a highly delicious temperate fruit but due to its perishable nature, it has to be either stored or processed. The production of fruit wines can be one of the alternatives for its utilization, besides increasing the foreign exchange earnings by export and industrialization of the fruit belt (Joshi, 1995). Wine is the oldest known alcoholic beverage which traces its antiquity to at least 5000 B.C. It has long association with human artistic, cultural and religious activities. *Rigveda* one of the oldest *vedas* has also mentioned and is recognized as safe and healthful beverage and provides calories, proteins, vitamins and minerals. The antimicrobial and therapeutic value of herbs, honey and spices are well known from the time immemorial. Garlic, ginger, mentha and hops showed antimicrobial activity against different microorganisms like *Staphylococcus* spp., *Escherichia coli*, *Bacillus subtilis*, *Aspergillus* spp. and *Candida* spp (Efem *et al.*, 1992; Moleyar and Narasimham, 1992; Dalvi and Salunkhe, 1993). The effectiveness of ethanol in preventing the growth of microorganisms has not been documented in literature. There is also no information available on the addition of different sources of sugars to apple must and their acceptability. Similarly, the effect of addition of medicinal plants/extract to the apple wine has not been recognised especially effect on the physico-chemical and sensory quality. There is no report available on the effect of addition of herbs and spices extract to the wine though a vermouth (fortified wine) with spices and herbs extract has been prepared from apple (Joshi and Sandhu, 2000; Panesar *et. al.*, 2009). In our earlier attempts effect of different concentrations of spices and herbal extract on fermentation behaviour was reported. (Joshi, 2009) An attempt made to prepare an apple wine with addition of different sugar sources and spices and herbal extract and evaluated as reported in this paper.

Materials and Methods

Raw material

Apple fruits of cultivar Golden Delicious were obtained from the local Solan market. Fruits were washed followed by grating and the juice was extracted with the help of hydraulic press. The juice was then, filtered with the help of a muslin cloth and pasteurized in crown corked bottles for further use. Apple juice concentrate used in the study was manufactured by hpmc at Parwanoo plant (HP), India. Honey, sugar, molasses and jaggery used to ameliorate the apple must for the studies were procured locally. The pectin esterase enzyme used in the studies was manufactured by M/S Triton Chemicals, Mysore, India under the brand name "Pectinol".

Yeast culture

The yeast culture viz. *Saccharomyces cerevisiae* var. *ellipsoideus*, (UCD 595) used in the study was originally obtained from the 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.

Preparation of spices extract

The garlic extract was prepared by removing the skin and washing, followed by crushing in the mixer. Afterwards, it was centrifuged and supernatant was taken. For ginger same procedure was followed. Aonla extract was made from the dried aonla. First, aonla was washed and extraneous materials were removed and juice was extracted after soaking in water for four hours. For mentha extract, the leaves were washed, then crushed in the mixer and the supernatant was taken, while in the case of hops the extract was prepared by boiling the female flowers of hops in the apple wine at a low temperature (50-55^{o}C) for the proper extraction of resins and other volatile compounds.

Preparation of the must

Apple juice was used to prepare apple must and its TSS was raised to 24°B by the addition of sugar syrup, jaggery, honey or apple juice concentrate depending upon the treatment. Different extracts as outlined earlier were added into the must at a concentration of 5% each *i.e.* hops extract, mentha, aonla, ginger and garlic extract except the control. To each treatment, pectinol and diammonium hydrogen phosphate at the rate of 0.5 and 0.1 per cent, respectively and sulphur dioxide in the form of potassium metabisulphite was added at the rate of 100 ppm. Musts were kept overnight before being inoculated with the active yeast culture.

Fermentation

Fermentation was initiated by addition of active yeast culture of *S. cerevisiae* var. *ellipsoideus* @ 5% at a temperature of 22±1^{o}C. When no further loss in TSS took place, the fermentation was considered as complete. Balloons were fitted in the mouth of the glass jars near the end of fermentation, to avoid any acetification. It was followed by siphoning/racking and filtration. All the wines were racked initially after every fifteen days and then, after one month. During fermentation, fall in TSS (^{o}B), titratable acidity and ethanol concentration of extracts were monitored. Based on the results, the concentration of extract that would not affect fermentability and physico-chemical characters were worked out. After the completion of fermentation, the wines were siphoned/ racked and kept for maturation in glass bottles for 6 months. Before starting the maturation, SO_2 in the form of KMS was added at the rate of 50ppm.

