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**STUDIES ON NATURAL AND INOCULATED ALCOHOLIC FERMENTATION OF  
WILD APRICOT FOR VINEGAR PRODUCTION**

**CHAUHAN P<sup>1</sup>, SHARMA S\* AND THAKUR AD<sup>2</sup>**

\*<sup>1,2</sup> School of Bioengineering and Food Technology, Shoolini University, Solan, Himachal Pradesh, India

\*Corresponding Author: E Mail : [puchauhan09@gmail.com](mailto:puchauhan09@gmail.com)

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**ABSTRACT**

In present studies the wild apricot crop has been utilized for the standardization of alcoholic fermentation for further vinegar production. Different concentration of total soluble solids (16, 20, 24°B), clarification enzyme and mode of fermentation were optimized for better alcohol yield and higher phenol content. The results obtained show that wild apricot fruit is a good source of total soluble solids (16°B) along with high acid content (1.2% as citric acid), vitamins C (11.11 mg/100g), β-Carotene (129 mg/100g) and total phenols (190 mg/100 ml). The high total soluble solid content of the fruit increases its utility for the development of base wine and vinegar at the later stages. Among the different treatments tried, for the optimization of alcoholic fermentation, initial sugar concentration of 24°B, 0.3% pectinase esterase enzyme and inoculated fermentation with *Saccharomyces cerevisiae* var. *ellipsoideus* at 5 percent inoculum concentration (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>) was found to be the best. However, natural fermentation resulted in development of base wine with low alcohol content. The base wine prepared with the above combination (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>) had higher amount of alcoholic content (9.16% v/v) and total phenols (167 mg/100 ml) than the other treatments. Since, the alcohol is the primary ingredient for further acetic fermentation so the treatment holds promising for the development of vinegar from wild apricot. Further, the higher content of phenols would also add to the medicinal value of the wild apricot vinegar.

**Keywords:** Wild Apricot (*Prunus armeniaca* Linn), Base wine, β-Carotene, Vitamin C, Phenols, Flavanoids

## INTRODUCTION

Wild Apricot (*Prunus armeniaca* Linn) is an important stone fruit widely grown in Turkey, Italy, Greece, Spain, USA and France (7). Turkey is the major country in the production of apricot due to its rich genetic resources (4). Fresh wild apricot fruit contains carbohydrates (33.1-45.7g), vitamin C (9.95-11.20mg), protein (0.67-1.32%), fibers 0.8-1.6g) and riboflavin (0.53-1.02mg) (14,15,21,11). Further, the fruits are also anti-diarrheal and anti-pyretic whereas the seeds are used as a tonic in liver troubles, pile, cold and asthma (14). The plant is also used as antidote, expectorant, tonic and anthelmintic. In traditional medicine, it is used for the treatment of fever, cold, cough, asthma, bronchitis, laryngitis, constipation, anemia, hemorrhages and certain tumors (18). Since, the crop is wild, so a lot of produce goes waste, except utilized for the development of some value added products such as Jams, jellies, chutneys, wines and oil etc. (22). So, development of fruit vinegar can be one of the alternatives to utilize the crop.

Fruit vinegar is manufactured through the conversion of sugars to alcohol by yeast fermentation and subsequent addition of acetic acid bacteria to induce the acetic acid fermentation (10). Since, the fruit is rich source of many nutrients, but being perishable in nature, it has not been utilized

to its best for the product development. Therefore, process needs to be developed for alcoholic fermentation before developing technology for vinegar production. Further, the functional properties of fruit vinegar such as antibacterial, blood pressure reducer, antioxidant rich, anti diabetic etc (5) also proved its medicinal values. Vinegar consumption has also been associated with diminished post-prandial glucose response following a high glycemic load meal (8). Cider vinegar from apple has also been proven advantageous from the perspective of human health (24). Therefore, the present investigation was carried out to study the physico-chemical and phytochemical characteristics of wild apricot and optimize the alcoholic fermentation for higher content of alcohol for vinegar production.

