

**STUDIES ON GROWTH, YIELD
AND WINE PRODUCTION FROM
DIFFERENT VARIETIES OF
GRAPE (*Vitis vinifera* L.)**

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M.Sc (Horti.)

DOCTOR OF PHILOSOPHY IN HORTICULTURE



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PRODUCTION FROM DIFFERENT
VARIETIES OF GRAPE (*Vitis vinifera* L.)**

By
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M.Sc (Horti.)

**THESIS SUBMITTED TO THE
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CHAIRPERSON : Dr. S. AMARENDER REDDY



**DEPARTMENT OF HORTICULTURE
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JUNE, 2011

CERTIFICATE

Mrs. VEENA JOSHI has satisfactorily prosecuted the course of research and that thesis entitled “**Studies on growth, yield and wine production from different varieties of Grape (*Vitis vinifera* L.)**” submitted, is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any University.

Date :

(Dr. S. AMARENDER REDDY)
Chairperson

CERTIFICATE

This is to certify that the thesis entitled “**Studies on growth, yield and wine production from different varieties of Grape (*Vitis vinifera* L.)**” submitted in partial fulfillment of the requirements for the degree of **DOCTOR OF PHILOSOPHY** of the **Acharya N. G. Ranga Agricultural University, Hyderabad**, is a record of the bonafide original research work carried out by **VEENA JOSHI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance and help received during the course of the investigations have been duly acknowledged by the author of the thesis.

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I, **VEENA JOSHI** hereby declare that the thesis entitled “**STUDIES ON GROWTH, YIELD AND WINE PRODUCTION FROM DIFFERENT VARIETIES OF GRAPE (*Vitis vinifera* L.)**” submitted to the Acharya N. G. Ranga Agricultural University for the degree of **DOCTOR OF PHILOSOPHY** is a result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	Percent
@	:	at the rate of
AOAC	:	Association of Official Analytical Chemists
CD	:	Critical difference
cm	:	Centimeter
cm ²	:	Centimeter square
CO ₂	:	Carbon-di-oxide
CRD	:	Completely Randomized Design
Cv.	:	Cultivar(s)
e.g.	:	Example
EC	:	Electrical conductivity
<i>et al.</i>	:	and others
Fig.	:	Figure
ft	:	feet
g	:	gram(s)
GAE	:	Gallic acid equivalent
ha	:	Hectare
ha ⁻¹	:	per hectare
Hrs	:	Hours
<i>i.e.</i>	:	Which is to say, in other words
K	:	Potassium
kg/vine	:	kilogram per vine
l	:	litre
mg	:	milligram(s)
µg	:	microgram(s)
min	:	Minutes
ml	:	milli litre

mm	:	millimetre
N	:	Nitrogen
NAOH	:	Sodium hydroxide
nm	:	Nanometer
No.	:	Number
NS	:	Non significant
°B	:	degree Brix
°C	:	degree centigrade
OD	:	Optical density
P	:	Phosphorus
pH	:	Negative logarithm of hydrogen ion
pp	:	Page number
ppm	:	parts per million
RBD	:	Randomized Block Design
SE _{m±}	:	Standard error of mean
SO ₂	:	Sulphur-di-oxide
t	:	tonnes
TSS	:	Total soluble solids
v/v	:	volume by volume
<i>viz.</i>	:	Namely

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ABSTRACT

An experiment entitled “Studies on growth, yield and wine production from different varieties of Grape” was conducted at College of Agriculture, Rajendranagar, in collaboration with Grape Research Station, Rajendranagar, Hyderabad from October 2006 to April 2008. Thirteen varieties (8 coloured and 5 white) were evaluated for performance of the growth, yield, wine production and quality.

The objectives of experiment was to study the varietal performance of different grape varieties in respect of their growth and yield and to study the wine recovery and quality parameters from different wine grape varieties. Further, the effect of blending of different grape varieties on the quality of wine was also studied.

Varieties differed significantly with respect to their growth and yield characteristics. Among the varieties, Athens and Shiraz recorded significantly higher pruning weight while minimum was noticed in Zinfandel. Cv. Pusa Navrang took minimum number of days for bud break after winter pruning, while Ruby Red took maximum number of days. The number of canes and cane diameter differed distinctly, among the varieties studied, Shiraz recorded higher number of canes followed by Chenin Blanc and lower in Thompson Seedless. Thicker canes was produced by the Cv. Italia followed by Thompson Seedless and thinner in Zinfandel. Days taken for 50% flowering varied significantly ranging from

minimum of 25.36 days in the variety Pusa Navrang to maximum of 44.37 days in Thompson Seedless.

Different varieties tested exhibited significant variation in yield parameters (no. of bunches, bunch weight, bunch length, number of berries, hundred berry weight and berry diameter). The variety Chenin Blanc recorded higher number of bunches per vine (113.78) and Thompson Seedless (37.26) recorded lower number of bunches, where as heavier bunches were produced by the variety Italia (331.61 g) followed by Thompson Seedless and lighter bunches in the variety Cabernet Sauvignon (88.06 g). The variety Italia besides having lower number of bunches and higher bunch weight showed maximum diameter of berry (17.9 mm) and higher berry weight (414.21 g per 100 berries). The variety Chenin Blanc (16.81 kg/vine) recorded maximum yield and it was minimum with Sauvignon Blanc (4.51 kg/vine). Heat unit requirement in different cultivars of grape varied from 1726.25 degree days to 2207.46 degree days with maximum being in case of Italia and minimum in Pusa Navrang.

With respect to the physico - chemical properties of juice, Chenin Blanc (78.38 %) followed by Pusa Navrang showed the highest juice content. Total soluble solids was highest in Shiraz (21.95 °B) and minimum in Italia (15.43 °B). Chenin Blanc recorded maximum titrable acidity content (0.85 %) and minimum by Ruby Red (0.38 %). There was a reduction in the TSS, titrable acidity, sugars, tannins, phenols and flavonoids in wine after aging. Among the varieties studied, Shiraz showed minimum TSS content in wine after aging and maximum was observed in Italia. The volatile acidity of all the varieties was within the range of the International standards (0.011 to 0.063%). The total phenols, tannin and flavonoid contents of wine showed a wide variation in which coloured varieties recorded higher content than the white ones. Alcohol content of wine varied from 8.78 to 12.25 %. The variety Shiraz recorded higher content of alcohol followed by Chenin Blanc and Cabernet Sauvignon and minimum recorded in Italia. Organoleptic evaluation of wine samples showed a significant variation among the varieties. Based on the average score, wine made from Cvs. Shiraz, Chenin Blanc and Cabernet sauvignon were graded as Good, while Cv.Italia showed ordinary quality.

Blending is an useful technique to overcome defects in varieties and improve the quality of wine from varieties which are deficient in colour or chemical composition. The bio chemical properties of juice revealed that TSS of the juice varied from 16.46 °B to 21.46 °B and T₇ has recorded maximum TSS which was significantly superior to the rest of the cultivars closely followed by T₁ while minimum content was observed with T₂₄. Maximum titrable acidity was recorded with T₁₂ (1.66 %) and minimum titrable acidity was observed with T₃ (0.64%).

Wine prepared from different blends showed wide variations in the biochemical properties of wine. Decrease in the TSS and titrable acidity, and sugars was observed after fermentation in all the treatments and among them, T₇ showed

minimum content of TSS, total and reducing sugars and highest was recorded with T₂₁. Volatile acidity, sugars, total phenols and flavonoids were found to decrease after aging in all the treatments while alcohol content was found to increase in wine upon aging. The volatile acid content of wine in the treatments after aging varied from 0.017 to 0.046 % with minimum in the treatment T₁₃ and maximum in T₂₂ and were within the range of International standards. Treatments blended with 3:1 ratio recorded maximum content than 2:1 ratio. Wine produced from the blends of Italia with Ruby Red showed higher content of volatile acidity. Alcohol content of blended wine after aging varied from 7.99 to 11.87 % with highest content being recorded by T₇ while least content was recorded with the treatment T₂₁. Tannin content of wine was maximum in T₂₁ (0.044%) and minimum in T₈ (0.007%). Significantly maximum content of total phenols and flavonoids was recorded with T₂₁ which was superior over the other treatments followed by T₂₂ while minimum content was observed in T₈. The white varieties blended with coloured variety Shiraz registered minimum content of total phenol and flavonoids in wine while wines blended with Ruby Red showed maximum content.

Organoleptic evaluation of wine samples after aging indicated that average score of wine blends ranged from 11.96 in T₂₃ to 17.23 in T₇. Based on the average score, wine made from blended varieties were graded as Good (T₇, T₁, T₈, T₁₂ T₄ & T₁₃), while rest of the treatments produced fair quality wine except T₂₃ which showed ordinary quality.

CHAPTER-I

INTRODUCTION

The domesticated grape (*Vitis vinifera* L.) is one of the oldest cultivated plants reported to be originated in middle east. The genus *Vitis* comprises of three natural groups based on geographical locations viz., North American, Eurasian and Asiatic. American and Asiatic group have 25-30 species whereas Eurasian has only one species i.e. *vinifera* which has contributed for advancement of grape cultivation throughout the world.

There are three distinct regions of grape cultivation in India viz., temperate (Jammu and Kashmir, and Himachal Pradesh), sub tropical (Punjab, Haryana, Rajasthan and western Uttar Pradesh) and tropical (Andhra Pradesh, Maharashtra, Karnataka and Tamil Nadu). However, 94 percent of the grape area falls under the tropical region (Chadha, 2008).

Man has been preparing and consuming a large variety of alcoholic beverages ranging from mild stimulants to highly intoxicating liquors since time immemorial, of which “Wine” is one. Many times, the word ‘Wine’ is considered synonymous with liquors. Astonishingly, even well educated people tend to forget the significance of wine which refers to the fermented product of grape.

Wine is perhaps the oldest fermented product known to the mankind, mentioned in the ancient scripts. Amongst the alcoholic beverages, Wine was the first to be made and had been used as food adjunct by man since the dawn of civilization. It has a long history as a therapeutic agent. Ancient scripts like Rigveda and New Testament have made references to the wines and the literary writings have described wine profusely. All over the world, some or other type of wines native to that place are produced and consumed. Admitably, except for water and milk and its products, no other beverage has earned such universal acceptance and esteem throughout the ages as wine.

Wine contains over 1000 different chemical constituents making it a very complex product. It generally consists of 85-90 % water, 10-14% alcohol and 1-5% phenolics. It also contains much smaller amounts of glycerol and sorbitol, acids primarily in the form of tartaric, malic, lactic and acetic acids. (Johnson and Halliday,1992) as well as minor concentrations of poly-peptides, amino acids, mineral salts and enzymatic or metallic catalysts. Although certain of these components are present in small quantities, they are presumed to play important roles in the sensory properties of the wine products (Lubbers and Voilley, 1997).

