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Functional properties of rich sweet vermouth from wild apricot fruits

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Wild apricot fruit (*Prunus armenica* L.) found grown naturally in hilly areas of northern India. The fruit is highly acidic, fibrous but good in TSS (°B) and thus, not utilized commercially. However it is used in the preparation of traditional distilled alcoholic beverage *moori* which is not only higher in methanol (2268.35 mg/L) but also in microbial pathogens. The present study was conducted to prepare wild apricot sweet vermouth having different alcohol levels (15, 17 and 19%), different sugar levels (8, 10 and 12°B) and spices and herbal extract levels (2.5 and 5.0%). The base wine prepared from wild apricot fruits found to posses better antioxidant activity and total phenols over traditional drink *moori.* Further, the base wine contained residual sugars, desirable acidity, proper amount of TSS, low volatile acidity and satisfactory amount of total phenols and total esters and hence was found suitable for vermouth preparation. Out of three different alcohol levels used, the highest TSS, ethanol, higher alcohols and total esters were found in 19% alcohol level vermouth whereas, total sugars, titratable acidity and total phenols were recorded in 15% alcohol level wild apricot vermouth. Out of three different sugar level used, vermouth having 12% sugar had the highest TSS, reducing sugars, total sugars and total esters as well as total carotenoids. Further, 5% spices extract had more pronounced effect on TSS, total sugars, titratable acidity, total esters and total phenols than 2.5% spices level. On the basis of functional properties, a product having 8% sugar, 17% alcohol and 5% spices extract was adjudged to be best and recommended for further preparation.

Keywords: Antioxidants, Base wine, Spices and herbal extract, Sweet vermouth, Wild apricot fruit
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Wild apricot fruit (*Prunus armenica* L.) is a drupe and is found growing naturally in hilly areas of northern India[1]. Major parts of Jammu & Kashmir; Kinnaur, Kullu, Chamba, Lahul- Spiti districts of Himachal Pradesh and the hilly areas of Uttar Pradesh[2,3] are the important sites of wild apricot collection and production. The fruits are rarely eaten fresh. The fruit contains about 81% pulp and is also a good source of nutrients viz., vitamins, sugar, acid, TSS, vitamin C, protein and minerals mainly phosphorous, potassium,

of carotenoids. But, the fruit is not as popular as fresh cultivated fruit. Being more acidic (acidity 1.6-3.4% as MA) and fibrous thus, has no market value[2,4]. The tribal people of the area uses the major portion of the crop to prepare their traditional distilled beverage locally called *moori* using crude technology, which completely lacks in nutrients and even have considerably higher methanol content[5,6]. These defects are due to lack of scientific technology adopted by them in the preparation of *moori*. A combination of ethanol fortification and addition of herbal and spices extract further sweetening it with some sweet agent make a medicinal properties rich sweet vermouth[7]. Since the higher hills where *moori* is produced is also rich in rare medicines and herbs beside the natural trees of wild apricot fruit. Therefore, present efforts has been made to prepare wild apricot fruit sweet vermouth by utilizing wild apricot fruits, herbs and spices to have better health drink full of medicinal properties over traditional

Methodology

The fruits of wild apricot fruits and *moori* (traditionally prepared distilled alcoholic beverage from wild apricots) were procured from Kinnaur district of Himachal Pradesh. The fruits were converted into pulp employed for fermentation. Cane sugar and di-Ammonium hydrogen phosphate (DAHP) used to ameliorate the must for preparation of base wine was procured from local market. Pectinase enzyme used was manufactured by M/S Triton Chemicals, Mysore, India, under the brand

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name of ‘Pectinol’. Different spices and herbs for the preparation of vermouth were obtained from the Department of Forest Products, College of Forestry, Nauni, Solan (India).

To prepare base wine, must of 24°B was prepared by diluting the pulp in 1:2 ratio with water, 200 ppm SO_2, DAHP 0.1% and 0.5% pectinase enzyme was added. A 24 h old activated yeast culture (*Saccharomyces cerevisiae* var. *ellipsoideus* strain UCD 595) was prepared and used for fermentation. The fermentation was carried over in 10 L capacity narrow mouth glass carboys.