## MATERIALS AND METHODS:

### Raw material

The fruits of *Prunus armeniaca* L. (Wild Apricot) were collected from village Mazhakal, (Janjali Mandi), higher region of Himachal Pradesh and got identified from Department of Pomology, Dr. Y.S. Parmar University of Horticulture and Forestry. Mature fruits of uniform size, well ripened were selected and utilized for further processing. Potassium metabisulphite and Di-ammonium hydrogen phosphate

(DAHP) of analytical grade were procured from M/S International Scientific and Surgical, Solan. Pectin esterase as “Pectinol” used as clarifying agent was manufactured and procured from M/S Triton Chemical, Mysore, India,

### **Wine yeast culture**

*Saccharomyces cerevisiae* var. *ellipsoideus*. Strain UCD 595 was obtained from the Department of Food Science and Technology, UHF Nauni, Solan (H.P). The culture was maintained on the Yeast extract malt agar medium and re cultured after every three months or whenever needed for stock yeast culture.

### **Must preparation**

The ripened wild apricot fruits were sorted for any spoilage, washed and cleaned. The pulp was made in the pulper after boiling the known quantity of fruit with 10 percent water. The must was prepared by diluting wild apricot pulp with water in 1:2 ratio to lower down its high acidity value. The initial TSS of the must was raised to different levels, viz. 16°, 22° and 24° B by adding sugar syrup, with (0.3% enzyme) and without enzyme. Di-ammonium hydrogen (0.1%) was also added and kept constant in all the treatments. In natural fermentation only the natural microflora of the fruits was employed for further fermentation. However, for the inoculated fermentation two days prior to the

preparation of must yeast starter culture of *Saccharomyces cerevisiae* var. *ellipsoideus* was prepared and activated for fermentation at a temperature of 28°C. The activated yeast culture was then added to the must at the rate of 5 per cent and fermentation was allowed to continue at a temperature of 28°C till bubbling ceases. After the completion of fermentation process, siphoning was carried out to separate the base wine from the sediment. Then, the clarified base wines were filled in sterilized bottles, corked and pasteurized at a temperature of 62-67°C for 15-20 minutes. The entire process is shown diagrammatically in Fig. 1. The wild apricot base wine of different treatments were then analysed for various physico-chemical characteristics.

### **Physico-chemical analysis**

Wild apricot fruits, must and base wine were analysed for various physico-chemical characteristics as per standard methods (1,17). TSS was measured using Erma hand refractometer (0 to 32° B) and the results were expressed as degree brix (° B). The readings were corrected by applying the correction factor for the temperature variation (1). The titratable acidity (as percent citric acid) was estimated by titrating a known aliquot of the sample against N/10 NaOH solution (1). Total and reducing sugars were estimated with the

Lane and Eynon method (17). The total phenolic content (TPC) was determined using the colorimetric Folin-Ciocalteu method (20) in which the absorbance was measured by UV-Vis spectrophotometer versus a prepared blank (760 nm). The  $\beta$ -carotene content was determined as per the method (13). Ethanol was estimated by the colorimetric method (6). However, the rate of fermentation ( $^{\circ}\text{B}/24\text{ hr}$ ) was determined by calculating the change in TSS over time.

Base wines of various treatments were also evaluated for various sensory characteristics on the basis of color, appearance, aroma, volatile acidity, sweetness, bitterness, astringency and overall impression (2) by a panel of semi-trained judges. Chilled samples were provided along with plain water for mouth rinsing in between the evaluation of the samples. Each sample was evaluated for various quality attributes on the prescribed performs.