Wines have always been considered as safe and healthful drink, an important adjunct to the diet and moderate quantity of wine consumption has been found to lower the mortality from heart diseases (Delin and Lee,1991). It also provides calories and vitamins. Since the wines are not distilled they have more nutrients like vitamins, minerals and sugars than the distilled beverages like beer, brandy and whisky. In addition to this, several therapeutic and medicinal values are found to associate with wines. The existence of alcohol and anti-oxidants in wine reduce a variety of human ailments especially the cardio vascular diseases (Joshi and Sharma, 2004). Wines contain antioxidants. The anti microbial activity found with wines is an added advantage.

Clearly wines and beers are more nutritious than distilled liquors. Their mineral composition would also support this contention. However, wine is safer one than the other two from the health point of view. In spite of the above, the wine market in India is still considered nascent, awaiting promotion and upliftment.

Wines are prepared from fruit juices by fermentation with micro organisms (e.g. yeast). Grape has been the principal fruit employed in the preparation of wine (Vyas and Chakravorthy, 1971). Nevertheless, other fruits also have been utilized for making wines such as Apple known for Cider (Sandhu and Joshi, 1995), Pear for sherry, Plum for table and fortified wine (Joshi and Attri, 1991), Strawberry (Sharma and Joshi, 2004), Banana (Shanmuga Sundaram *et al.*, 2005), Pineapple (Wang *et al.*, 2005) and Mango (Onkarayya,1985). In fact the word 'Wine'

signifies the fermented product from grape only and for wines other than grape, the name of the fruit from which the wine was made, is pre-fixed, for example, wine from plum is called plum wine (Joshi 2000, 2001). Virtually wine can be made from any substrate having adequate fermentable sugar and other requirements for yeast growth (Jackson, 1994).

At present, the grape is grown over an area of 60,200 ha with an annual production of 1.6 million tones (Chadha, 2008). Maharashtra is the leading grape growing state in the country with highest area under cultivation (around 71.5 percent of total area) and 80 percent of country's production (Karibasappa *et al.*,2006).Karnataka and Andhra Pradesh occupy second and third places in grape cultivation. In Andhra Pradesh grape is grown in an area of 1765 ha with an annual production of 85,000 metric tones.

The grapes can be utilized in the following three ways

- 1) As fresh fruit for table purpose
- 2) For making raisins
- 3) For making wine

About 80 % of the world production is utilized for wine making, 10% for table use and the balance 10 % for raisin and juice purposes. On the other hand, in India, 78 % of country's production is used for table purpose, around 17-20% is used for raisin production and less than 2 % is used for manufacture of Juice and wine.

Arrival of more than 70 % of the total production in the country occurs in a short span of time of 2- 2 ½ months (February- April). Lack of cold storage facilities and single type of market i.e. fresh fruit trade create a market glut, resulting in the fall of prices and financial loss to the growers and traders. Hence, there is an urgent need to diversify grape usage as juice and wine which can ease out the marketing problems. Efforts in this direction are urgently required.

India does not produce much wine, while fresh grapes are exported to more than 20 overseas markets, we at the same time import fermented products (Katyal and Gupta, 1978). The per capita consumption of wine in India is only 0.07 litre per person per year, as against 60-70 litres in France and Italy, 25 litres in USA, 20 litres in Australia, 4 litres in China. One of the reasons why wine drinking has not caught in the country is that quality wines are not produced and whatever little produced is priced relatively high and is out of reach of large population. If quality wines are produced in adequate quantities and marketed at lesser cost, there will be greater increase in per capita consumption of wine in India. Due to limited domestic consumption and non availability of standard wine grape varieties, much emphasis was not bestowed for research to increase wine production (Shikhamany, 1997). However, the wine industry and the market for this product in the country is growing by and large to the extent of 25-30 percent every year.

Quality wines can only be produced from specific and quality grape varieties. Such specific grape cultivars are lacking in the country. Thus production of quality wines can be achieved by introducing wine grape varieties from major grape growing countries of the world and evaluating their performance under Indian climatic conditions, to ascertain their suitability for wine making in India. In addition, the existing varieties in different parts of the country are also needed to be screened for their suitability for wine making qualities. In this regard, some world famous grape wine varieties have been introduced in to India. Such introduced cultivars are being maintained in germplasm collections in various grape research stations across the country and are being commercially grown in small pockets around these research stations.

Raisins, juices and wines are the major processed products of grape in India. Several varieties were screened for raisin and juice making and their processing techniques were standardized, however, not in the case of wine grapes. Though some work has been done on screening various existing grape varieties for wine making (Patil, 2005 and Havinal *et al.*,2008) a comprehensive study on the

introduced wine grape cultivars for their growth, yield, suitability and quality performance under different agro-climatic regions of the country is still lacking. Since Andhra Pradesh is one of the important grape growing state in the country and is blessed with suitable climate for cultivation of different grape cultivars and information regarding availability of suitable wine cultivars and standardization of quality wine production technology is meagre, it is imperative to study and identify suitable varieties for production of quality wines. It is the need of the hour, to undertake research in screening of grape wine varieties for their growth, yield and fruit quality parameters and their suitability for making quality wines.

Keeping in view the above facts and requirements, the present investigation is designed to study the growth, development, suitability and production of wine from different wine varieties grown under semi- arid conditions of Hyderabad, Andhra Pradesh with the following objectives

- 1) To study the varietal performance of different wine varieties in respect of their growth and yield under semi- arid conditions of Hyderabad.
- 2) To study the wine recovery and quality parameters from different wine grape varieties.
- 3) To study the effect of blending of different white varieties with coloured varieties of grape on wine quality.

CHAPTER-II

REVIEW OF LITERATURE

The literature published on wine industry and work done on the growth and yield performance of different grape varieties and wine making, in India and abroad is reviewed in the following chapter. A perusal of the literature indicates that much less studies were made in case of wine grapes, hence the literature on table and other grape varieties is also reviewed. An excellent review on status, prospects and development of wine industry in India was published by Adsule (2008), from which some information is presented below.

2.1 Past work on Wine research

In the past, a number of studies in wine making have been made at Department of Microbiology of Haryana Agricultural University, Hissar; Central Food Technological Research Institute (CFTRI), Mysore and Indian Institute of Horticultural Research, Bangalore. At Haryana Agricultural University (HAU), Hissar, work was done on the evaluation of enological properties of various grape varieties *viz.*, Anab-e-Shahi, Perlette, Early Muscat, Pandhari Sahebi, Cheema Sahebi (Selection-7), Khalili, Delight and Gulabi using wine yeast (*Saccharomyces cerevisiae ellipsoidea*) and reported wine of excellent quality from Perlette and red wine of high quality from Beauty Seedless. Work carried out at CFTRI, Mysore indicated that the good quality wines comparable to many foreign countries can be prepared by utilizing grapes of Anab-e-Shahi, Bangalore Blue and Bhokri. Work on hybridization for evolving wine grape varieties and evaluation of the important introduced of grape varieties for wine making has been reported from IIHR, Bangalore. Further must composition of 60 grape varieties was analysed and the results showed the possibility of using Black Hamburg, Black Muscat, Golden Queen, Isabella, Muscat and Crimpson for making red dry wine; Crossa Decotnari,

Rekastali, Bhokri, White No.1, Chaseless Dose and White Riesling for making white dry table wine and Black Champa and Convent large Black for making sweet wine or dessert wine.

Production of wine from Bangalore Blue grape attracted considerable attention during 1960's. Sreekantaiah and Johar (1968) studied the suitability of Bangalore Blue for wine manufacture. Venkataramu *et al.*(1979) studied the production of red wine from Bangalore Blue grapes. Later, Patel *et al.*(1978) studied the colour stability of wine by sulphites.

Thus the development in wine making in India during pre-period of 2000 AD was very less, which includes ancient wine making in states of Jammu and Kashmir and Himachal Pradesh, setting up few winery units in Karnataka, Andhra Pradesh and Maharashtra with the foreign collaboration and the research work carried out by HAU, Hissar, CFTRI, Mysore and IIHR, Bangalore on the evaluation of table grape varieties for making wine.

2.2 Present Work on Grape Wine Research

Grape research was earlier initiated at Punjab Agricultural University (PAU), Ludhiana; Indian Agricultural Research Institute, New Delhi; Central Fruit Station, Pune in early 1960's and at IIHR, Bangalore and Grape Research Station of State Agricultural Universities in early 1970's and then continued further by National Research Centre for Grape (NRCG) at Pune since 1997. The work on wine was initiated systematically at NRCG from 2002 with close interaction with the winery units, wine promoting agencies or departments of concerned State and Union Governments.

The work was intensified on the introduction of wine grape varieties and various rootstocks from leading wine producing countries in the world and evaluation in the context of their suitability and performance under Indian agro-climatic conditions. Data generated so far on these aspects has indicated that the grape wine varieties *viz.*, Sauvignon Blanc, Chenin Blanc and Ugni Blanc for

making white wine, while Cabernet Sauvignon, Shiraz, Merlot, Pinot Noir, Zinfandel for red wine have shown better performance under Indian conditions. Most of the wineries in the country have shown their preference for these varieties for producing wine. A lot of research in respect of training, pruning and management of soil, nutrients, water, pests and diseases has been done in table grapes of India. However, this data in respect of wine grape varieties is lacking and being built up now to give appropriate recommendations to the grape growers.

Work in the area of plant propagation for making available grape grafts of compatible scion and rootstock varieties is also initiated to give quality plant material. Further, their evaluation for wine quality through enological studies is also being undertaken at the pilot winery units in NRCG. In addition to this, work on geographical labelling of wine based on the location or region of grape growing and preparing wine standards of national and international levels was also initiated.

2.3 Experiment I: Study on growth and yield of different varieties of grape for wine production

Performance of plant species in respect of growth and production is variable depending on the agro-climatic conditions under which it is grown. A cultivar that performs well under a set of agro-climatic conditions need not perform well similarly under another set of agro-climatic conditions, *i.e.* its performance varies from one set to another set of conditions. Similarly different varieties when grown under a particular set of conditions perform differently. This necessitates performance studies of different plant species particularly their varieties under different situations to choose a suitable variety for that location. Such studies are especially needed when varieties are introduced from one country to another country or from one zone to another zone within the country. Keeping this in view, a few performance studies in respect of growth and production (yield) were conducted within the country and elsewhere in the world (Amerine and Winkler, 1963; Vyas and Gandhi, 1971; Daulta and Bakshi, 1978; Frovlov,1979;

Kulkarni *et al.*, 1980; Suresh *et al.*,1985; Suresh *et al.*, 1989; Tomar, 1990; Cheema *et al.*, 1998; Gaser *et al.*, 1998; Sivcev, 1998; Cheema *et al.*,2000; Garav *et al.*, 2000; Ram Kumar *et al.*,2002; Aulakh *et al.*,2003; Benz *et al.*,2006; Fidelibus *et al.*, 2006; Martin *et al.*, 2006; Ghosh *et al.*,2008; Havinal *et al.*, 2008; Kumar and Rajan, 2008; Karibasappa and Adsule, 2008; Patil and Patil, 2008; Possingham, 2008; Ravi Kumar *et al.*, 2008; Thakur *et al.*, 2008 and Gill and Arora, 2009).