Physico-chemical analysis of juice and wine

pH was taken with ELTOP-3030 pH meter. Prior to pH measurement, the instrument was standardized with the buffer solution of pH 4 and 7. Lovibond Tintometer Model-E was used to measure the colour of the wine using one inch cell. The colour was expressed as red, yellow and blue units. Total soluble solids (TSS) of apple juice, must and wine were measured using Erma hand refractometer (0-32°B). The results were expressed as degree Brix (^{o}B). The readings were corrected by applying the correction factor for the temperature variation (AOAC, 1980).

Titratable acidity (% malic acid) was estimated by titrating a known aliquot of the sample against N/10 NaOH solution using phenolphthalein as an indicator (AOAC, 1980). The total and reducing sugars were estimated by Lane and Eynons volumetric method (Ranganna, 1986) by titrating against Fehling's solutions (before and after hydrolysis). Quantity of ethanol was estimated by spectrophotometric method (*Caputi et. al.*, 1968), whereas, fusel oil (higher alcohols) in wine was estimated by the standard method Guymon and Nakagiri (Guymon and Nakagiri, 1952). Volatile acidity was determined by the standard method (*Amerine et. al.*, 1980). The distillate was titrated with 0.025 N NaOH and the volatile acidity was expressed by acetic acid (g/100 ml). The total phenols or tannin contents in different wines were determined by Folin-Ciocalteu procedure given by Singleton and Rossi (Singleton and Rossi, 1965). The total aldehyde contents as acetaldehyde present in wines were estimated by the method of Amerine and Ough (Amerine and Ough, 1979). Total esters in different apple wines were determined as per the method of Liberaty (Liberaty, 1961).

Sensory analysis

The sensory analysis of different wines was conducted by a panel of 10 judges. Chilled and coded samples of wine were given to the judges. They were asked to rinse their mouth with water before or in between tasting the given sample. Each sample was evaluated for various quality attributes on the prescribed performa (Amerine *et. al.*, 1980); (Joshi and Sandhu, 2000)

Statistical Analysis

Depending upon the requirements, the statistical analysis of the data was carried out. The data of physico-chemical studies were analysed by completely randomized design (CRD) with or without factors (Cochran and Cox, 1963). Data of sensory analysis generated by different experiments in general were analysed by randomized block design (RBD) as per the recommended methods (Mahony, 1985).

Results and Discussion

Physico-chemical characteristics of apple juice

The results on physico-chemical characteristics of apple juice, show that it had medium titrable acidity (0.382% MA), total soluble solids (14.17°B), sugars (13.40%) and reducing sugars (8.63%) and pH of 3.22. Since the juice had only 13 per cent sugar so to make a table wine amelioration of juice with sugar is needed. A TSS of normally 24°B for preparation of apple wine is recommended (Amerine *et al.*, 1980) (Joshi *et al*, 1991). For effective alcoholic fermentation, pH of the juice should be below 4 as reported by Amerine *et al.* (Amerine *et. al.*, 1980) The pH of apple juice in our studies was also below 4 and is therefore desirable. The pH being suitable for alcoholic fermentation, would not call for any correction in titratable acidity of juice therefore no additional acid was

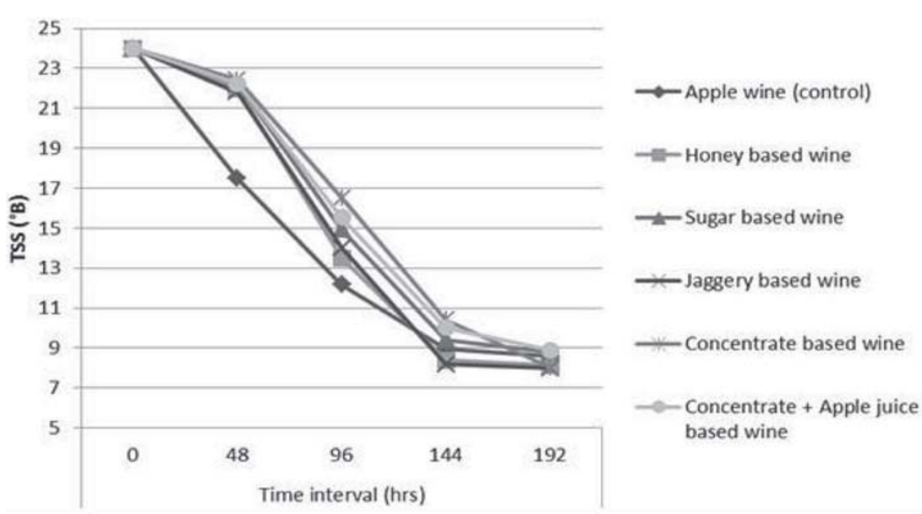

Fig. 1: Change in total soluble solids of apple must of different treatments during fermentation

added. The various colour units indicated yellow colour as the dominant colour while the red colour was minor component (2.03) and blue negligible (0.10).