### Sensory analysis

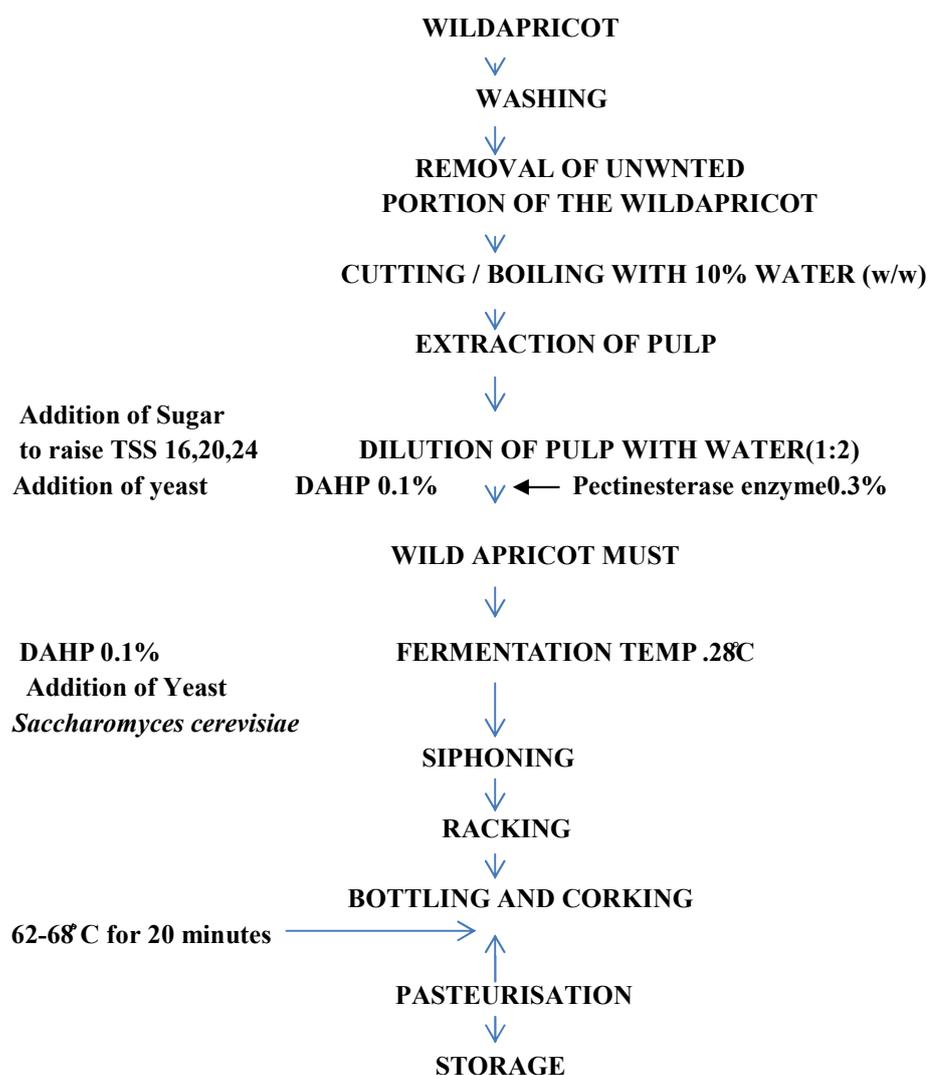


Fig 1 - Flow sheet of preparation of Wild apricot base wine

## RESULT AND DISCUSSION

### Physico-chemical characteristic

The wild apricot fruits were analysed for various physical characteristics. It is clearly seen from the Table 1 that the fruits have mean weight of 10.4g with pulp recovery of 78.8%. The total sugar content in wild apricot fruit was 11.8% with high titratable acidity (1.2% as citric acid). Further, the fruit was also found to be a good source of vitamin C (10.83mg/100g) and

carotenoids (0.129mg/100ml), highlighting the nutritional significance of wild apricot fruit. Though, the fruit has a quite high amount of TSS (15.3° B) to facilitate fermentation but also contains high acid (1.2%) and phenol (190mg/100ml) content. The high acidity and phenol content affect the rate of fermentation and finally, the quality of wine (23). Hence, due to high acidity of fruit the pulp needs dilution with water for must preparation.

**Table: Physico-chemical characteristic of wild apricot fruit**

Characteristics	Mean± S.D.
Fruit Weight(g)	10.4± 2.22
Pulp (%)	78.8± 0.87
TSS° B	15.3± 0.67
Acidity (% citric acid)	1.2 ± 0.02
Total sugar (%)	11.8± 1.20
Reducing sugar (%)	2.0±0.14
Ascorbic acid(mg/100g)	10.83±0.20
Phenols(mg/100ml)	190 ± 0.02
Carotenoid(mg/100ml)	0.129±0.01

### Fermentability of musts of different treatment

The results clearly show that the base wine treatment prepared with 24°B initial total soluble solids, clarified with 0.3% pectinase enzyme and fermented with *saccharomyces cerevisiae* var *ellipsoides* (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>) recorded the highest reduction in TSS (7.0°B) followed by other treatments. Whereas, the minimum reduction in TSS was recorded in treatment T<sub>1</sub>E<sub>2</sub>F<sub>1</sub> having 16°B total soluble solid, with 0.3% pectinase enzyme and fermented naturally. The fermentation behaviour of naturally fermented wild apricot musts shows slow reduction in total soluble solids

along with low rate of fermentation (Figure 2,3). However, in inoculated fermentation with starter culture of *saccharomyces cerevisiae* var *ellipsoides* there was fast reduction in total soluble solids (Figure 4,5). A comparison of rate of fermentation revealed that the must fermented within a culture of *saccharomyces cerevisiae* var *ellipsoides* has the highest rate of fermentation (2.14) while that of T<sub>1</sub>E<sub>3</sub>F<sub>1</sub> recorded the lowest. Hence, high rate of fermentation had lowest total soluble solids and that is because of utilization of sugar content and production of ethanol.