Growth Parameters

2.3.1 Pruning Weight

Grape vine is pruned all over the world to maintain its growth and production. It is the cheapest and commercial means of crop regulation in grape. When vines are pruned some amount of its shoots, canes and leaves etc are obtained. This is called “Pruning Weight”. The amount of pruning weight depends upon the vigour of the vine in the other words the vigour of vine is expressed in terms of pruning weight. This parameter is an important growth attribute for distinguishing different grape varieties as vigorous, non vigorous etc. Shikhamany (1983), Fawzi *et al.*(1984); Satisha and Shikhamany (1999) and Benz *et al.*(2006) judged vine vigour on the basis of pruning weight.

Smith (1996) obtained pruning weight ranging from 2.42 to 3.19 kg/ vine in eleven Chardonnay clones and claimed that high yielding clones produced larger pruning weights and vice versa. Havinal *et al.* (2008) reported maximum pruning weight (2.93 kg/vine) in Chenin Blanc and minimum (0.44 kg/vine) in Merlot at Rahuri.

Kadu *et al.*(2007) observed a range of pruning weight from 0.04-2.42 kg/vine among 15 wine grape varieties in Maharashtra. Pruning weight ranged from 4.6 to 20.4 kg/vine in 23 red and 6 white wine grape varieties at South west Idaho (Shellie, 2007). Ratnacharyulu (2010) reported highest pruning weight in the variety Black Cornichon (3.78 kg/vine) and lowest in Concord (0.91 kg/vine).

Pruning weight indicated that Champanel (11.09 tons ha⁻¹) was the most vigorous vine, Arka Soma (7.9 tons ha⁻¹), Convent Large Black (5.83 tons ha⁻¹), Arka Thrishna (5.2 tons ha⁻¹) and Pusa Navrang (5.11 tons ha⁻¹) were moderately vigorous, while Pinot Noir (2.65 tons ha⁻¹), Chardonnay (2.67 tons ha⁻¹), Saperavi (2.66 tons ha⁻¹), Clariette (2.8 tons ha⁻¹) and Zinfandel (2.51 tons ha⁻¹) as less vigorous at Pune (Karibasappa and Adsule, 2008).

2.3.2 Days taken to bud sprouting after pruning (Bud Burst)

Bud burst makes the beginning of seasonal growth and production in grape. The sprouting of buds (bud burst) on the spurs is a varietal character and is a clear response of vine to prevailing environmental conditions particularly the temperature. The time taken for bud burst is taken as an index to classify the grape varieties as early, mid and late varieties.

Rajaram (1964) reported that under Tamil Nadu conditions, Anab-e-Shahi sprouted within 12-18 days from the date of pruning, while Muthukrishnan (1969) under Coimbatore conditions observed that the time of bud burst ranged from 5 days to 18 days in different cultivars.

Lingaraj (1965) under Bangalore conditions observed that the bud burst was earliest in Bangalore Blue and Kemmangundi (2 days) followed by Gulabi, White No.1 (6-7 days).

Average period for bud burst varied from 10 days in cultivar Phakdi and 18 days in Bangalore Purple (Kulwal, 1968); 12 days in Bangalore Purple, 13 days in Ruby Red and 22 days in Hur (Bharat, 1997); 14 days in cultivar Gulabi and 23 days in Pandhari Sahebi (Shinde and Patil, 1978) ; from 14 days in Bhokri and 25 days in Selection – 94 (Patil, 1968).

Valor and Bautista (1997) recorded 50% bud break at 9.4, 11.5 and 12 days in cultivars Chenin Blanc, Villanueva and Tempranillo respectively in Venezuela. Pina and Bautista (2004) noticed the period from pruning to bud burst as 11-12 days in cultivars Italia and Red globe while it was 13-14 days in Sultania, Alphonse Laval cultivars at Venezuela.

Bharat (1997) reported that variety Bangalore Purple took minimum number of days (12 days) for bud burst after October pruning while the cultivar Hur recorded maximum days (22 days).

Seif and Abd Ei-Samad (2000) studied the bud dormancy of different wine grape cultivars and observed that Cv. Early superior was earliest to bud break while the cultivar Red Globe was late to bud break. Mandelli *et al.* (2003) studied the phenological pattern of 12 wine grape cultivars based on the average number of days taken for bud break from pruning and classified the cultivars in to early cultivars (Chardonnay, Italice, Concord and White Niagara), mid season cultivars (Cabernet Franc, Cabernet Sauvignon, Merlot) and late cultivars (Trebiano and White Moscato) in Serra Gaucha region of Brazil.

According to Ratnacharyulu (2010) the varieties *viz.*, Pusa Navrang, Bangalore Purple and Ruby Red took less than 8 days for bud burst from pruning while 13 days was noticed in the variety Concord.

2.3.3 Number of Canes

Besides pruning weight, vine vigour can also be judged by the number of canes produced per vine after pruning (Fawzi *et al.*,1984). Several scientists recorded the number of canes per vine in different cultivars (Kadu *et al.*,2007; Havinal *et al.*,2008).

Kadu *et al.* (2007) studied fifteen wine grape varieties for the performance of vine vigour by means of number of canes wherein a range of 3.67 to 41.73 was reported. Muscat of Alexandria had significantly more number of canes (37.7) while the variety Pinot Meunier had lower number of canes (3.67). The difference in the number of canes might be due to the differences in vigour and age of variety. Ratnacharyulu (2010) recorded highest number of canes in the variety Ruby Red (104.33) and lowest in the variety Concord (32.33).

2.3.4 Cane Diameter

Havinal *et al.* (2008) observed maximum diameter of cane (0.69 cm) in Cv. Grenchae and minimum in Pinot Meunier (0.41 cm).

2.3.5 Number of leaves and leaf area per cane

Leaves are the sites of photosynthesis, more the number and more the area of leaves on a plant, more will be the photosynthesis. Hence all efforts should be made to enhance the number and area of leaves on plant. Shirsath (1965) and Chadha & Randhawa (1974) categorized grape varieties on the basis of leaf area. Among the 15 wine grape cultivars evaluated, maximum leaf area (180.13 cm²) was registered by Bangalore Purple and minimum (68.93 cm²) in Pinot Meunier (Kadu *et al.*, 2007).

Flowering Parameters

2.3.6 Days taken for 50 % flowering and duration of flowering

The number of days taken for 50% flowering in grape vary according to the cultivar and environmental conditions. Bright warm weather causes earlier blooming while rainy and cool weather reduce bloom duration (Weaver, 1976). Duration of flowering is important to harvest fruit all in one or two pickings to reduce the cost of picking. Duration of flowering has also exhibited differences depending on the variety and prevailing environmental conditions.

Under the sub- tropical conditions of Punjab, almost a month time was required from panicle emergence to flower opening in different grape cultivars (Jawanda *et al.*, 1965), whereas under tropical conditions of Bangalore, the flower buds of Cvs. White No.1, Gulabi, Bangalore Blue and Kemmangudi took 41.0, 47.0, 33.5 and 44.0 days respectively to reach the anthesis.

Sumbli (1970) reported that the development of flush was completed in all the varieties within 16-23 days, the Cv. IHRI took maximum number of days (23), while Bangalore Blue took minimum number of 16 days. Prasad (1971) observed that the number of days taken from bud initiation to anthesis ranged from 25-28

days in certain grape cultivars screened at U.P. conditions. According to Nalwadi *et al.* (1972) 19-25 days were required for full bloom from flower bud emergence at Dharwad.

Under Delhi conditions, the Cv. Sahebi registered the shortest flowering duration (12 days), followed by Golden Queen, Tas and Hur cultivars (14 days) whereas the longest flowering duration was observed in Bhokri (23 days) (Randhawa and Sharma,1960). Randhawa and Negi (1965) observed flowering duration of 14-15 days in Alamwick, Bharat Early, Black Muscat and Pusa Seedless cultivars under Delhi conditions.

Bharat (1997) reported that the duration of flowering varied from 16-30 days in different grape cultivars. The cultivar Pandhari Sahebi showed maximum duration of flowering and Bangalore Purple with minimum duration of flowering. Huang and Lu (2000) reported that the duration of flowering ranged from 11 to 22 days in different grape cultivars.

Negi *et al.*(1974) reported that number of days required from pruning to flowering varied with variety, being 69 days in Katta Kurgan, 65 days in Anab-e-Shahi, 60 days in Angur Kalan, 53 days in Convent Large Black, 50 days in Queen of Vine yards and 45 days in Bangalore Blue.

Bunch Characteristics

Fruits of grape vine are botanically called as “Berries” and a cluster of berries on main rachis and secondary rachis are referred to as “Bunches”. Bunch and berry attributes include bunch weight, bunch length, number of berries, diameter of berry and 100 berry weight which contribute to the yield of vines.

These characteristics are specific to each variety, hence are used in describing the different grape varieties by various workers (Hedrick, 1908, Bioletti, 1938; Singh and Singh ,1940; Joshi ,1961; Shirsath ,1965; Kashyap *et al.* ,1988 and Shanmugavelu ,1989).

2.3.7 Bunch Weight

Bunch weight is an important yield attribute. Heavier the bunches more will be the yield. Daulta *et al.* (1972) studied the phenotypic variability in 30 grape cultivars with reference to bunch weight and reported that bunch weight ranged from 44.9 to 436.1 g in different cultivars. A range of 41 to 436 g bunch weight was also reported (Bhujpal, 1972 and Anonymous, 1984a). Sharma *et al.* (1993) observed a wide range of bunch weight from 230 to 575 g in six different cultivars of grape. Richard *et al.* (1999) recorded bunch weight ranging from 88 to 310 g in 5 cultivars of grape (Chenin Blanc, Sauvignon Blanc, Arinarnoa, Arriloba and Barbera).

Highest average weight of bunch was recorded by Muscat of Alexandria (317 g) followed by Bangalore Purple (277.8 g) and lowest bunch weight was registered by Sauvignon Blanc (28.49 g) (Kadu *et al.*, 2007). Patil (2005) reported that average bunch weight was highest in Chenin Blanc (415 g) followed by Cabernet Franc (320 g) and minimum was noticed in Syrah (300 g).