Fermentation behaviour

In general, TSS decreased in all the musts, evidently due to fermentation of sugar by the yeast (Fig. 1). It is a normal trend in any alcoholic fermentation for wine making. It is also clear that upto 144 hours, the fermentation was fast (as shown by TSS reduction) followed by a decline and subsequent stabilization indicating consumption of all fermentable sugar and completion of fermentation. In the initial stage (upto 48 hours), the must of all the wines except control showed a slow reduction in TSS and later on all the musts witnessed a fast reduction in TSS. During ethanolic fermentation at first 48 hrs, the yeast increase in number and then, in the anaerobic environment the alcoholic fermentation was conducted (Fleet, 1994).

The concentrate based wine had slowest reduction in TSS while the control wine had the fastest reduction. Jaggery based wine showed significantly the lowest TSS after 192 hours followed by honey wine, while the highest TSS was recorded in concentrate based wine. The trend continued throughout the fermentation of the apple based wines. The initial slow decrease in TSS in herbs/spice blended must might be the cumulative inhibitory effect of different herb/ spice extracts on yeast growth but later on (48 hrs) yeast might have acclimatized to the conditions resulting in faster decrease in TSS as described earlier. After 144 hr, the decrease in TSS was slow because of depletion of sugar and the higher ethanol content exerting inhibitory effect on the fermentability (Nishino *et.al.*, 1985; Mata *et.al.*, 1984; Joshi and Sharma, 1994). Processing techniques can alter the composition of juice (Downing, 1989) and may be due to this the slow fermentation rate in apple juice concentrate based wine was observed. As with the TSS reduction, control apple must (without spices extract) had the highest rate of fermentation, while the lowest rate was in concentrate based must (at par with each other). The lower RF in case of wine blended with spice/herb is apparently due to the inhibitory effect of substances coupled with availability of nutrients like fermentable sugar and the amino acids for completion of alcoholic fermentation by the yeast. Based upon these findings, it is apparent that addition of extracts did slow down the fermentation but the effect was comparatively less in honey/jaggery based wines, which was almost comparable to the original must. Further, Efem *et al.* (1992) and Hass and Barsoumian (Hollebeek *et.al.*, 2007) reported that honey was antimicrobial activity against yeast as the case is with hops resins. But, the inhibitory effect might have been compensated by the avaibility of more fermentable sugar available in honey based apple must. The rate of fermentation after the completion of fermentation, however, shows, jaggery based must ranking the highest followed by honey and control wines. Nevertheless, the inhibitory effect at the concentration of spices extract selected did allow the fermentation of apple must to complete. The apparent effect was delaying the fermentation to some extent.

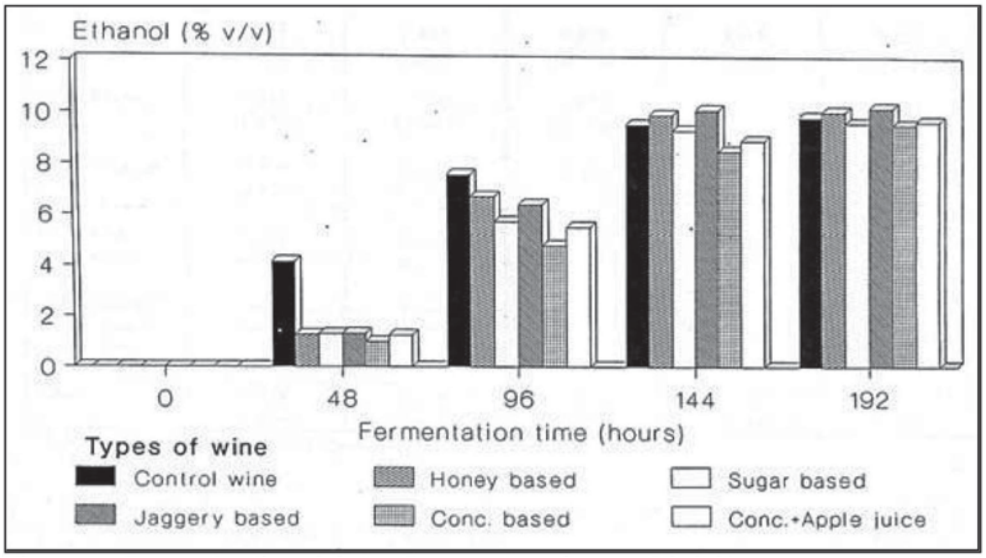

Fig. 2: Changes in ethanol during fermentation of must with different sugar sources