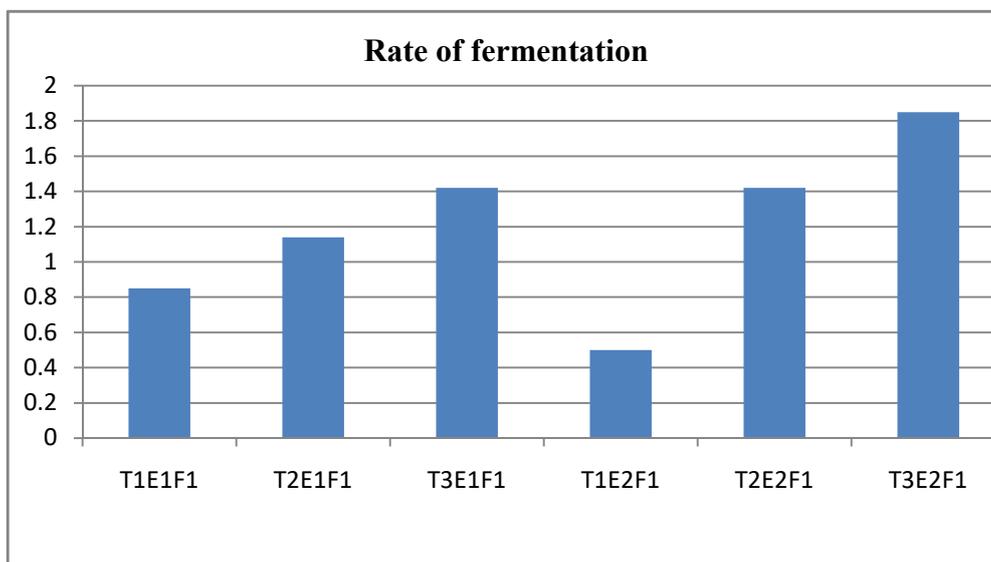


Fig 2: A comparison of fermentation behaviour of wild apricot musts of different treatments fermented with natural microflora

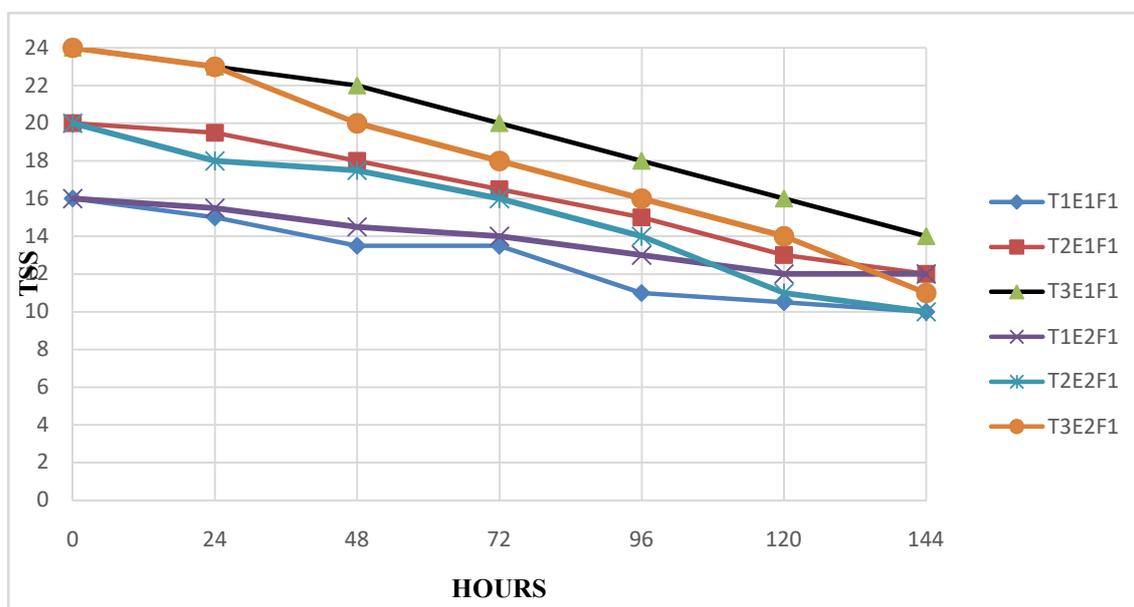


Fig 3: Comparison of rate of fermentation of wild apricot musts of different treatments fermented with natural microflora