Thakur *et al.* (2008) reported bunch weight of 389.6 g, 384.6 g and 335.3 g respectively in Cvs. Banqui Abyad, Selection -7 and Perlette. Kumar and Rajan (2008) observed maximum bunch weight in Pusa Seedless (280.0 g) and minimum in Pusa Urvashi (75.7 g). Ghosh *et al.* (2008) found heaviest bunches (194 g) in Arka Neelamani and very light bunches in E 25/11 (60.5 g) in West Bengal. Karibasappa and Adsule (2008) recorded maximum bunch weight of 251.5 g in Arka Soma (251.5 g) and minimum (65.2 g) in Champanel in Maharashtra.

Several workers have reported bunch weight in different cultivars of grape viz., Cabernet Franc (147.7 g), Ugni Blanc (135.6 g), Chenin Blanc (132.8 g) by Havinal *et al.* (2008); in Pearl of Csaba (163 g) by Aulakh *et al.* (2003); in Black Champa (280 g) by Sharma (1993); Thompson Seedless (226 g) by Bhujpal (1972); Red Globe (850.1 g) by Colapietra *et al.* (2000).

Havinal *et al.* (2008) recorded maximum weight of bunch in Cabernet Franc (147.7 g) and minimum in Merlot (114.8 g). Leao and Pereira (2001) observed the average weight of bunches varying from 164.8 g to 203.5 g in six seedless grape cultivars at Portugal. Highest bunch weight was reported in the variety Black Cornichon (161.33 g) while lowest in Bangalore Blue (97.3 g) (Ratnacharyulu, 2010).

The differences in bunch weight in different varieties was attributed to inherent characters of the variety, difference in number of berries per bunch and berry size (Walker *et al.*, 2000; Havinal *et al.*, 2008).

2.3.8 Number of Bunches per vine

Number of bunches per vine differed significantly with variety, nutrition of the vine and site of growing. At Bangalore, 8 to 88 bunches per vine with mean bunch weight ranging from 41 g to 335 g in different grape varieties was observed by Anonymous (1984a).

Walker *et al.* (2000) evaluated 5 Shiraz wine grapes and recorded that the number of bunches per vine varied from 131 to 162 with an average weight of 107 to 130 g. The number of bunches per vine was highest with Syrah (33.43) and was minimum in Bangalore Purple (9.30) (Kadu *et al.*, 2007). Maximum number of bunches per vine was observed in Cv. Cabernet Sauvignon (93.1) followed by Chenin Blanc (91.8), while it was minimum Pinot Meunier (17.35) as reported by Havinal *et al.* (2008).

Ratnacharyulu (2010) evaluated different grape varieties at Hyderabad and reported that the variety Ruby Red has recorded highest number of bunches per vine (142) and lowest number in the variety Black Cornichon (60.67).

2.3.9 Length of bunch

Length of the bunch ranged from 12 cm to 19.2 cm in 5 wine varieties of grapes in South Australia (Richard *et al.*, 1999). Cultivar Banqui Abyad had

produced longer bunches measuring 21.7 cm, while the bunches in Arka Shyam were the shortest measuring only 13.7 cm at Bhatinda (Thakur *et al.*, 2008). Similarly, longest bunches were observed in cultivar Arka Neelamani (15.4 cm) and shortest bunches in Hybrid 25/11 (10.1 cm) in West Bengal (Ghosh *et al.*, 2008). The bunch length was highest in Cabernet Sauvignon (11.0 cm) and lowest in Pinot Meunier (6.22 cm) as reported by Havinal *et al.* (2008).

2.3.10 Berry Characteristics

Ratnacharyulu (2010) recorded that average number of berries was maximum in the variety Ruby Red (95.33) and minimum in Bangalore Purple (31). According to Havinal (2007), highest number of berries per bunch was obtained from the variety Chenin Blanc (132.56) and minimum in Merlot (70.78).

Kadu *et al.* (2007) reported maximum diameter of berry in Bangalore Purple (19mm) and minimum in Cabernet Sauvignon (10.0mm). Diameter of berry was minimum in Ruby Red (13 mm), while maximum in berries of Cardinal (20.7 mm) (Thakur *et al.*, 2008). Diameter of berries ranged from 10 to 16 mm in certain wine grapes *viz.*, Arinarnoa, Arriloba, Merlot and Barbera. (Richard *et al.*, 1999) and 12.84 mm (Cabernet Sauvignon) to 14.56 mm (Grenache) reported by Havinal *et al.* (2008).

Weight of individual berry varies according to the variety and appears to be a varietal character, nevertheless it was influenced by environmental as well as nutritional and irrigation factors.

Daulta *et al.* (1972) reported berry weight ranging from 0.45 - 3.98 g in 30 grape varieties. Sharma *et al.* (1993) observed wide variation in average weight of berry ranging from 2.08-7.55 g in 6 different varieties of grapes. Similarly, Richard *et al.* (1999) while studying the oenological characteristics of some wine grape varieties recorded a range in berry weight from 1.1 to 1.6 g.

Peynaud and Ribereau-Gayon (1971) reported berry weight of 1.60 g and 1.62 g in the cultivars Sauvignon Blanc and Merlot. The individual berry weight in Cv. Sursahibi was 3.6 g (Sharma, 1993). Patil (2005) reported heaviest berries

weighing maximum in Chenin Blanc (3.62 g) followed by Cabernet Franc (3.48 g), Ugni Blanc(3.32 g) and Syrah (3.26 g) at Rahuri. Havinal (2007) observed highest berry weight of 169.8g per 100 berries in Cv.Ugni Blanc and lowest of 105 .0g in Merlot at Maharashtra.

Berry weight was maximum in Arka Chitra (3.0 g) followed by Arka Neelamani (2.8g) and minimum in cultivars Pusa Navrang (1.5 g) and E25/11 (1.3g) in West Bengal (Ghosh *et al.* ,2008). Higher berry weight of 4.8g in Cardinal and lower weight of 1.30 g in Ruby Red were observed at Bhatinda (Thakur *et al.*, 2008). The berry weight was 3.22 g in Convent Large Black; 3.13 g in Arka Soma, 2.87g in Merlot, 2.67 g in Zinfandel, 2.06 g in Chenin Blanc and 2.55 g in Sauvignon Blanc at Pune (Karibasappa and Adsule, 2008).

Sharma (1987) reported that Anab-e-Shahi recorded highest berry weight (251.87g for 100 berries) and lowest in Karachi Gulabi (141.67g). Hundred berry weight ranged from 45.6 to 398.4 g in 30 grape varieties (Daulta *et al.*, 1972). Masoodi *et al.*(1991) reported hundred berry weight of 198-269 g in the same variety of Perlette grapes harvested at different dates. Hundred berry weight was minimum in Pusa Navrang (104 g) and maximum in Cardinal (275 g) at Lucknow (Ram Kumar *et al.*, 2002). Ratnacharyulu (2010) reported highest hundred berry weight (403.3g) in the variety Bangalore purple and least in Pusa Navrang (106.67 g).

2.3.11 Yield

Yield is the most important factor from commercial point of view and varies significantly with the variety, age, severity of pruning etc. it also varies from year to year in the same variety and grown in different areas.

Daulta *et al.*(1978) reported a wide range of yield from 5.0 to 65.6 kg per vine in 30 grape varieties. Thatai *et al.* (1987) observed a range of 2.56 to 3.79 kg yield per vine in Perlette variety at different pruning levels. Kadu *et al.*(2007) registered a wide range of yield from 0.37 to 6.8 kg/vine in different cultivars of

grape, wherein highest yield per vine was recorded in Muscat of Alexandria and lowest in Merlot (0.48 kg/vine). Ram Kumar *et al.* (2002) reported highest yield (17.6 t/ha) with Flame Seedless and lowest yield (20.2 t/ha) with BA x PER 75-32 at Lucknow.

Maximum yield per vine was observed in Chenin Blanc (12.19 kg/vine) followed by Cabernet Sauvignon (11.12 kg/vine) and Shiraz (7.59 kg/vine) while minimum was in Merlot (2.28 kg/vine) and Pinot Meunier (2.27 kg/vine) under Rahuri conditions (Havinal *et al.*, 2008). Pusa Navrang recorded maximum yield (19 t ha⁻¹) followed by Convent Large Black (18.4 t ha⁻¹), Shiraz (17.87 t ha⁻¹), Arka Trishna (16.8 t ha⁻¹), Zinfandel (14.8 t ha⁻¹) among the red varieties while Ugni Blanc recorded maximum yield (22.6 t ha⁻¹) followed by Chenin Blanc (20.7 t ha⁻¹), Angur Kalan (19.5 t ha⁻¹) and Clariette (15.2 t ha⁻¹) among the white varieties under the prevailing conditions of Pune (Karibasappa and Adsule, 2008).

According to Sharma (1987), highest yield was recorded in the variety Selection-94 (43.16 kg/vine) followed by Anab-e-Shahi (26.03 kg/vine) while minimum was registered by Bangalore Blue (3.63 kg/vine) under Hyderabad conditions. Kumar and Rajan (2008) from Lucknow reported maximum marketable yield in Arka Neelamani (27.5 kg/vine) followed by Pusa Navrang (21.5 kg/vine) confirming the earlier results of Cheema *et al.* (1998) at Ludhiana.

Thakur *et al.* (2008) noticed that the Cv Perlette was the highest yielder (25.0 kg/vine) followed by Beauty Seedless (19.9 kg/vine) while Arka Hans (4.38 kg/vine), Black Prince (5.11 kg/vine) as poor yielders. Ghosh *et al.* (2008) evaluated 8 grape cultivars in West Bengal and reported that Pusa Navrang as highest yielder with 12.2 kg/vine followed by Arka Neelamani with 4.70 kg/vine and stated that the yield increased with the age of vine irrespective of the variety. Ratnacharyulu (2010) reported highest yield in the variety E12/2 (19.06 kg/vine) and lowest in Bangalore purple (7.27 kg/vine).

Ram Kumar *et al.* (2002) observed that the cultivars Flame Seedless and Pusa Navrang as high yielders while Pusa Urvashi and Kishmish Beli as low

yielders. Other workers recorded highest yield in different grape cultivars i.e. Pearl of Csaba (4.6 kg/vine) by Aulakh *et al.* (2003); Punjab Purple (17.5 kg/vine) as reported by Gill and Arora (2009).

The difference in the yield per vine in different cultivars might be due to difference in weight of bunch, number of bunches and age of the vines besides their successful adaptation to the varying agro-climatic conditions under which they are cultivated (Thatai *et al.*, 1987; Havinal *et al.*, 2008).