A part of the base wine was distilled into brandy as per the standard procedure[8]. List of spices and herbs used to prepare extract for use in wild apricot vermouth production is given in Table 1. The spices and herbal extract was prepared by taking wine and brandy in 1:1 ratio[9] and gently heated for 10 minutes for 10 days continuously in a closed container. The extract was kept at low temperature for 2 days for precipitation. The supernatant was separated by filtration and used in the vermouth preparation. To optimize and develop wild apricot sweet vermouth, different ethanol concentrations (15, 17 and 19%), sugar concentrations (8, 10 and 12%) and spices extract (2.5 and 5.0%) were employed and the products were evaluated for various functional properties.

Total soluble solids (TSS) were measured using an Erma hand refractometer (0 to 32°B) and the results were expressed as degree Brix (°B)[10]. The readings were corrected by incorporating the appropriate correction factor for temperature variation[11]. 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[11]. The total phenols content in different wines were determined by Folin Ciocalteu procedure given by Singleton and Rossi[12]. The total and reducing sugars of fruit and sweet vermouth were estimated by Lane and Eynon volumetric method[11] by titrating the sample against Fehlings solutions.

Ascorbic acid content was determined as per AOAC[11] method using 2, 6-dichlorophenol-indophenol dye. Volatile acidity of wild apricot sweet vermouth was determined by the standard method[8]. Quantity of ethanol in wine/vermouth was estimated by spectrophotometric method[13] while that in brandy was determined by alcoholometer[8]. Total esters were estimated as per the method of Liberaty[14] and methanol content in base wine and *moori* was estimated as per method prescribed by Amerine[8]. Antioxidant activity (Free radical scavenging activity) of wild apricot wine and *moori* was measured as per the method of Brand-Williams et al.[15]. DPPH (2, 2-diphenyl-1-picrylhydrazyl) was used as a source of free radical. A quantity of 3.9 mL of 6×10^{-5} mol/L DPPH in methanol was put into a cuvette with 0.1 mL of sample extract and the decrease in absorbance was measured at 515 nm for 30 min or until the absorbance become steady. Methanol was used as blank. The remaining DPPH concentration was calculated using the following equation:

$$\text{Antioxidant activity (\%)} = \frac{Ab_{(B)} - Ab_{(S)}}{Ab_{(B)}} \times 100$$

Where,
$Ab_{(B)}$ = Absorbance of blank

Table 1 — Spices and herbs used in the preparation of wild apricot fruit vermouth

Botanical name	Common name	Parts used	Qty/L (g)
Piper nigrum L.	Black pepper	Fruit	0.75
Coriandrum sativum L.	Coriander	Seeds	0.70
Cuminum caninum L.	Cumin	Seeds	0.50
Syzygium aromaticum L.	Clove	Fruit	0.25
Amomum subulatum Roxb.	Large cardamom	Seeds	0.50
Crocus sativus L.	Saffron	Flower	0.01
Myristica fragrans	Nutmeg	Seed	0.25
Cinnamomum zeylanicum Breyn	Cinnamon	Bark	0.25
Papaver somniferum L.	Poppy seed	Seed	1.00
Zingiber officinale Rosc.Rosc.	Ginger	Dried root	1.00
Woodfordia floribunda	Woodfordia	Flower	0.25
Asparagus spp.	Asparagus	Leaves	0.10
Withania somnifera	Ashwagandha	Roots	0.20
Adhatoda spp.	Vasaka	Leaves	0.25
Rosmarinus officinalis	Rosemary	Flowering plant	0.10

$Ab_{(S)}$ = Absorbance of sample
Statistical analysis of the quantitative data of chemical parameters obtained from the experiments was done by Completely Randomized Design (CRD) factorial as per standard method[16].

Results

Physico-chemical characteristics of fruit

The physico-chemical characteristics of wild apricot fruit are given Table 2. It is clear that the fruit was of medium size but had quite good amount of pulp. The kernel had sweet taste and the fruit contained 10.0°B total soluble solids, while titratable acidity (as malic acid) was very high. The reducing sugars and total sugars were however, low. Carotene content was recorded to be 2.50±0.07 mg/100 g.