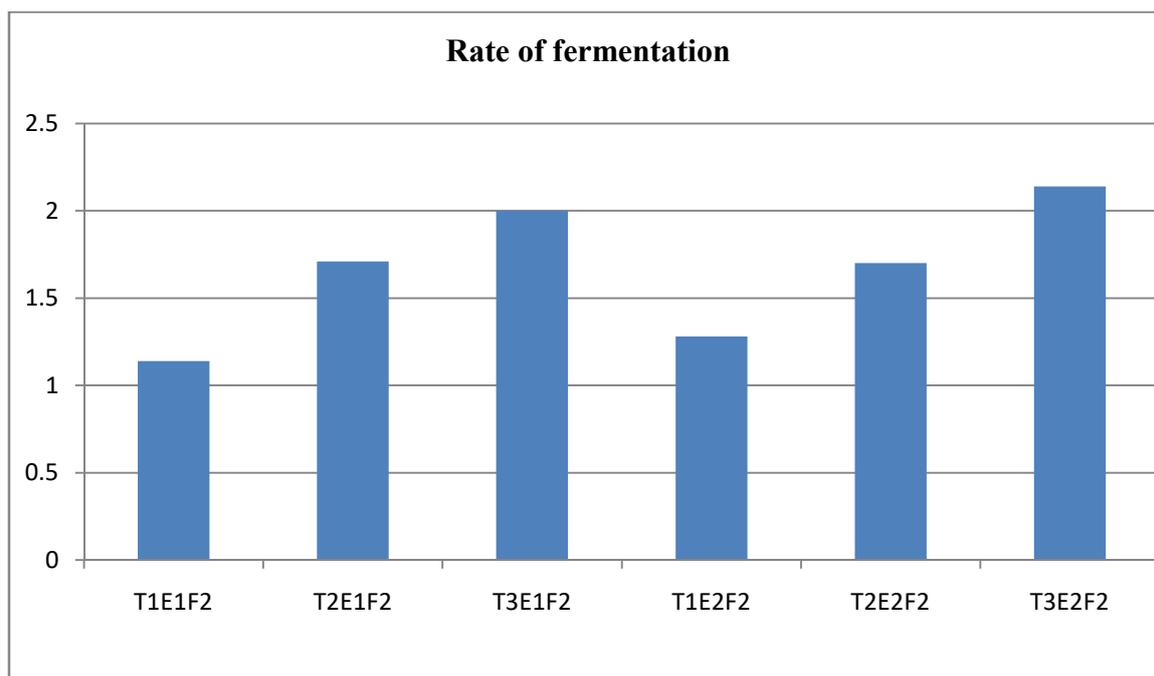


Fig 4: A comparison fermentation behaviour of wild apricot musts of different treatments fermented withinoculum of *saccharomycescerevisiae* var *ellipsoids*