2.3.12. Heat Units

To complete its growth cycle and to complete one growth and development phase and to proceed to next phase, a plant requires certain amount of heat, which is expressed as “Heat units” or “Degree days”. This amount varies from plant species or varieties to another cycle, The daily mean temperature is calculated from which its base temperature is subtracted. The effective temperature thus obtained is summed for the plant species or growth stage in the entire life cycle. This is called “Heat unit requirement” for the particular variety for whole life cycle or for the particular growth stage expressed in terms of degree days (Winkler *et al.*, 1974).

The concept of heat unit requirement can be effectively used for determining the optimum time of harvest (Jacob, 1950). The use of heat summation data as the harvest index was suggested by several workers in different crops. As early as 1940, Winkler and Williams reported that the grape harvesting date can be determined by calculating the approximate heat summation from date of pruning to harvest. The time required for grapes to reach maturity is determined by the total amount of heat received from full bloom to ripening, which is expressed in terms of degree days (Thakur *et al.*, 2008).

According to Bammi (1968) most of the grape growing areas in India receive heat summation of 4000 to 4800 degree days from the start of growth to fruit maturity. According to Osterwalder (1949) grape require 1889 degree days from anthesis to fruit maturity with 756-876 degree days from bud break to

flowering. The cultivar Bangalore blue required 3562 degree days to attain maturity at Coimbatore (Palaniswamy *et al.*, 1965). Murakami *et al.* (2002) stated that in Cv. Italia the duration of life cycle was 138, 151, 150, and 157 days for different dates of pruning *i.e.* April, May, June and July in Brazil accordingly, the heat unit requirement with a base temperature of 12 °C was 1727, 1564, 1702 and 1840 degree days respectively.

Each cultivar had a specific heat summation requirement and it showed great variability from place to place and year to year. Rameshwar (1993) recorded 2000, 3284, 3508 and 3582 degree days for cultivars Thompson Seedless, Bhokri, Gulabi and Bangalore Purple respectively. Mohammed and Omran (2004) from Egypt, from an experiment on heat unit requirement of 3 cultivars *viz.*, Flame Seedless, Perlette and Superior concluded that Flame Seedless required more heat units (43,336 degree days) followed by Superior (39,122 degree days) and Perlette (37,394 degree days) from bud break to harvest. Similar findings were reported earlier in respect of Cvs. Cardinal, Regina and Sanganelu wherein Sanganelu required more heat units (2285.7 degree days) over the other cultivars (Ghawawi *et al.*, 1995).

Ei-Sese and Mohammed (2003) from Egypt reported that heat units required for the start and the end of bud break in case of Red Roamy were 11882 and 23441, and in Thompson Seedless, it was 8566 and 12,591 respectively. Santos *et al.*(2007) worked out heat unit requirements for Cabernet Sauvignon and Tannat cultivars as 1295 and 1375 respectively.

Makhija *et al.*(1984) reported that the early maturing variety 'Pearl of Csaba' required 1600 degree days, mid season variety 'Black Muscat' required 2080 degree days and the late variety 'Alam wick' required 2250 degree days under Delhi conditions and concluded that early maturing varieties required less heat units than the late maturing ones. Similar observations was made at Bhatinda, Punjab by Thakur *et al.*(2008), who observed lesser heat units (890.1 to 1050.1 day degrees) in case of early maturing varieties as compared to late maturing varieties

(1020.1 to 1491.7 day degrees). The variation in heat unit requirement with variation in the date of maturity was earlier reported in Ber (Singh *et al.*,1998); Mango (Shinde *et al.*, 2001) and Litchi (Rai *et al.*, 2002). Thus the variation in heat unit requirements among the different grape cultivars was attributed to the variation in the date of maturity (Thakur *et al.*, 2008).

2.4 Experiment II: Evaluation of different coloured and white varieties for wine production

Physiochemical analysis of Juice

2.4.1 Juice Recovery

Juice yield from a given variety depends primarily on the pulpiness (Selvaraj *et al.*,1975; Jindal, 1990), size and seediness of berries (Selvaraj *et al.*,1975). The ultimate quantity of wine depends largely upon the amount of juice recovered from the berries.

Cultivar Early Muscat recorded highest juice recovery (63.5 %) followed by Jaos beli (64.0 %) and lowest in Reisling cultivar (Kundu *et al.*,1980). Highest juice percent was recorded with the variety Zinfandel (77.27) and lowest was observed in Karachi Gulabi (6.23) at Hyderabad (Sharma, 1987). Jindal (1990) recorded 80-90 percent juice content in different grape cultivars. Masoodi *et al.* (1991) obtained 70-74 percent juice recovery from Perlette grapes at different data of harvesting, which indicates that juice recovery depends on dates of harvesting also.

Variation in the juice recovery was reported in Cvs. Arka Chitra and Arka Krishna under Bangalore Conditions (Singh *et al.*,1998). In West Bengal, Cv. Perlette provided a juice recovery of 76 percent followed by Pusa Navrang with 69.1 percent juice recovery, minimum in Arka Chitra (64.5%) (Ghosh *et al.*, 2008).

Pawar (2002) recorded highest juice percent in Cabernet Sauvignon (75.56 %) followed by Ugni Blanc (74.05 %) and lowest in Thompson Seedless (60.55 %). Juice yield was higher in Ugni Blanc (69.9%) followed by Chenin Blanc

(67.8%) and lower in Champanel (56%), Chardonnay (55.1%) and Black Prince (55.4%) at Pune (Karibasappa and Adsule, 2008).

Patil *et al.* (2007) evaluated three red cultivars (Cabernet Franc, Syrah and Grenache) and two white varieties (Ugni Blanc and Chenin Blanc) and observed that white cultivars yielded maximum juice percentage as compared to red varieties. Highest juice recovery was reported in the variety Pusa Navrang (76%) while least was noticed with the variety Madhu Angur (47.33%) (Ratnacharyulu, 2010).

2.4.2 Total Soluble Solids of Juice

Total soluble solids (TSS) are commonly used as an indirect measure for sugars (for sweetness) as they can be determined rapidly with a refractometer (Amerine, 1968). TSS is an important factor in getting quality wine. According to Ough (1966), grape juice should have a TSS of 15 to 20 °B for ease of fermentation process to get quality wine. However, the TSS varies with variety etc. Varietal differences in TSS were reported by several workers (Selvaraj *et al.*, 1975; Kundu *et al.*, 1980; Suresh *et al.*, 1985; Chikkasubbanna *et al.*, 1990; Masoodi *et al.*, 1991; Singh, 1995; Garav *et al.*, 2000; Patil *et al.*, 2007; Ghosh *et al.*, 2008; Havinal *et al.*, 2008; Karibasappa and Adsule, 2008).

Suresh and Negi (1975) reported TSS for different varieties of grape as follows: Chenin Blanc (22.2 °B), Sauvignon Blanc (21.6 °B), Muscat Hamburg (21.4 °B), Zinfandel (20.4 °B), Bangalore Purple (19.8 °B). Among the wine grape varieties maximum TSS was found in Grenache ((22.1 °B) followed by Cabernet Franc (21.2 °B) and least in Ugni Blanc (18.8 °B) as reported by Havinal *et al.* (2008). Tambe *et al.* (2008) reported the range of TSS in grape varieties varying from 19.13 to 27.85 °B. Similar reports on TSS ranging from 11.5 to 27.0 °B was registered by Suresh *et al.* (1985) and Chikkasubbanna *et al.* (1990).

According to Ghosh *et al.* (2008) TSS was highest in Arka Neelamani (20.2 °B) and lowest in Pusa Seedless (16.2 °B) in West Bengal. From Pune,

Karibasappa and Adsule (2008) reported highest TSS in Pinot Noir (24.8 °B) followed by Cabernet Sauvignon (22.2 °B) and lowest (18.5 °B) in Chenin Blanc. Maximum TSS was observed in Cv. Cabernet Sauvignon (22.6 °B) and minimum in Viognier (20.5 °B) at Rahuri (Havinal *et al.*, 2008). Highest TSS was recorded in Cv. Delight (18.23 °B) and lowest in Cv. Ruby Red (14.3 °B) at Bhatinda by Thakur *et al.*(2008). The variety Concord recorded highest TSS (22.33 °B) and lowest was reported in Bangalore Purple (16.90 °B) at Hyderabad by Ratnacharyulu (2010).

Thus it is clear from the above that TSS not only differs among the varieties, but also among the locations for the same cultivars. The differences in TSS might be due to differences in maturity period among the varieties. Negi and Suresh (1972) stated that varieties having atleast 24 °B or above content of TSS in must were suitable for sweet wines and those having below were suitable for dry table wine preparation.

2.4.3 Titrable Acidity

Acidity of the grape is one of the criteria that determines the suitability of the grape variety for wine making. (Ethiraj and Suresh, 1978). Acidity is expressed as percentage. In grape, tartaric acid is the principal organic acid present in large amount followed by other acids present like malic, citric, succinic, fumaric, glycolic, shikimic and quinic acids of which both tartaric and malic acids account for more than 90 percent of total acidity. Organic acids like malic, tartaric and citric acids contribute to the tartness in the wine. Wine tartness was related to titrable acidity and pH of the fruit juice (Amerine *et al.*,1965).

Buttrose *et al.*(1971) suggested that under continuously warm conditions acid accumulation in the green berry decreased and the consumption of malic acid during subsequent ripening period was enhanced, both phenomenons resulted in lower acid content at maturity. According to the Indian standards for wine constituents the acidity should be in the range of 4 to 15 g/l (Bhalerao, 2001).

Several scientists reported different ranges of acidity in grape juice varying from 1.54 to 1.65 percent (Joseph *et al.*(1963); 0.32 to 0.98 percent (Revis *et al.*,1974); 0.34 to 0.95 percent (Chohan *et al.*,1979); 0.34 to 0.88 percent (Radvanyi *et al.*,1981);0.50 to 1.85 percent (Ethiraj and Suresh, 1982); 0.4 to 1.0 percent (Parhad, 1983); 0.76 to 0.80 percent (Kulkarni *et al.*, 1986); 0.55 to 0.83 percent (Sharma, 1987); 0.42 to 0.72 percent (Sandhu *et al.*,1988); 0.49 to 0.94 percent (Chikkasubbanna *et al.*,1990); 0.44 to 1.11 percent (Sharma *et al.*, 1993); 0.64 to 0.83 percent (Patel, 1994); 0.24 to 1.25 percent (Diakou *et al.*, 1997); 0.56 to 0.96 percent (Kadu, 2002); 0.43 to 0.88 percent (Tambe *et al.*, 2008).