Fermentation ability of 'must'

The fermentation behaviour of wild apricot must (TSS 24ºB) measured as fall in TSS with time is depicted in Fig. 1. During fermentation, sugar was utilized by the yeast to form ethanol and thus reduced TSS content. Rate of fermentation (RF, ºB/24 h) of wild apricot must was recorded to be 1.22.

The Table 3 summarizes various characteristics of base wine. The TSS of wild apricot base wine was recorded as 8.2ºB, whereas acidity and pH were found to be 0.764% and 3.152, respectively. Traditional distilled alcoholic drink *moori* contains approx. 15 times more methanol content *viz*. 2268.35 mg/L compared to wild apricot base wine prepared in the lab which contains only 119.34 mg/L methanol content (Fig. 2). A relation between total phenols and antioxidant activity is presented in Fig. 3. Wild apricot wine found to contain 253.6±0.03 mg/L total phenols with 92 % free radical scavenging activity as a DPPH assay while traditionally prepared wild apricot distilled alcoholic beverage *moori* found to be low in both total phenols and antioxidant activity.

Table 2 — Physico-chemical characteristics of fresh wild apricot fruit

Characteristics	Mean ± SD* (n=10)
Fruit weight (g)	12.42 ± 3.32
Fruit diameter (cm)	2.46 ± 0.38
Fruit volume (cm^3)	10.55 ± 1.35
TSS (°B)	10.00 ± 0.24
Titratable acidity (% MA)	2.23 ± 0.16
Ascorbic acid (mg/100g)	37.30 ± 0.13
Reducing sugars (%)	4.83 ± 0.22
Total sugars (%)	6.16 ± 0.03
Carotenoids (mg/100g)	2.50 ± 0.07
Pulp content (%)	77.00 ± 0.2

*SD: Standard deviation

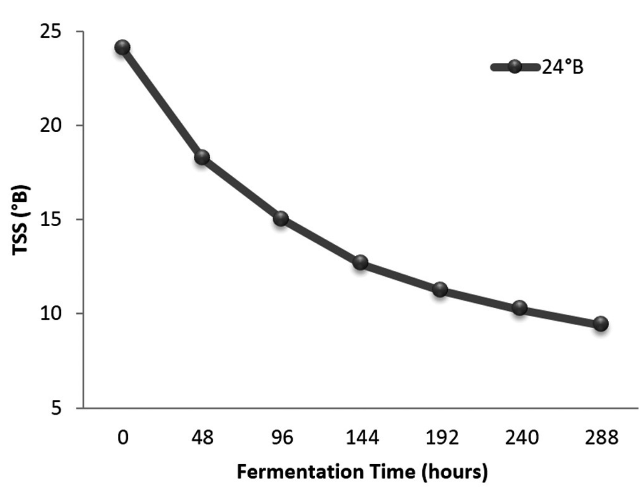

Fig. 1 — Changes in TSS during fermentation of wild apricot fruit must

Effect of treatments:

Effect of ethanol level

With the increase in alcohol level, TSS of vermouth was increased and ranged between 17.09 to 17.45% (Table 4). However, a significant decrease in

Table 3 — Functional properties of base wine prepared from wild apricot fruits

Characteristics	Mean ± SD* (n=5)
TSS (°B)	8.20 ± 0.07
Titratable acidity (%MA)	0.76 ± 0.02
Alcohol (%v/v)	10.64 ± 0.09
Reducing sugars (%)	0.34 ± 0.01
Total sugars (%)	1.11 ± 0.02
Volatile acidity (%AA)	0.025 ± 0.002
Total esters (mg/L)	135.40 ± 0.55