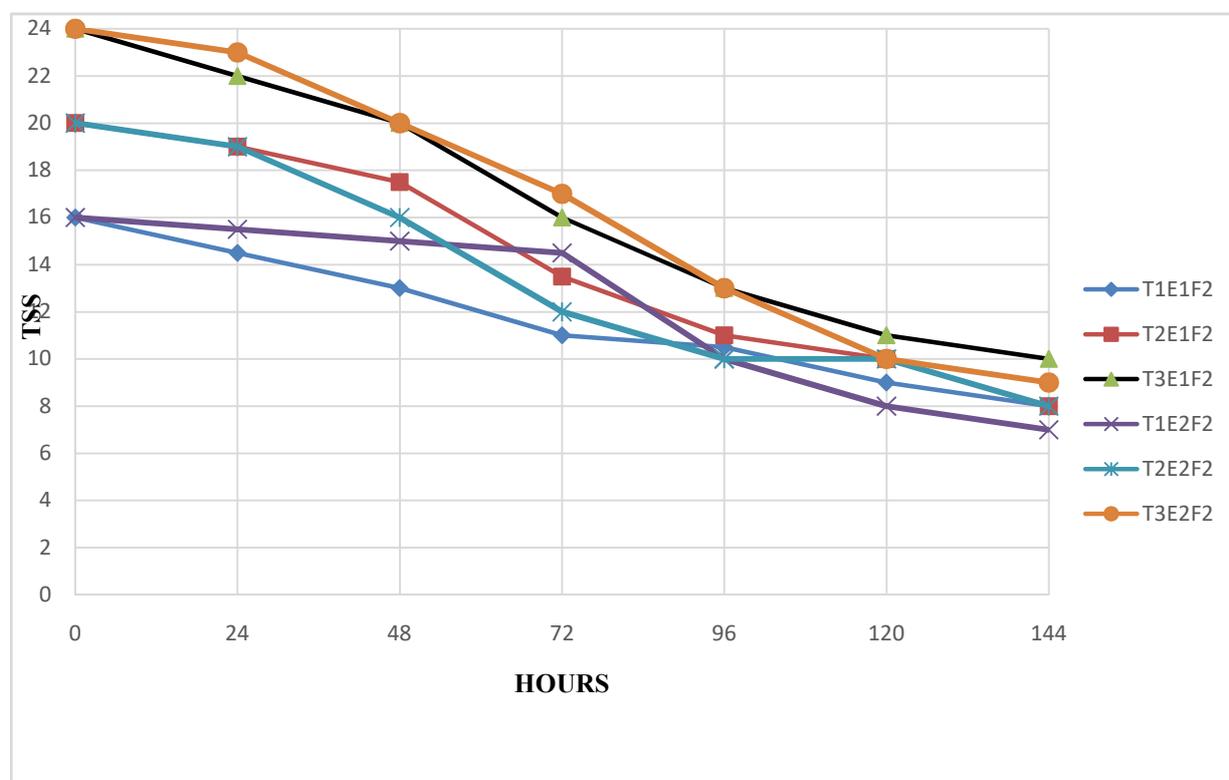


Fig 5: Comparison of rate of fermentation of wild apricot musts of different treatments fermented with inoculum of *saccharomycescerevisiae* var *ellipsoids*

### Physico-chemical characteristic of wild apricot base wine

Physico-chemical characterisation (Table 1) of wild apricot base wines revealed that the Total soluble solids (TSS) of base wines of different treatment ranged between 7.0 to 13.0° B and the wide variation in the Total soluble solids (TSS) is apparently related to the difference in the fermentation of the must as discussed earlier. The finding showed that the base wine prepared using natural microflora prepared from must having 16°B initial sugar concentration and 0.3% pectinase esterase (T<sub>1</sub>E<sub>2</sub>F<sub>1</sub>). However, the maximum reduction was recorded in musts prepared with 24 °B total soluble solids, 0.3% pectinase esterase enzyme and fermented with *saccharomyces cervices* (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>). Further, the same treatment (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>) had higher ethanol production (9.16%). Among the different treatments, the titratable acidity as per cent citric acid ranged between 0.60 to 1.05 percent. As the titratable acidity is an important characteristic of fruit due to its effect on taste hence, the apricot pulp needs dilution due to its higher acidity values (27). The data (Table 4) on the alcohol content in different base wines revealed that base wines of different treatments differed significantly. The alcohol content in different wines was recorded between 2.60 to 9.16 percent. The

highest alcohol content (9.16%) was recorded in base wine prepared with initial sugar concentration of 24°B, 0.3% pectinase esterase enzyme and fermented with *saccharomyces cervices* (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>) and lowest alcohol content (2.60%) was recorded in base wine prepared with initial sugar concentration 16°B, 0.3% pectinase esterase enzyme and fermented with natural microflora (T<sub>1</sub>E<sub>2</sub>F<sub>1</sub>). This is because of utilization of sugar content and production of ethanol as higher the fermentation and lower is the total soluble solids (2,9). There are also significant differences for the total phenol content among different apricot base wines. The highest (167.7 mg/l) total phenol content was recorded in base wine prepared with initial sugar concentration 24°B, 0.3% pectinase esterase enzyme and fermented with *saccharomyces cervices* (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>). Whereas, lowest (70 mg/l) total phenol content was recorded in base wine prepared with initial sugar concentration total 20° B, 0.3% pectinase esterase enzyme and fermented with natural microflora (T<sub>2</sub>E<sub>2</sub>F<sub>1</sub>). The variations in total phenol content were recorded due to source of fruit, maturity of fruit and method of wine making (19,26) and modification of the phenolic profile through different fermentation processes e.g. enzyme activity, condensation and polymerization reaction, oxidative and hydrolysis process (12).