Suresh *et al.* (1983) reported that Thompson Seedless grape had 0.65 percent total titrable acidity and considered as good for wine making. Pawar (2002) recorded highest acidity in Ugni Blanc (0.90%) and least in Cabernet Sauvignon (0.56%). Patil (2005) found maximum titrable acidity in juice of Chenin Blanc (0.90%) and least in Ugni Blanc (0.60%). Tambe *et al.*(2008) reported maximum acidity of 0.96% in the must of Ugni Blanc which was found to be at par with Bangalore Purple (0.95%) while lowest was found in Cabernet Sauvignon (0.56%).

Suresh *et al.*(1985) analysed total titrable acidity of juice in 30 grape varieties and found it to range from 0.43 to 1.23 g tartaric acid per 100 ml of juice. Acidity levels were high in Pusa Navrang (5.93 g L⁻¹), Cabernet Sauvignon (5.70 g L⁻¹), Shiraz (5.4 g L⁻¹) and Zinfandel (5.37 g L⁻¹) and were low in Angur Kalan (3.39 g L⁻¹), Clariette (3.53 g L⁻¹) and Chardonnay (3.65 g L⁻¹) as reported by Karibasappa and Adsule (2008). Highest titrable acidity was observed in Cv.Chenin Blanc (0.94 %) and lowest in Viognier (0.76 %) (Havinal *et al.*,2008). The titrable acidity level was highest in Cv.Ruby Red (1.45%) and lowest in Cv.Delight (0.68%) (Thakur *et al.*,2008). The berries of Perlette and Pusa Navrang (0.53%) had lowest acidity of 0.53% while highest was noticed in E 25/11 (1.06%) (Ghosh *et al.*, 2008).

Bammi (1968) stated that dry table wines require high acidity of 0.6 to 0.9 percent while sweet dessert wines require 0.5 to 0.6 percent. A titrable acidity of 0.70 and 0.65 percent is required for making white table and red table wines. (Rama Srinivas *et al.*, 1998).

2.4.4 pH

pH plays an important role in the occurrence and process of malolactic fermentation, prevention of microbial spoilage, stability of soluble proteins, solubility of potassium bitartrate and calcium tartarate and colour stability in red wine (Morris *et al.*, 1984). It is a very important factor in the biological process of fermentation and is responsible for retention of flavouring substances in wine.

For good wine stability, upper limit of pH for white wine should be 3.4 and for red wine it should be 3.5 (Morris *et al.*, 1984). A pH of grapes 3.3 and 3.4 in grapes is optimum for white table and red table wines respectively (Rama Srinivas *et al.*, 1998). A higher pH causes red wine to be less intense and more susceptible to browning (Sim and Morris, 1985). A pH greater than 3.6 make a wine unstable (Amerine and Ough,1980). Wines made from grapes that are too low in pH (*i.e.* acids) will be flabby and flat and that from high pH (acids) will be tart and metallic (Mullins *et al.*,1992).

Selvaraj *et al.* (1975) reported pH range from 3.2 to 3.7 in different grape cultivars, wherein Black Corinth recorded maximum pH (3.7) and Bangalore Blue showed minimum pH (3.2). Suresh and Negi (1975) reported a pH range of 3.1 to 3.7 in thirty grape varieties in their must. Sharma (1987) reported maximum pH (3.54) in Black Muscat and minimum in Selection-94 (3.21). Highest pH was recorded in the variety Pusa Navrang (4.29) and lowest in E12/2 (3.16) respectively under Hyderabad conditions (Ratnacharyulu, 2010).

Vyas and Gandhi (1971) and Sharma (1997) reported a range of pH from 3.2 to 3.5 and 3.28 to 3.52 respectively in various grape cultivars under subtropical North Indian conditions. Selvaraj *et al.* (1975) reported a pH range from 3.2 to 3.7

in different grape cultivars. Similarly Suresh and Negi (1975) observed a pH range of 3.1 to 3.7 in 30 grape varieties in their juice. pH varied from 3.07 to 4.95 in different wine grape cultivars screened at Pune (Karibasappa and Adsule, 2008). Cultivar Black Cornith registered maximum pH (3.7) and Cv. Bangalore Blue showed minimum pH (3.2) (Selvaraj *et al.*, 1975).

According to Havinal *et al.*(2008) maximum juice pH was recorded in the variety Viognier (3.87) followed by Grenache (3.84) while minimum was in Chenin Blanc (3.35). A range of pH from 3.33 (Ugni Blanc) to 3.97 (Cabernet Sauvignon) was obtained in the musts of different varieties (Tambe *et al.*,2008). Several research workers reported different ranges of pH of must such as 3.3 to 4.1 (Peynaud and Ribereau Gayon,1971) and 2.96 to 3.67 (Sharma *et al.*,1993).

2.4.5 Sugars

The sugars of *vinifera* species grape are predominantly dextrose (glucose) and levulose (fructose) accounting for about 99 percent of the total carbohydrates in grape juice. Other sugars present are sucrose, raffinose, stachyose, maltose and galactose (Jindal, 1990).

A large variation in the total sugars and reducing sugars of grape juice ranging from 10.94 to 27.00 percent and 9.10 to 22.20 percent respectively was reported by various scientists (Hristov, 1991; Mane, 1995), 15.8 to 24.1 percent and 14.15 to 23.80 percent (Parhad, 1983; Kulkarni *et al.*, 1986; Sandhu *et al.*, 1988; Sharma *et al.*, 1993 and Sharma, 1993), 10.94 to 27.00 percent and 9.10 to 22.20 percent (Jindal, 1990; Masoodi *et al.*, 1991).

Pawar (2002) reported highest content of reducing sugars (21.53%) and total sugars (22.04%) in Cabernet Sauvignon and lowest in the variety Ugni Blanc (16.67 and 17.72%) respectively. Havinal *et al.* (2008) noticed maximum total and reducing sugars (24.70% and 21.19 %) in the variety Pinot Noir and minimum in Ugni Blanc (17.66% and 16.79%). According to Tambe *et al.*(2008), Arkavati recorded the highest total and reducing sugars (24.54% and 22.59%) while lowest was noticed in Pinot Meunier (16.79% and 15.37%). Total sugar content in the

range of 10.49 % to 27.00 % and reducing sugar content of 9.1 to 22.2% in must of different varieties was reported by several workers (Divakar *et al.*,1974; Jindal, 1990; and Sharma *et al.*,1997).

Physicochemical Analysis of Wine

A typical wine contains sugars, acids, alcohol, phenol, tannins and flavonoids etc (Joshi, 1998) which show variation according to the variety from which the wine is made.

2.4.6 Total Soluble Solids

Fall in the Total soluble solids in wine after fermentation was used as a criteria to determine the rate of fermentation and completion of fermentation when TSS dropped to 7 °B (Rana *et al.*, 1986 and Azad *et al.*, 1987). Decrease of TSS in wines may be due to greater utilization of sugars (Ronnie *et al.*, 2001).

TSS content declined from initial 23.00 ° B in must to 7.63 ° B after completion of fermentation thus showing 67 percent utilization of TSS during fermentation of Karonda wine (Bhajipale *et al.*, 1998).

A maximum decrease in TSS content from 23.00 ° B to 6.07 ° B was observed in the wine prepared from grapes with hot extraction and pasteurized juice and it might be due to the elimination of acetic acid bacteria and inhibitory substance which were responsible for under utilization of sugar (Ghadge *et al.*, 2006).

2.4.7 Titrable Acidity

Acidity in wine is an important attribute as the flavour of the wine depends upon the optimum acidity of grapes, hence acidity plays an important criteria in wine making (Ethiraj and Suresh, 1978). The acids are important in maintaining pH low enough to inhibit the growth of many undesirable bacteria, thus giving advantage to wine yeasts. Bammi (1968) stated that dry table wines require high acidity of 0.6-0.9 percent while sweet dessert wines require 0.5-0.6 percent.

According to Sim and Morris (1984) organic acids such as tartaric, malic and citric acids which are present in the must are also found in resultant wine and these acids contribute to the acid taste of the wine and protect it from spoilage. However, the total titrable acidity of must after fermentation shows some reduction in the corresponding wine which may be due to both metabolism of malic acid and precipitation of potassium acid tartarate. Malic acid is known to be metabolized to an extent of 30 percent during alcoholic fermentation and also potassium acid tartarate was found to get precipitated after fermentation (Ethiraj and Suresh, 1978).

The titrable acidity in the wines prepared from four grape varieties ranged from 0.64 to 0.69 percent (Patel, 1994). According to Tambe *et al.*(2008), maximum acidity was recorded in the wine of Sauvignon Blanc(0.88%) while minimum of 0.43 % was observed in Pinot Noir. Pawar (2002) reported that titrable acidity of wine prepared from Cabernet Sauvignon, Thompson Seedless and their blends ranged from 0.62 to 0.69 percent. The titrable acidity of red wines prepared by blending the grape wine varieties ranged from 0.61 to 1.26 percent (Suresh *et al.*, 1983). A range of 0.31 to 0.65% was reported in cultivars Arkavati, Arka Shyam, Arka Kanchan and Arka Hans (Suresh *et al.*,1985). According to Bhalerao (2001) wine should contain total acids in the range of 4-15 g/lit as tartaric acid.

Sharma (1987) observed decreasing tendency in respect of titrable acidity of wines, compared to their must at Hyderabad. This might be due to the precipitation of tartaric acid as potassium acid tartarate after fermentation. Similar observations were also registered by Amerine *et al.*,1979; Chikka Subbanna,1982; Kundu *et al.*, 1980 & Padshetty *et al.*, 1982.

The nine white grape varieties with titrable acidity ranging from 0.43 to 0.75 percent produced dry table wines (Suresh and Negi, 1975). Titrable acidity of wine prepared from Thompson Seedless and Cabernet Sauvignon and their blend

ranged from 0.62 to 0.69% while that of Ugni Blanc and Sharad Seedless ranged from 0.58 to 0.66% respectively (Pawar, 2002).

According to Gollmick *et al.*, (1991), tartaric acid content in grape wine ranged from 0.5 to 4.0 g/litre of wines. Suresh *et al.*(1985) analyzed total titrable acidity in 30 grape cultivars and found that it ranged from 0.44 to 0.99 g per 100 ml. A significant decrease in the total acidity of plum wine was noticed during storage due to removal through precipitation of potassium tartarate (Padshetty *et al.*,1982; Kundu *et al.*,1980. The titrable acidity of pulm vermouth registered a significant decline with increase in the alcohol content (Joshi *et al.*, 1995).