*SD: Standard deviation

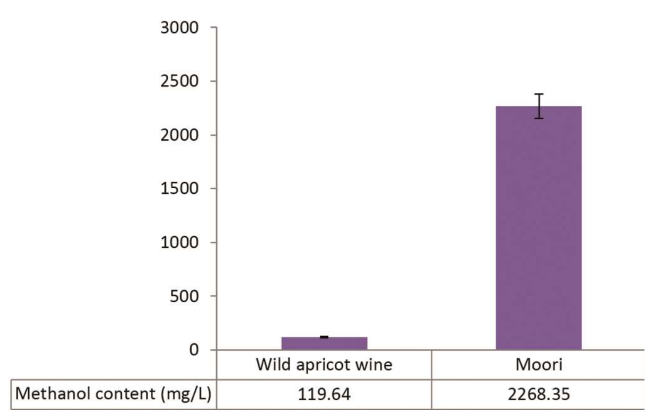

Fig. 2 — Methanol content comparison between wild apricot wine and *moori*

reducing sugars content (5.55 to 5.38%) of wild apricot vermouth took place with increase in alcohol level. Similarly, total sugars also decreased from 10.41 to 9.96% with the increase in ethanol level in the sweet vermouth preparation. Titratable acidity of 17% alcohol level vermouth was found at par with 19% alcohol level vermouth. The lowest (0.026% A.A.) volatile acidity was found in 15% alcohol level vermouth and highest (0.029% A.A.) in 19% vermouth which was at par with 17% alcohol level vermouth (0.028% A.A.). An increase in total esters took place with the increase in alcohol level and was found in the range of 260.8 to 267.4 mg/L. With the increase in alcohol levels, the quantity of total phenols was reduced (range between 454.4 to 446.4 mg/L).

Effect of sugar level

A significant increase in TSS level took place with the increase in sugar level from 14.88 to 19.50ºB (Table 4). Same was the case of reducing and total sugars content. With the increase in sugar level, titratable acidity decreased (range between 0.82 to 0.77%). Out of three different sugar concentrations used for vermouth production (8, 10 and 12%), concentration of 12% sugar level wild apricot vermouth was found at par with 10% sugar level wild apricot vermouth, whereas, 8% sugar level vermouth was found to be significantly different from these. However, for volatile acidity, out of vermouth with three sugar levels (8, 10 and 12%,) that with 10% sugar level was at par with 12% sugar level vermouth. The highest (301.3 mg/L) total esters were found in 12% sugar level vermouth and lowest in 8% sugar level vermouth (233.1 mg/L). With increase in sugar level, decreases in total phenols concentration was recorded.

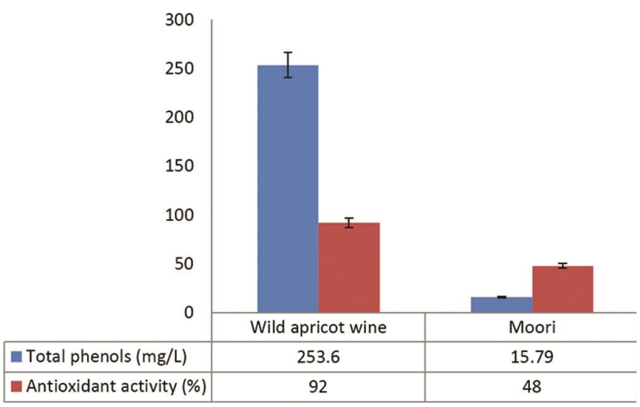

Fig. 3 — Total phenols and antioxidant activity of wild apricot wine and *moori*.

Effect of spices level

Vermouth having 5% spices level had higher level of TSS (17.28ºB) than that with 2.5% spices level (Table 4). It is the contribution of soluble solids by spices extract. Out of two spices level used, product with 5% spices extract level had higher (10.32%) quantity of total sugars than that with 2.5% spices level (10.04%). Vermouth with 5% spices extract had lower titratable acidity (0.79%) than 2.5% spices level. Out of two different concentrations of spices extract used for wild apricot vermouth production, 2.5% spices level vermouth had higher (17.11%) ethanol quantity than that with 5% spices extract vermouth (17.04%). It is due to the dilution by higher quantity of spices extract. Increased concentration of spices extract (5%) recorded higher (0.029% A.A.) volatile acidity than 2.5% spices level vermouth (0.027% A.A.). Higher quantity of spices extract, imparted higher total esters (266.8 mg/L) than the lower level (260.5 mg/L). The spices extract had total soluble solids that may contain acids, sugars and salts, naturally its addition increased to acidity, reduced pH and increased total and reducing sugars. Addition of higher quantity spices extract level (5%) gave higher quantity of total phenols (452.1 mg/L).