As expected, with the increase in time of fermentation, the ethanol content registered an increase (Fig. 2) in all the 6 musts. The trend continued upto 192 hrs. At the end of fermentation (192 hr), the ethanol content of jaggery based wine was the highest followed by honey based wine while that of concentrate based wine was the lowest. The results are in conformity with their respective mean fall of TSS and rate of fermentation. The trend of ethanol increase or TSS decrease during fermentation discussed earlier was similar to the fermentation of any other fruit to make a wine (Amerine *et. al,* 1980; Joshi and Blutani, 1990).

It is clear that from the very initial stages that the concentrate based wines had higher titratable acidity and the trend continued throughout the fermentation (Table 1). It also had the highest titratable acidity and lowest pH at the end of fermentation (Table 3). The control wine had the lowest titratable acidity. However, at the end of fermentation, titratable acidity was nearly maintained in all the wines except concentrate based. The increment of titratable acidity during fermentation is attributed to the production of different organic acids as observed in banana wine earlier (Kundu *et. al.*, 1976). The higher acidity of concentrate based wine is due to the higher initial acid contents of apple juice concentrate used in the must preparation (Joshi and Sandhu, 1997). The addition of spices/herbs did not affect the titratable acidity prior or after fermentation, as the addition of concentrate only increased the titratable acidity. Irrespective of the musts, the pH remained below 4.00, which is considered suitable for the ethanolic fermentation (Amerine *et. al.* 1980). There is no limit for the titratable acidity of the musts, though it is very important in the sensory quality of the wine and is directly related with taste perception.

Based on the results on the fermentability of apple must with different sugar sources, it is concluded that addition of extract with different sugar sources like honey, jaggery, apple juice concentrate and cane sugar did not affect the fermentation rate, alcohol content, TSS and titratable acidity in the wines adversely, although compared to the control the fermentability was reduced to some extent.

Effect of treatments on physico-chemical characteristics of apple wine

Total soluble solids were significantly different in different treatments and the highest TSS was found in case of concentrate based wine and the lowest in case of jaggery based wine (Table 2). The higher TSS of concentrate based wine is due to the low fermentability of the must discussed earlier. Joshi and Bhutani (Joshi and Bhutani, 1991) observed that TSS in apple wine varied from 6-8^{o}B. There was also a significant difference in total and reducing sugars content in different wines. The highest total and reducing sugars were found in concentrate based wine, while the lowest in case of honey based wines. Kime and Lee (1987) and Joshi and Bhutani (1991) observed that reducing sugar content in apple wine varied from 0.1 - 0.4 per cent. Lower reducing sugar concentration also indicates the completion of fermentation. Titratable acidity and pH of wines of different treatments were significantly different. The concentrate based wine had the highest acidity and pH while apple wine (control) showed the lowest. The higher titratable acidity of apple juice concentrate based wines is due to the higher

Table 1: Changes in titratable acidity (% MA) of apple must with different sugar sources during fermentation

Treatment	Time interval (hrs)					
	0	48	96	144	192	Mean
Apple wine (control)	0.383(0.619)	0.427(0.653)	0.433(0.658)	0.450(0.671)	0.460(0.678)	0.431(0.656)
Honey based wine	0.387(0.622)	0.443(0.666)	0.450(0.671)	0.457(0.676)	0.463(0.681)	0.440(0.663)
Sugar based wine	0.385(0.621)	0.440(0.663)	0.473(0.688)	0.473(0.688)	0.480(0.693)	0.450(0.671)
Jaggery based wine	0.389(0.624)	0.450(0.671)	0.460(0.678)	0.477(0.690)	0.480(0.693)	0.451(0.671)
Concentrate based wine	0.492(0.701)	0.510(0.714)	0.520(0.721)	0.535(0.732)	0.512(0.716)	0.514(0.717)
Concentrate + Apple juice based wine	0.473(0.688)	0.480(0.693)	0.500(0.710)	0.513(0.716)	0.497(0.710)	0.493(0.702)
Mean	0.418(0.646)	0.458(0.677)	0.473(0.687)	0.484(0.694)	0.482(0.696)	

**Values in parentheses are the transformed values, M.A = Malic acid*

$CD_{0.05}$

Treatment	=	0.005
Time interval	=	0.005
Treatment x Time interval	=	0.117

Table 2- Changes in pH of apple must with different sugar sources during fermentation