2.4.8 Volatile Acidity

Volatile acids in wine are acetic acid, butyric and propionic acid. The volatile acid is a good indicator of growth and activity of acetic acid bacteria. The amount of acetic acid produced during alcoholic fermentation is usually less than 0.03g/ml. The higher concentration indicates spoilage due to bacterial contamination. Butyric acid is present in very small amounts (10 to 20 ppm), while propionic acid is not found in unspoiled (Amerine *et al.*,1980). According to the Indian standards for wine constituents, a wine should not contain volatile acidity as acetic acid more than 1 g/litre of wine (Bhalerao, 2001), since higher than this resulted in poor fermentation (Sepulveda and Kliewer ,1986).

Ribereau-gayon *et al.* (1976) reported volatile acidity content of 0.28 and 0.21 g per litre in red wine before and after fermentation. The volatile acidity in the wines prepared from 4 grape cultivars ranged from 0.015 to 0.072 percent (Suresh *et al.*, 1985). A wide range of volatile acidity in the wine was reported by several researchers *viz.*, 0.015 to 0.072% (Suresh *et al.*, 1985); 0.02 to 0.04 % (Sharma, 1987); 0.01 to 0.08% (Tambe *et al.*,2008).

Padshetty *et al.* (1982) noticed a decrease in the volatile acidity in wine samples during aging which might be due to the enhanced synthesis of esters from ethyl alcohol and volatile acids.

2.4.9 Sugars

Sugars are the primary carbon source required for fermentation and the production of alcohol in the wine. It is not only used for the production but also required for the growth of yeast during fermentation (Amerine *et al.*, 1980). Sugars may be reducing, non reducing and total sugars whose concentration depends upon the type of wine. They are important in developing a proper acid-sugar blend. Sucrose is rapidly hydrolysed during the fermentation and is present in wine in very small amounts (0.01 to 0.06%) as reported by Amerine *et al.* (1980).

According to Patil (2005) Ugni Blanc recorded maximum reducing sugars (5.23%) followed by Chenin Blanc (5.23%) in white varieties and Shiraz (4.92%) followed by Cabernet Sauvignon (4.80%) among the coloured varieties reported to be maximum. Patel (1994) reported comparatively larger amounts of reducing sugars (5.89 to 6.09%), non reducing sugars (0.51 to 0.84%) and total sugars (6.40 to 6.81 %) in the wines.

The intensity of fermentation depends upon the level of reducing sugars in fruit juices. Sepulveda and Kliewer (1986) observed poor fermentation due to the presence of low reducing sugars. Singh Nagi and Manjrekar (1976), observed decrease in the reducing sugars was observed during storage of cider.

The reducing sugars in the wines prepared from blended juice ranged from 0.11 to 0.41% (Suresh *et al.*, 1983). The reducing sugar content in the wine of blends of Thompson Seedless and Cabernet Sauvignon ranged from 5.48% to 6.17%, while that of blends of Ugni Blanc and Sharad Seedless were of 5.8 to 6.4% and total sugars were in the range of 6.4 to 6.8% in the blends of Thompson Seedless and Cabernet Sauvignon (Patil, 2005).

2.4.10 Alcohol

Wine is a grape juice which has undergone alcoholic fermentation by wine yeast (Venkataramu *et al.*, 1980). Wine contains ethyl alcohol and traces of methyl and other higher alcohol (Guymon and Heitz, 1952; Amerine, 1954).

The yield of alcohol depends upon the following factors (Amerine *et al.*,1979)

- i. Initial sugar content
- ii. Amount of bye products formed
- iii. Amount of sugar utilized by yeasts and other micro-organisms for their growth.
- iv. Loss of alcohol due to evaporation.

Singleton and Esau (1969) stated that the solvent action of ethanol in wine enhances the taste of wine. TSS content was directly related to yield of alcohol during fermentation (Somers and Evans, 1977; Amerine and Ough, 1980; Mullins *et al.*, 1992). Percentage of alcohol in the wine is approximately equal to the brix of the must multiplied by the factor 0.57 (Cruess, 1958). Alcohol percentage of wine equals to the sugar concentration (g/l) divided by 17 (Ribereau-Gayon *et al.*,1998). The alcohol content in the wine depends on grape cultivar and also on type of wine.

Suresh *et al.*(1985) reported 12.6 to 15.5 percent alcohol in Arkavati wines while it ranged from 11.5 to 14.2 percent alcohol in Arka Shyam wine. Patil (2005) also reported variation in the alcohol content of wines prepared from different varieties of grape. The alcohol content was maximum in Shiraz (10.68%) followed by Cabernet Sauvignon (10.60 %) and minimum in Grenache (9.75%). Alcohol content of wine ranged from 8.41 to 12.15 % with maximum content in Shiraz and minimum recording in Grenache (Tambe *et al.*,2008). A range of 8.3 to 11.6% was reported by (Sharma, 1987); 7.4 to 15.5% (Suresh and Negi ,1977 and Suresh *et al.*, 1985).

Alcohol content of white table wine was 7.4 to 10.5 percent, while red wines contained 8.3 to 11.9 percent alcohol (Suresh and Negi, 1975). Dessert wines contain 8 to 9 percent (v/v) ethyl alcohol, dry wine contain 9 to 11 percent (v/v), semi dry wine contain 10 to 12 percent and sweet wine 12 to 14 percent (Jarczyk and Wzorek, 1977).

The alcohol content of wine prepared from blended juice of grape cultivars was in the range of 11.2 to 12.6 percent (Suresh *et al.*,1983). The alcohol content in the blends of Thompson Seedless and Cabernet Sauvignon wines ranged from 7.3 to 8.2 while that of Ugni Blanc and Sharad Seedless ranged from 7.6 to 8.4 percent (Pawar, 2002).

Amerine and Ough (1980) and Amerine *et al.*(1980) noticed that total soluble solids content was directly related to yield of alcohol during fermentation. Similar findings were also registered by Somers and Evans (1977) and Mullins *et al.* (1992). Chikkasubbanna *et al.*(1990) stated that alcohol percentage of grape wine increased due to increase in total soluble solids as well as yeast activity during fermentation. Singh Nagi and Manjrekar (1976) found that the alcohol content of ciders increased continuously during the storage.

2.4.11 Total Phenols

The phenolic substances present in the grape and their effect on the quality of wines have been reported by Amerine *et al.* (1979) and Amerine and Joslyn (1970). The phenolic compounds possess many important properties which influence colour stability of wines besides influencing mouth feel, depth and astringency (St-Cricq *et al.*,1988). Polyphenolic content is one of the basic indices for assessing the quality of a wine as they contain certain organoleptic attributes closely associated with these compounds (Bourzeiz and Saquet, 1975 and Mazza and Miniati, 1993). Phenols are responsible for both bitterness and astringency in wine presumably because of the interactions with salivary proteins as well as colour stability and oxidation substrate (Ritchey and Waterhouse, 1990).

The phenolic compounds analyzed from red wine include free and conjugated myricetin, kaempferol and isohamnetin, epicatechin, gallic acid, coumaric acid, caffeic acid and anthocyanin (Burns *et al.*, 2000). Anthocyanin and tannins are the main phenolic compounds responsible for colour and flavour of red wine (Singleton and Esau, 1969 and Jackson *et al.*, 1978). Red colour of wine is

due to presence of monomeric anthocyanin and other phenols (Venkataramu *et al.*,1980).

The type and concentration of polyphenols present in the wine depend mainly upon the grape variety (Arnold *et al.*,1980). The polyphenol content of wines prepared from blended juice of grape varieties was in the range of 0.06 to 0.64 percent (Suresh *et al.*, 1983). Rodriguez *et al.* (1987) reported that the contents of polyphenols in Malaga wines ranged from 400- 900 mg per litre. In red wines the phenolic content ranged from 0.15 to 0.69 g per 100 ml; and in white wines 0.015 to 0.9 g/100ml (Van Buren ,1970).

A wide range of total phenols in white wines as well as in red wines was observed. Singleton and Esau (1969) reported that phenol content in white wine ranged from 246 to 426 mg/l whereas in red wine it ranged from 910 to 2160 mg per litre. In white wines the phenols ranged from 50 to 2500 mg per litre whereas in red wines it ranged from 1000-4000 mg per litre (Salunkhe *et al.*,1990; Joseph *et al.*,1983).

According to Nissen *et al.* (2004) the total phenol content was higher at higher levels of total soluble solids and vice versa. This may be due to the reason that in completely fermented product, the ethanol content was directly proportional to total soluble solid level. Similar results were observed by Kliewer (1967).

The phenolic content found to decrease significantly with aging period (Shankar *et al.*, 2004). The possible reason for such decrease might be combination with aldehyde and subsequent polymerization to precipitation with natural proteins of wines (Kundu *et al.*, 1980).

2.4.12 Tannins

Tannins are a group of phenolic compounds present in the wine. Amount of tannins present in wine determines the astringency of wine (Patil and Patil, 2006). Tannins present in complexes with neutral and acid polysaccharides coupled with proteins greatly improve sensory properties of aged red wines (Montedoro and

Bertuceioli, 1988). Sim and Morris (1986) studied the effect of tannins on the colour and chemical aging of Muscadine wine and reported that tannic acid did not show effect on browning, but increased the intensity of colour.

A wide range of tannin content in white wines (46 to 143 mg/100ml) and in red wines (28 to 328 mg/100 ml) was reported (Suresh *et al.*, 1985). The white wines made from grape varieties *viz.*, Thompson Seedless, Bian-Shi-Rai, Queen of the vineyards, Selection-94 and Anab-e-Shahi had lesser content of tannins compared to the wines from coloured grapes, since the musts of white grape were fermented without skin and seeds. The higher tannin content in the wines made from coloured grapes could be attributed to extraction of more tannins for skins and seeds during fermentation (Sharma, 1987).

Radvanyi *et al.* (1980) investigated composition and quality of wines of three bronze and five purple cultivars and found that the tannin content in red grapes wine was higher compared to bronze type. The content of tannins in white wine ranged from 0.05 to 0.4 g/l and in red wines 1.0 to 2.5 g/l (Gollmick *et al.*, 1991). Highest content of tannins was recorded in Ruby Red (0.174 g/100ml) and lowest in Thompson Seedless (0.063g/100ml) (Sharma, 1987).

Tannins decrease upon storage due to complexing of tannins with proteins (Padshetty *et al.*, 1982). According to Leslie (2000), tannins tend to polymerise with increased aging leading to less astringency and greater softness. For instance, the tannin content in new and aged wines was 550mg/l and 450 mg/l respectively (Joshi, 1998).

2.4.13 Flavonoids

According to Neri and Boulton (1996) flavonoids are the derivatives of flavanol and flavones groups which are involved in co-pigmentation; accounts for half of the colour of young red wine. Involvement of flavonoids in co-pigmentation was revealed by decreased flavonoid content in wine (Ritchey and Waterhouse, 1990).