### Sensory evaluation

The sensory profile of the apricot base wine was built using the marks given for each attribute by the semi trained panel members. The Fig 6 shows the spider chart for each base wine samples. As a result, apricot base wine production method (using natural microflora and inoculated with *Saccharomyces cerevisiae*) affected some sensorial characteristics. In addition to this higher scores were obtained for sensorial

characteristics in base wines prepared with *Saccharomyces cerevisiae* var *ellipsoides* having initial sugar 24°B(TSS) and with clarifying enzyme (E<sub>2</sub>). Further, the apricot base wine prepared with inoculum of *Saccharomyces cerevisiae* var *ellipsoides* was found superior to other treatment mainly because of better appearance, colour, total acidity, aroma, sweetness, body and overall impression, except volatile acidity and bitterness.

Table 1 Effect of total soluble solids (TSS°B), type of fermentation and enzyme concentration on alcoholic fermentation of wild apricot.

Treatments	Type of fermentation/Enzyme concentration						Grand Mean (T)
	Natural (F1)			Inoculated (F2)			
	Without enzyme (E1)	With enzyme (E2)	Mean	Without enzyme (E1)	With enzyme (E2)	Mean	
16°B (T <sub>1</sub> )	10.00	12.33	11.16	8.33	7.00	7.66	9.41
20° B (T <sub>2</sub> )	12.00	10.33	11.16	7.66	8.33	7.99	9.57
24°B (T <sub>3</sub> )	13.33	11.33	12.33	10.33	8.66	9.49	10.89
Mean (E)	11.77	11.33		8.77	7.99		
Grand Mean (E)	10.27	9.66					
Grand Mean (F)	11.44	8.38					

	CD (P≤0.05)				
Enzyme(E)	0.90			T×F	0.15
Treatment (T)	0.11			E×F	0.12
Fermentation (F)	0.09			T× E × F	0.22
T×E	0.15				

Table 2 Effect of total soluble solids (TSS°B), type of fermentation and enzyme concentration on titrable acidity of wild apricot wine.

Treatments	Type of fermentation/Enzyme concentration						Grand Mean (T)
	Natural (F1)			Inoculated (F2)			
	Without enzyme (E1)	With enzyme (E2)	Mean	Without enzyme (E1)	With enzyme (E2)	Mean	
16°B (T <sub>1</sub> )	0.92	0.80	0.86	0.80	0.91	0.85	0.85
20° B (T <sub>2</sub> )	1.05	0.90	0.97	0.89	0.89	0.89	0.93
24°B (T <sub>3</sub> )	0.82	0.89	0.85	0.98	0.60	0.79	0.82
Mean (E)	0.93	0.86		0.89	0.80		
Grand Mean (E)	0.91	0.83					
Grand Mean (F)	0.89			0.84			

	CD (P≤0.05)				
Enzyme(E)	0.01			T×F	0.03
Treatment (T)	0.02			E×F	0.02
Fermentation (F)	0.01			T× E × F	0.04
T×E	0.03				

Table3 Effect of total soluble solids (TSS°B), type of fermentation and enzyme concentration on Total phenol of wild apricot.

Treatments	Type of fermentation/Enzyme concentration						Grand Mean (T)
	Natural (F1)			Inoculated (F2)			
	Without enzyme (E1)	With enzyme (E2)	Mean	Without enzyme (E1)	With enzyme (E2)	Mean	
16°B (T <sub>1</sub> )	88.33	89.67	89.0	100.3	114.0	107.15	98.07
20° B (T <sub>2</sub> )	78.67	70.33	74.5	119.7	117.3	118.5	96.5
24°B (T <sub>3</sub> )	97.33	91.33	93.33	108.3	167.7	138.0	115.6
Mean (E)	88.11	83.77		109.3	133.0		
Grand Mean (E)	98.70	108.38					
Grand Mean (F)	85.94			121.2			

CD (P≤0.05)

Enzyme(E)	0.86	T×F	1.50
Treatment (T)	1.06	E×F	0.86
Fermentation (F)	0.86	T× E × F	2.13
T×E	1.50		

Table 4: Effect of total soluble solids (TSS°B), type of fermentation and enzyme concentration on Ethanol of wild apricot.