Treatment	Time interval (hrs)					
	0	48	96	144	192	Mean
Apple wine (control)	3.24	3.22	3.20	3.19	3.17	3.21
Honey based wine	3.23	3.20	3.19	3.19	3.17	3.19
Sugar based wine	3.23	3.22	3.19	3.19	3.19	3.20
Jaggery based wine	3.22	3.20	3.19	3.18	3.18	3.19
Concentrate based wine	3.18	3.17	3.16	3.15	3.16	3.17
Concentrate + Apple juice based wine	3.19	3.18	3.16	3.16	3.19	3.17
Mean	3.21	3.20	3.18	3.18	3.18	

$CD_{0.05}$
Treatment = 0.010
Time interval = 0.009
Treatment x Time interval = NS

Table 3- Effect of treatments on physico-chemical characteristics of apple wine

Treatment	TSS (°B)	Reducing sugar (%)	Total sugar (%)	Titratable acidity (%M.A)	pH	Volatile acidity (% A.A)	Total aldehyde (mg/l)	Total esters (mg/l)	Total phenols (mg/l)	Higher alcohol (mg/l)	Alcohol (% v/v)
Control apple wine	7.50	0.260 (0.507)	1.897 (1.380)	0.371 (0.609)	3.26	0.021 (0.145)	41.20	76.80	124.50	197.70	10.50 (3.23)
Honey based wine	7.20	0.250 (0.496)	1.790 (1.340)	0.380 (0.618)	3.24	0.020 (0.141)	47.25	90.80	229.00	175.00	10.67 (3.25)
Sugar based wine	7.30	0.250 (0.496)	2.120 (1.450)	0.380 (0.618)	3.46	0.020 (0.141)	44.90	88.20	230.00	186.00	10.27 (3.25)
Jaggery based wine	6.30	0.250 (0.496)	1.880 (1.370)	0.380 (0.618)	3.22	0.021 (0.145)	45.00	89.90	225.00	183.70	11.27 (2.36)
Concentrate based wine	7.80	0.290 (0.540)	2.170 (1.470)	0.460 (0.682)	3.18	0.023 (0.149)	50.86	98.50	220.00	190.00	10.23 (3.21)
Concentrate +apple juice based wine	7.70	0.270 (0.538)	2.130 (1.460)	0.450 (0.670)	3.19	0.024 (0.153)	47.90	92.97	236.00	192.00	10.43 (3.23)
Mean	7.31	0.26 (0.51)	1.99 (1.41)	0.405 (0.630)	3.27	0.023 (0.146)	46.20	89.52	211.00	184.20	10.57 (3.25)
CD(0.05)	0.152	0.016	0.044	0.009	0.106	0.007	2.09	2.95	2.58	14.99	0.03

**Figures in parentheses are transformed values.* *M.A. = Malic acid*

initial acid content of the apple juice concentrate (Joshi *et al.*, 1991). The acidity of fruit wine depends upon the type of fruit and its variety used for the preparation of wine (Singh and Manjrekar, 1975). Overall, the pH mostly corroborated with the acidity of wine, in terms of absolute values the pH remained less than 4.00 there by eliminating the chances of spoilage.

The volatile acidity of different wines was significantly different (Table 3). Volatile acidity was the highest in case of concentrate + apple juice based wine, while the lowest was found in sugar and honey based wines, which were found to be at par. Addition of extract did not influence the volatile acidity of the wines made with different sugars. It being an important quality parameter lack of any change due to addition of extract is desirable. Total aldehyde content of different wines were significantly different. The highest aldehyde content was observed in case of concentrate based wine and the lowest was observed in case of apple wine control. The aldehyde content of grape wine has been found to range between 100-125 mg/l (Joshi *et. al.*, 1991). The aldehyde content of different apple based wines were found to be within the range as reported earlier by Amerine *et. al.*, (1980) and Joshi and Sandhu (1997). A small increase in the aldehyde content of wines made from apple must with addition of extract as compared to control wine might be the contribution of essential oils of herbs/spices used in the preparation of musts which are known to consist of aldehydes besides other organic compounds, as reported earlier (Wildeuradt and Caputi, 1977). Similar aldehyde contributions to the wines have been observed to take place in the preparation of vermouth from grape and plum (Amerine *et.al.*, 1980) (Joshi *et.al.*, 1991).