Table 4 — Effect of alcohol level, sugar level and spices extract on functional properties of wild apricot fruit vermouth

Characteristics	Alcohol level (%)			$CD_{0.05}$	Sugar level (%)			$CD_{0.05}$	Spices extract (%)		$CD_{0.05}$
	15.0	17.0	19.0		8	10	12		2.5	5.0	
TSS (°B)	17.09	17.23	17.45	0.04	14.88	17.39	19.50	0.04	17.23	17.28	0.04
Reducing sugars (%)	5.55	5.46	5.38	0.01	4.98	5.42	5.99	0.01	5.49	5.43	0.01
Total sugars (%)	10.41	10.16	9.96	0.07	8.43	9.99	12.11	0.07	10.04	10.32	0.06
Titratable acidity (%MA)	0.85	0.78	0.77	0.02	0.82	0.80	0.77	0.02	0.79	0.82	0.01
Ethanol (%v/v)	15.09	17.10	19.04	0.05	17.11	17.08	17.04	0.05	17.11	17.04	0.04
Volatile acidity (%AA)	0.026	0.028	0.029	0.001	0.029	0.027	0.027	0.001	0.027	0.029	0.001
Total esters (mg/L)	260.8	262.7	267.4	1.1	233.1	256.6	301.3	1.1	260.5	266.8	0.9
Total phenols (mg/L)	454.4	451.6	446.6	1.6	456.3	454.9	441.4	1.6	449.6	452.1	1.3
Total carotenoids (mg/L)	1.122	1.120	1.118	0.001	1.118	1.119	1.122	0.001	1.115	1.124	0.001

*n = 3

Discussion

As expected, fermentation during initial period was quite high but declined near the end of fermentation. During fermentation, sugar was utilized by the yeast to form ethanol and thus reduced TSS content. Fermentation behaviour of "must" indicates satisfactory fermentation rates and indirectly reflects that the pre-requisite for proper alcoholic fermentation such as yeast culture and proper amount of nitrogen in the must might have been met[8,17,18]. After completion of fermentation, the low value of TSS revealed that the proper fermentation has taken place. The low volatile acidity (0.025% A.A.), shows the soundness of wine, which was within the limits of the legal standards (0.040%)[8]. It also reflects that no bacterial spoilage in the base wine has taken place. Total esters, total phenols and sugar content were found within the limits. Based on the functional properties it is concluded that the base wine was sound and was of medium alcohol content, thus suitable for conversion into vermouth. Moreover, there is clear relationship between total phenols and antioxidant activity was found in the study which is also reported in earlier wine productions[19,20]. DPPH is stable free radical with characteristic absorption at 515 nm and antioxidants in wine react with DPPH radicals and converts it in to 2,2-diphenyl-1-picrylhydrazine which results in degree of discolouration that indicates scavenging potential of the antioxidants present in the wine. Further, it is the ability of antioxidants characterised by hydrogen ion donation[21,22].

Methanol content in *moori* is higher than wine because in traditional method the fermentation source is always contaminated, method of fermentation is crude and they collect all the parts (head, body and tail) in one fraction during distilation[23,24]. At higher methanol concentration 4000 mg/L or more gets converted into formaldehyde which destroys the optical nerve and even consumption of higher concentrations is lethal[25,26].

Effect of treatments

An increase in reducing sugars took place in all the treatments because of hydrolysis of non-reducing sugars into reducing sugars. The decrease in reducing sugars with increase in alcohol content may be because of dilution effect. Further a slight change in volatile content might be a result of addition of brandy. It is expected as brandy addition contains esters that might be contributed in wine which is observed in the vermouth with an increment. Amerine[8] have summarized total esters in various wines ranging between 200 and 400 mg/L. Total phenols in the sweet vermouth is comparable to the results reported earlier in sand pear vermouth, plum vermouth, apple vermouth and mahua vermouth[27,28,29,30]. The difference in alcohol content with addition of different spices and herbs level could be due to the dilution on ethanol by addition of spice extract and sugar syrup.