Treatments	Type of fermentation/Enzyme concentration						Grand Mean (T)
	Natural (F1)			Inoculated (F2)			
	Without enzyme (E1)	With enzyme (E2)	Mean	Without enzyme (E1)	With enzyme (E2)	Mean	
16°B (T <sub>1</sub> )	2.83	2.83	2.83	4.83	3.66	4.24	3.53
20° B (T <sub>2</sub> )	4.16	5.33	4.74	5.66	6.93	6.29	5.51
24°B (T <sub>3</sub> )	4.83	5.16	4.99	8.33	9.16	8.74	6.86
Mean (E)	3.94	4.44		6.27	6.58		
Grand Mean (E)	5.10	5.51					
Grand Mean (F)	4.19			6.42			

CD (P≤0.05)

Enzyme(E)	0.83	T×F	1.44
Treatment (T)	1.01	E×F	1.17
Fermentation (F)	0.83	T× E × F	2.03
T×E	1.44		

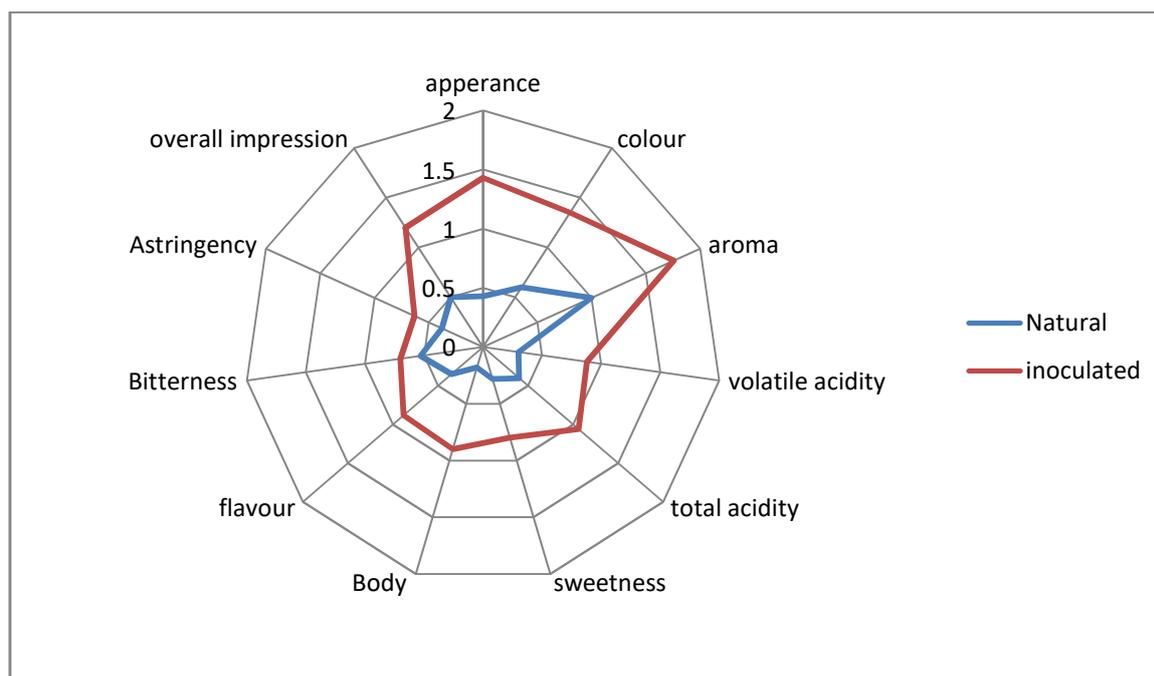


Fig 6 Sensory profile of wild apricot wine

## CONCLUSION

Wild apricot is one of the important temperate fruit of Himalayan region. The fruit has lot of potential for its economic utilization. Although, some of the products are already available in the market with high nutritional value. But to add variety to the diet, wild apricot can also be utilized for vinegar production. Hence, in the present studies the optimization of alcoholic fermentation for high yield of alcohol has been done. Therefore, from the present studies it can be concluded that among the different treatments tried for optimization of alcoholic fermentation, inoculated fermentation with *Saccharomyces cerevisiae* at 5 percent inoculum concentration, with 0.3% pectin esterase enzyme and initial sugar concentration of 24<sup>o</sup>B was recorded as the best (T<sub>3</sub>E<sub>2</sub>F<sub>2</sub>). On the basis of physico chemical and sensory quality characteristic, wild apricot base wine of treatment T<sub>3</sub>E<sub>2</sub>F<sub>2</sub> was best due to optimum TSS, acidity, ethanol content, appearance, colour, sweetness, body and overall impression. Further, the particular treatment also contains higher amount of alcohol (9.16 v/v) and total phenols (167.7mg/100ml) that are required for acetic fermentation in vinegar production.

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