Total ester content of different wines was significantly different. The highest ester content was found in case of concentrate based wine, while the lowest in the case of apple wine (control). The ester content in wine varied from 200-400 mg/l as ethyl acetate. Joshi *et al.* (Joshi *et al.*, 1991) reported that addition of spice/herbs extract increased the ester contents in plum vermouth. Total phenols in the wines were significantly different (Table 3). The highest phenol content was found in case of concentrate + apple juice based wine and the lowest in case of control wine. The increased phenol content in the extract treated wines is apparently the contribution of extracts. Amerine *et al.* (Amerine *et al.*, 1980) observed that phenols in grape wine varied from 2000-6000 mg/l while in case of apple wine it varied from 85 mg to 1250 mg/l as tannic acid. In general, increased phenolic content in extract treated wines might have been contributed by different extracts used in the wine making. According to Sastry *et al.* (Singleton and Asau, 1969) aonla extract is rich in phenolics and its addition might have increased the phenols. Joshi *et al.* (Joshi *et al.* 1991) also recorded an increase in phenolic content in the vermouth as a result of addition of spices and herb extract. Higher alcohol content in different wines was non-significant. Guymon and Heitz (Guymon and Heitz 1952) reported that higher alcohol content in table wines vary from 0.14-0.42 g/l. The results show that the higher alcohol contents in the wines was within the level as reported earlier by Amerine *et al.* (Amerine *et al.* 1980) Lesser quantity of higher alcohol denotes the non-oxidative conditions and proper storage of the wine (*Guymon et.al.*, 1961). The ethyl alcohol content of the different wines differed significantly (Table 3). The highest ethyl alcohol content was found in case of jaggery based wine and the lowest in case of concentrate based wine. Joshi and Bhutani (Joshi and Bhutani, 1991) and Kim and Lee (Kim and Lee, 1987) observed that ethanol content in apple wine varied from 9-11 per cent. It could go, however, upto 14 per cent as a table wine (Warning, 1989).

Effect of maturation

Total sugars recorded a non-significant decrease while reducing sugar in different wines during maturation increased significantly. The increasing trend of reducing sugar is apparently the result of hydrolysis of total sugars during maturation (*Amerine et. al.*, 1980). No significant effect on total sugars took place and is on the expected lines and indicates that wines have been preserved during maturation without any microbial spoilage, due to the correct quantity of sulfur dioxide during maturation. During maturation, changes in TSS was non-significant. The increase in ethanol content also confirms these results.

Table 4: Changes in total sugar, reducing sugar and pH of different wines during maturation

Treatment	Total sugar (%)			Reducing sugar (%)			pH		
	0 hour	6 month	Mean	0 hour	6 month	Mean	0 hour	6 month	Mean
Control apple wine	1.89(1.38)	1.86(1.36)	1.88(1.37)	0.26(0.51)	0.28(0.53)	0.27(0.52)	3.26	3.33	3.29
Honey based wine	1.79(1.34)	1.74(1.32)	1.76(1.33)	0.25(0.50)	0.28(0.53)	0.26(0.51)	3.24	3.26	3.25
Sugar based wine	2.12(1.45)	2.06(1.43)	2.09(1.44)	0.25(0.50)	0.31(0.56)	0.28(0.53)	3.46	3.35	3.40
Jaggery based wine	1.88(1.37)	1.81(1.34)	1.85(1.36)	0.25(0.50)	0.30(0.55)	0.27(0.52)	3.22	3.26	3.24
Concentrate based wine	2.17(1.47)	2.08(1.44)	2.12(1.46)	0.29(0.54)	0.33(0.57)	0.31(0.55)	3.18	3.22	3.20
Concentrate + apple juice based wine	2.13(1.46)	2.07(1.44)	2.10(1.45)	0.27(0.52)	0.31(0.56)	0.29(0.54)	3.19	3.21	3.20
Mean	1.99(1.41)	1.93(1.39)		0.26(0.51)	0.30(0.55)		3.27	3.26	

**Figures in parentheses are transformed values, M.A. = Malic acid*

Effect	$CD_{0.05}$			
Treatment	=	0.044	0.016	0.106
Maturation	=	0.025	0.009	0.061
Treatment x maturation	=	NS	NS	0.015

Table 5- Average changes in volatile acidity, titratable acidty and total soluble solids (TSS) of different wines during maturation