Higher TSS in sweet wild apricot vermouth having 5% spices level may be a result of contribution of soluble solids by spices extract. Vermouth of 5% spiced level had lower reducing sugars than that with 2.5% level apparently due to dilution effect of higher concentration of spices extract, as observed in apple vermouth[28]. The spices extract had total soluble solids that may contain acids, sugars and salts, naturally its addition increased to acidity, reduced pH and increased total and reducing sugars which is similar to the results reported in earlier work[27,30,31]. With the increase in spices extract level a significant increase in total carotenoids content also took place. It is expected that the colour of extract might have added the pigment to the vermouth. The spices extract in general increased total esters, volatile acids and total phenols. The vermouth of various treatments was found to have volatile acidities of less than the legal limits for the wine[8]. Amerine and Ough[32] recommended that in sound and aged wines the volatile acidity should not exceed 0.07%, however Onkarayya[33] have found volatile acidity in a range between 0.071% and 0.091% which is quite higher than found in our study. A significant increase in total phenols in vermouth of all the treatments than the base wine might possibly be due to the addition of spices and herbal extract[34,35,36,37]. These are the contributions made by the extract to the vermouth. In earlier work, similar observations were also obtained[29,30,31].

Conclusion

The fruit is acidic in nature and contains low level of TSS but the base wine and vermouth prepared from it was quite acceptable product over *moori,* which is found higher in methanol content. It was apparent that variations in the alcohol, sugar level and spices extract concentration affected the functional properties of wild apricot sweet vermouth. It can be further concluded that, vermouth with 5% spices level, 8% sugar and 17% alcohol level was the best and can be easily prepared and has best functional properties, so the present product can be better to uptake by alcoholic beverage production industries and should be replaced by *moori* production. Since, spices and herbal extract is added during vermouth preparation which makes the vermouth rich in nutrition and antioxidants. But the extraction methodology is old and time consuming which need to be replaced with easy and quick extraction methodology. Further, to impart sweetness in the vermouth, sugar amelioration is adept which need to be replaced with honey or some types of fruit juices to make vermouth more healthy and nutritious.