Treatment	Volatile acidity (% A.A.)			Titratable acidity (% M.A.)			TSS (°B)		
	0 hour	6 month	Mean	0 hour	6 month	Mean	0 hour	6 month	Mean
Control apple wine	0.021(0.145)	0.022(0.149)	0.022(0.147)	0.371(0.609)	0.368(0.607)	0.370(0.608)	7.500	7.400	7.430
Honey based wine	0.020(0.141)	0.022(0.149)	0.021(0.144)	0.380(0.618)	0.380(0.618)	0.380(0.618)	7.200	7.100	7.200
Sugar based wine	0.020(0.141)	0.021(0.145)	0.021(0.143)	0.380(0.617)	0.380(0618)	0.380(0.618)	7.300	7.400	7.370
Jaggery based wine	0.021(0.145)	0.022(0.149)	0.022(0.147)	0.380(0.618)	0.377(0.614)	0.380(0.616)	6.300	6.000	6.180
Concentrate based wine	0.023(0.149)	0.024(0.156)	0.023(0.153)	0.460(0.682)	0.460(0.682)	0.460(0.682)	7.800	7.500	7.650
Concentrate + apple juice based wine	0.024(0.153)	0.027(0.164)	0.025(0.159)	0.450(0.670)	0.450(0.670)	0.450(0.670)	7.700	7.500	7.620
Mean	0.023(0.146)	0.214(0.152)		0.405(0.630)	0.401(0.630)		7.310	7.160	

**Figures in parentheses are transformed values* *M.A. = Malic acid*

Effect	$CD_{0.05}$			
Treatment	=	0.007	0.009	0.152
Maturation	=	0.004	NS	0.087
Treatment x maturation	=	NS	NS	0.214

Table 6- Average changes in total phenols, aldehyde and total esters contents of different wines during maturation

Treatment	Total phenols (mg/l)			Total aldehydes (mg/l)			Total esters (mg/l)		
	0 hour	6 month	Mean	0 hour	6 month	Mean	0 hour	6 month	Mean
Control apple wine	124.5	123.7	124.1	41.2	52.6	46.9	76.8	101.7	89.2
Honey based wine	229.0	227.7	228.3	47.2	60.8	54.0	90.8	112.0	101.4
Sugar based wine	230.0	228.0	229.5	44.9	58.1	51.5	88.2	111.0	99.58
Jaggery based wine	225.0	222.0	223.7	45.0	56.1	50.5	89.9	120.0	104.9
Concentrate based wine	220.0	219.0	219.7	50.8	67.5	59.2	98.5	132.3	115.4
Concentrate + apple juice based wine	236.0	235.0	235.8	47.9	61.7	54.8	92.9	122.0	107.6
Mean	210.9	209.4		46.18	59.50		89.562	116.6	

Effect	$CD_{0.05}$			
Treatment	=	2.58	2.09	2.95
Maturation	=	1.49	1.21	1.70
Treatment x maturation	=	3.65	2.96	4.17

Table 7: Average changes in ethanol and higher alcohol of different wines during maturation

Treatment	Ethanol (% v/v)			Higher alcohols (mg/l)		
	0 hour	6 month	Mean	0 hour	6 month	Mean
Control apple wine	10.53(3.23)	10.60(3.25)	10.57(3.24)	197.7	194.0	196.0
Honey based wine	10.67(3.27)	10.77(3.29)	10.72(3.28)	175.0	180.0	177.8
Sugar based wine	10.27(3.25)	10.40(3.22)	10.33(3.23)	186.0	196.0	191.0
Jaggery based wine	11.27(3.36)	11.60(3.38)	10.43(3.37)	183.7	195.0	189.0
Concentrate based wine	10.23(3.21)	10.47(3.25)	10.35(3.23)	180.0	181.0	180.7
Concentrate + apple juice based wine	10.43(3.23)	10.63(3.26)	10.53(3.24)	182.0	187.7	185.0
Mean	10.57(3.25)	10.74(3.28)		184.2	189.0	

**Figures in parentheses are transformed values*

Effect	$CD_{0.05}$		
Treatment	=	0.030	14.99
Maturation	=	0.017	8.65
Treatment x maturation	=	NS	NS

During maturation, changes in titratable acidity and pH of the different wines are non-significant (Table 4 and 5). A slight increase in titratable acidity might have occurred due to evaporation of water from the wine during maturation as reported earlier (*Amerine et. al.,* 1980). The volatile acidity changed significantly during maturation (Table 5) but it ranged in different wines from 0.02-0.27 per cent indicating the soundness of wine during maturation (Amerine *et. al.,* 1980).

A significant decrease in total phenols or tannins was observed during aging (Table 6). Decrease in tannin content during maturation may be due to complexion of tannins with proteins or their polymerization and subsequent precipitation as observed (Sonia *et. al.*, 1980). The aldehyde content increased significantly during maturation in different wines and varied between 41-67.5 mg/l. Amerine *et al.* (1980) reported that during aging aldehyde content increased in wine which has sensory importance also. non-significant which indicates the proper storage conditions during maturation of wine i.e. maintenance of non-oxidative conditions during aging (Guymon, *et. al.*, 1961).

Sensory evaluation of wine

In Fig. (3), the numerical scoring of sensory qualities of different apple based wines is shown. It is evident that honey based wine scored the highest for almost all the quality attributes, except aroma and bouquet, bitterness and astringency in which the concentrate based wine control apple wine (without extract) and concentrate + apple juice based wine showed maximum score. The overall score also showed that honey based wine is more acceptable followed by concentrate + apple juice based wine, while, the lowest sensory scores were awarded to jaggery based wine. The low score awarded to jaggary based wine is attributed to the dominant undesirable jaggery flavour. The

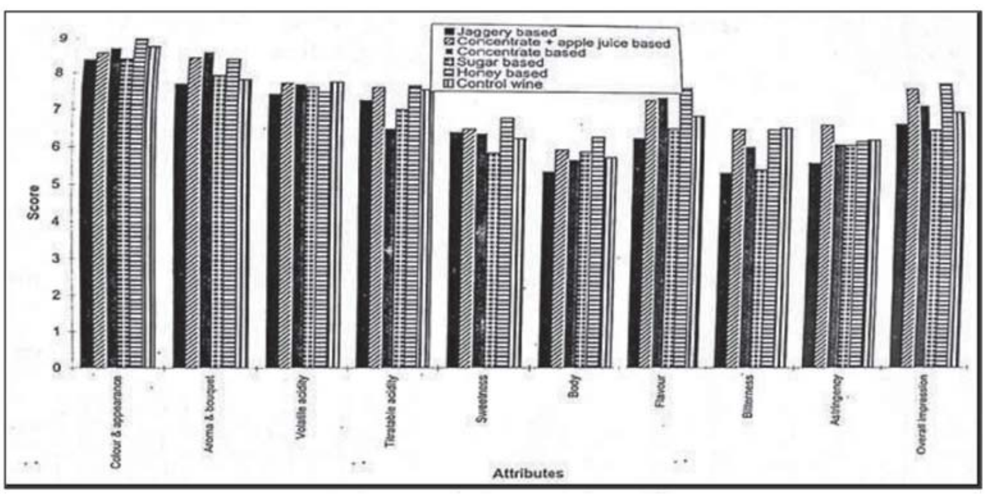

Fig. 3: Sensory numerical scoring of wines made from different sugar sources

Similarly, total esters of different wines were significantly different during maturation. Increase in total esters during maturation is attributed to the phenomenon of aging (Amerine *et. al.* 1980) and is desirable for the development of proper flavour. The ethanol contents of the wines were also significantly increased during maturation (Table 7) but increase in ethanol in absolute terms is not appreciable. This might be due to the post maturation fermentation as the total sugar showed a decreasing trend. However, during maturation changes in higher alcohol were found to be highest acceptability of honey based wine is due to the pleasant and desirable fruity scores in regard to both flavour and aroma. Better flavour and the high clarity of honey based wine might be a reason for better acceptability compared to the control wine, improvement in the flavour and aroma of the apple wine as a result of additon of spices and herbal extract. Therefore, from the sensory quality improvement point of view, the addition of extract is considered advantageous. Lee and Kim (1987) also of reported that proteins in honey are responsible for clarifying the juice and resulting in production of wine from honey with better clarity. Besides the other quality attributes like colour and appearance, body, sweetness and volatile acidity were also desirable level in the honey based wine than other wines. It was followed by concentrate + apple juice based wine in overall quality.

Conclusion

An over-view of the physico-chemical and sensory attributes of the wine showed that the wines prepared with extract were higher in phenolics, esters, aldehyde contents as compared to the control wine. During maturation of the wines, an increase in esters aldehydes and ethanol was observed, while the titratable acidity, phenols and higher alcohol were not changed significantly showing the soundness of wine. Among the different wines, concentrate based wine had the highest ester content, while total phenols were highest in concentrate + apple juice based wine and for alcohol jaggery based wine had the highest. Lowest amount of aldehyde was found in case of control apple wine. From the sensory point of view, extract treated honey based, concentrate based or concentrate + apple juice based wines were superior to the control apple wine in most of the sensory qualities. Sugar based and jaggery based wines did not score to the same extent compared to the control wine. However, all the wines were found to be acceptable. It is concluded that addition of extract improved both the physico-chemical characteristics as well as sensory quality of wine.

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