References

1 Parmar C & Sharma AK, *Chulli*: A wild apricot from Himalayan Cold Desert Region, *Fruit Varieties Journal,* 46 (1992) 35-36.
2 Sharma SD, Variation in Local Apricots growing in Kinnaur of Himachal Pradesh (India), *Varieties Journal,* 48 (1994) 225-228.
3 Sharma JK, Morphological studies on apricot and its wild relatives, *Journal Hill Research*, 13 (2000) 5-10.
4 Parmar C & Kaushal MK, *Prunus armenica*, In: *Wild Fruits*, Kalyani Publishers, New Delhi, 1982, pp. 66–69.
5 Joshi VK, Bhutani VP, Lal BB & Sharma R, A method for the preparation of wine from the wild apricot, *Indian Food Packer*, 44 (1990) 50-55.
6 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*, 41(3) (1990) 229-231
7 Panesar PS, Kumar N, Marwaha SS & Joshi VK, Vermouth production technology- an overview, *Natural Product Radiance*, 8(4) (2009) 334-344.
8 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.
9 Joshi VK, Fruit Wines. 2nd edn. Directorate of Extension Education, Dr YS Parmar UHF, Nauni-Solan, India, 1997.
10 Ranganna S, Handbook of analysis and quality control for fruit and vegetable products, Tata McGraw Hill Publishing Company Ltd., New Delhi, 1986 p.1112.
11 A.O.A.C., Assocation of Official Analytical Chemists, Official Methods of Analysis, Hortwitz, W. (Ed.), 13th ed. Washington, D.C., 1980 p.1015.
12 Singleton VL & Rossi JA Jr, Colorimetry of total phenolics with phosphomolybadic phosphotungstic acid reagents, *American Journal of Enology and Viticulture*, 16 (1995) 144-158.
13 Caputi A, Ueda M & Brown J, Spectrophtometric determentaion of ethanol in wine, *American Journal of Enology and Viticulture*, 19 (1968) 160-165.
14 Liberaty V, Ester determination and their applications to wine, *M.Sc.* Thesis, Univ. of California, Davis, 1961.
15 Brand-Williams W, Cuvelier ME & Berset C Use of a free radical method to evaluate antioxidant activity. *Leben Wiss U Tech,* 28 (1995) 25-30
16 Cockrane WG & Cox GM, Experimental Designs, 14th edn, Asia Publishing House, Bombay, 1963.
17 Azad KC, Vyas KK, Joshi VK & Sharma RR, Observations on juice and cider made from scabbed apple fruit, *Indian Food Packer*, 41 (1987) 47-54.
18 Zoecklein BW, Fugelsang KC, Gump BH & Nury FS, Wine analysis and production, Chapman Hall, New York,1995.
19 Arnous A, Makris DP & Kefalas P, Correlation of pigment and flavanol content wine antioxidant properties in selected aged regional wines from Greece, *Journal of Food Composition and Analysis*, 15 (2002) 655-665.
20 Katalinic V, Milos M, Modun D, Music I & Boban M, Antioxidant effectiveness of selected wines in comparison with (+)-catechin, *Food Chemistry*, 86 (2004) 593-600.
21 Van GA, Joubert E & Hannsman CT Comparison of the antioxidant activity of aspalathin with that of other plant phenols of roolbos tea (*Aspalathus linearis*) tocoferol, BHT and BHA, *Journal of Agricultural and Food Chemistry,* 45 (1997) 623-638.
22 Lima D, Agustini B, Silva E, *et al.*, Evaluation of phenolic compounds content and in vitro antioxidant activity of red wines produced from Vitis labrusca grapes, *Food Science and Technology*, 31(3) (2011) 783-800.
23 Geroyiannakia M, Komaitisa ME, Stavrakasa DE, Polysioub M, Athanasopoulosa PE & Spanosa M, Evaluation of acetaldehyde and methanol in greek traditional alcoholic beverages from varietal fermented grape pomaces (*Vitis vinifera* L.), *Food Control,* 18(8) (2007) 988-995
24 Cortés S, Luisa GM and Fernández E, Volatile composition of traditional and industrial Orujo spirits, *Food Control*, 16 (2005) 383-388.
25 Bertrand A, Recherches sur l analyse des vins par chromatographie en phase gazeuse. Thèse dEtat, Universiè de Bordeaux II, Bordeaux, France, 1975.
26 Cabaroglu T, Methanol contents of Turkish varietal wines and effect of processing, *Food Control*, 16 (2005)177-181
27 Attri BL, Lal BB & Joshi VK, Preparation and evaluation of sand pear vermouth, *Journal of Food Science and Technology*, 30 (1994) 435-437.
28 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*, 43 (2000) 537-545.
29 Joshi VK, Attri BL & Mahajan BVC, Production and evaluation of vermouth from plum fruits, *Journal of Food Science and Technology*, 28 (1991) 138-141.
30 Yadav P, Garg N & Dwivedi D, Preparation and evaluation of Mahua (*Bassia latifolia*) Vermouth, *International Journal of Food and Fermentation Technology*, 2(2012) 57-61
31 Chauhan H, Kaul RK, Ahmed N, Gupta P & Anjum A, Preparation and Evaluation of Bael (*Aegle marmelos*) Vermouth, *International Journal of Food and Fermentation Technology,* 6(2016) 41-47.
32 Amerine MA & Ough CS, Fermentation of grapes holding under anaerobic conditions, I: Red Grapes, *American Journal of Enology and Viticulture*, 19(1979) 139.

33 Onkarayya H, Mango Vermouth - A new alcoholic beverages, *Indian Food Packer*, 39(1985): 40-45.

34 Joshi VK, John S & Abrol GS, Effect of Addition of Herbal Extract and Maturation on Apple Wine, *International Journal of Food and Fermentation Technology*, 3(2013): 107-118.

35 Joshi VK, John S & Abrol GS, Effect of addition of extracts of different herbs and spices on fermentation behaviour of apple must to prepare wine with medicinal value, *National Academy Science Letters*, 37(2014): 541-546.

36 Chun SS, Vattem DA, Lin YT & Shetty K, Phenolic antioxidants from clonal oregano (*Origanum vulgare*) with antimicrobial activity against *Helicobacter pylori*, *Process Biochem*. 40(2005) 809–816.

37 Zafrilla P, Morillas J, Mulero J, Cayuela JM, Martinez-Cacha A, Pardo F & Lopez-Nicola JM, Changes during storage in conventional and ecological wine: Phenolic content and antioxidant activity, *Journal of Agriculture and Food Chemistry,* 51(2003) 4694–4700.