Flavonoid concentration in white wines ranged from 10 to 50 mg/l while in red wines it may reach 800mg/l (Joshi, 1997). Interestingly, Glories (1999) and Ravikumar (2008) detected flavonoids in red grapes but not in white grapes. Flavonoid content was higher at lower levels of TSS and vice versa. This might be due to higher TSS in the grapes. Sugar content has an affinity towards anthocyanins which might have led to greater co-pigmentation resulting in lower flavonoids content in the wine (Mullins *et al.*,1992).

2.4.14 Organoleptic Evaluation

Wine is a fermented product prepared from the fresh juice and its acceptability by the consumers is assessed by organoleptic evaluation (Patil and Patil, 2006). Sensory evaluation is a scientific discipline used to evoke, measure, analyse and interpret results to those characteristic of food and materials as they are perceived by the 5 senses of human body *viz.*, sight, smell, taste, touch and hearing (Katyal and Gupta, 1978).

Amerine *et al.*(1965) stated that sensory taste were conducted to meet five purposes which include selection of qualified judge, study of human perception of food attributes, correlation of sensory properties with chemical and physical measurements, evaluation of product quality and determination of consumer reaction to the product. Evaluation of product (*e.g.* wine) is done by selected panel of 5 or more members. For evaluation, 20 point scale is taken in to consideration based mainly on the appearance, colour, aroma, taste, flavour and overall acceptability (Amerine and Ough, 1980).

According to Ough and Baker (1961), wines with an organoleptic score of 13 and above can be considered as wines of commercially acceptable. Suresh *et al.*(1985) carried out evaluation of grape wines by a panel of four judges on 20 point Devis score card of Ough and Baker (1961) in which the average sensory evaluation scores for wines from four grape varieties ranged from 11.9 to 16.0 out of 20 .

According to Ravikumar *et al.*,(2008) organoleptic score of Muscat and Bangalore Blue ranged from 14 to 15 and 9 to 11 respectively and hence Muscat wines is considered as “Excellent” and Bangalore Blue wine as “Commercially acceptable”. Among the white cultivars, Thompson Seedless and Tas-e-Ganesh were found to be suitable for white dry table wines having an organoleptic score of 12-14 for the former and 0-5 for the later one, hence the wine from Thompson Seedless was termed as ‘Good’ and Tas-e-Ganesh as ‘Poor’ from the consumer point of view.

In a study by Suresh and Negi (1975) among the white varieties Chenin Blanc ranked ‘Good’, Sauvignon Blanc ‘ Satisfactory’ and among the red cultivars Black Cornichon ranked ‘Good’ and Ruby Red and Zinfandel as ‘ Satisfactory’. The average sensory score for wine prepared from blended juice of grape varieties ranged from 11.3 to 14.6 out of 20 and was judged as ‘Good’ commercially (Suresh *et al.*, 1983).

2.5 Experiment III: Wine production by blending white varieties with the coloured varieties

All the varieties of grape do not have all the desirable characteristics required for making quality wine. A variety may have a good number of characteristics but lack in one or more characters. In such cases two or more are combined together to make a wholesome product by making good in lacking characteristics. Such a combining process is referred to as “Blending”.

Blending of wines is an important cellar operation, carried out to develop specific types of wines and to maintain uniformity in quality and character of these wines (Amerine *et al.*,1965). Blending of different varieties help to overcome vintage variation. It is an useful technique to overcome defects in varieties and improve the quality of wine from varieties which are deficient in colour or chemical composition. Ough and Amerine (1962) studied the effect of anti-fermentation on blending of Cabernet Sauvignon musts with the white juice to

improve colour and wine quality and found some practical advantages. Lal *et al.*(1967) reported that coloured as well as white grape could be used for making blended grape juice. Akopyan (1979) reported that the quality of red wines can be improved by proper blending of grapes.

The juice of Bhokri to an extent of 50 percent was blended with highly coloured sweet juice of Beauty Seedless grape and an organoleptically acceptable blend could be prepared (Murali Krishna and Khurdiya, 1969). Parhad (1983) tried blending of juices of different grape varieties and reported that blend of juices of Thompson Seedless and Ruby Red was better than other combinations tried, in respect of nutritional quality. However, from the point of view of overall acceptabilities, varietal combinations of Cheema Sahebi and Ruby Red was the best followed by Cheema Sahebi and Bangalore Purple.

Blending studies between white and coloured varieties of grapes were conducted at IIHR, Bangalore. Two white varieties (Thompson Seedless and Anab-e-Shahi) and three red varieties (Gulabi, Ruby Red and Baily Alicante) were used in the study. Blends were prepared by mixing juice in different proportions. The variety Gulabi is light coloured with muscat flavour, but gives wine with light colour. In order to improve the colour, it was blended with deep coloured varieties such as 'Baily Alicante' and 'Ruby Red' as a result a marked development in the colour of the wine was obtained in all the blends. Based on the chemical composition and organoleptic evaluation the wines obtained by blending 'Gulabi with Baily Alicante' or 'Ruby Red' in the proportion of 2:1 and 3:1 were better than the other blends. The colour of wines from 'Ruby Red' was deep but the wine was highly acidic and astringent. To overcome this defect, 'Ruby Red' was blended with 'Thompson Seedless' and 'Anab-e-Shahi' grapes while making wines. This resulted in the reduction of content of acidity and tannin. Chemical composition and organoleptic evaluation suggested that the above combinations in proportions ranging from 1:1 to 1:4 were suitable for making red dry table wine. However, wines from blends of 1:1 and 1:2 had sufficient intensity in colour for dessert wines

(Suresh *et al.*,1983). Similarly blending of Thompson Seedless of Anab-e-Shahi with Ruby Red resulted in good quality table and dessert wine to impart sufficient intensity of colour (Kadam, 2000).

According to Pawar (2002), wines prepared from the blended juice were more or less similar to wines from pure juice in their chemical composition and also these wines were organoleptically acceptable. The wines from white varieties *viz.*, Thompson Seedless and Ugni Blanc were blended with the coloured varieties *viz.*, Cabernet Sauvignon, Sharad Seedless on 1:1 and 1:3 proportion helps to produce desirable colour and flavour. Considering the organoleptic properties of wines, the wine from blended juice of Ugni Blanc and Sharad Seedless (1:3) ratio gave better quality wine over the other blends. Commercially acceptable sweet wine can be prepared by mixing Mango pulp with Thompson Seedless in the ratio of 1:1. (Suresh and Ethiraj, 1988).

2.6 Suitability of different grape varieties for wine making

Vitis vinifera L grape consists of several varieties spreading all over the world. Grapes are cultivated for different purposes *viz.*, table, raisin, juice and wine. All varieties are not suitable to all the above purposes. There are varieties exclusive for one purpose as well as there are varieties suitable for dual purposes. The suitability of a grape variety is judged based on certain criteria which differ from one purpose to another purpose.

The chief characteristics of varieties suitable for wine making are as follows (Katyay and Gupta, 1978).

- i) The variety should not preferably be a table variety
- ii) It should be hardy
- iii) Heavy yielder
- iv) Available in bulk so that the cost of raw material may be cheap.
- v) Should have a high sugar content of TSS 20 and above with acidity ranging from 0.6 to 0.8 percent.
- vi) Should have a typical flavour developing during fermentation and aging.

For selection of grape variety for wine making, varietal characters like aroma, adequate sugar and acid content in berries, resistance to pests and diseases, yield and stability of the colour of wines have to be considered (Ethiraj and Suresh, 1978).

Katyal and Gupta (1978) claimed that the following existing varieties could be found suitable for the various types of wines

- A) White dry and Sweet wines – Perlette, Bhokri, Early Muscat and Khalili
- B) Red wine - Beauty Seedless and Hur
- C) Vermouth – Perlette, Bhokri, Early Muscat, Pearl of Csaba and Khalili.

Several workers have tested the suitability of grape varieties for wine making. Ambadan *et al.*(1972) found that Thompson Seedless and Mendeline Anguine were suitable for the production of white wines and Beauty Seedless and Rubi Red for red wines in Delhi. Similarly, Early Muscat, Champion and Perlette were found suitable for white wine (Vyas And Gandhi, 1972; Kundu *et al.*, 1980). Possibility of using Bangalore Blue, Bangalore Purple and Beauty Seedless for quality red wine production; and Anab-e-Shahi and Selection-7 for the production of low alcoholic beverages has been suggested by Central Food Technological Research Institute, Mysore (Sreekantaiah and Johar, 1968; Subba Rao, 1972). On the basis of screening of exotic grape varieties for wine making at Indian Institute of Horticultural Research (IIHR), Bangalore, varieties such as Chenin Blanc and Bayan Sherei for white wine; Black Cornichon and Feteasca Niagra for red wine and Convent Large Black and Black Champa for dessert wines have been recommended (Negi *et al.*,1972; Suresh and Negi, 1975). New grape hybrids have been developed at IIHR for specific uses like juice, raisin and wine making. Arkavati for good quality dry white table wine, Arka Shyam for dry red table and Arka Kanchan for dessert wine were found suitable (Suresh *et al.*,1985).

It has been found that good quality wines can be prepared from a number of varieties. For making dry white table wines, the varieties Bayan Sherei, Chenin Blanc, Sauvignon Blanc and White Riesling are suitable. Similarly, good quality dry red table wine can be prepared from Black Champa, Cabernet Sauvignon, Gamsa and Zinfandel. The dessert type wines can also be prepared from Convent Large Black and Black Muscat (Katyal and Gupta, 1978). Finally they suggested a co-ordinated programme for screening of existing varieties and hybrids of future in different agro climatic zones in the country, for their oenological qualities. Accordingly, a number of screening trials of grape varieties were conducted at different institutions and research stations of grape, few of which are reviewed below.

Singh (1970) studied the suitability of certain grape varieties under Delhi conditions and found that Beauty seedless, Black Prince & Perlette gave good quality wine. Suresh and Negi (1975) while evaluating grape varieties under Bangalore conditions for wine making found that several varieties produced wine of commercial acceptability & among them Chenin Blanc, Black Cornichon and Black Champa produced good quality wines. In Haryana, Beauty Seedless and Carignane produced wines of acceptable quality (Vyas and Gandhi, 1972; Bardiya *et al.*,1980).

Vyas and Chakravorthy (1971) reported that grape varieties like Perlette, Anab-e-Shahi, Delight and Early Muscat gave white wine of standard commercial acceptability, while Beauty seedless gave good quality red wine under Haryana conditions. The cultivars Syrah, Cabernet Sauvignon, Merlot and Pinot Noir were potentially good quality red wine grape varieties, while Sauvignon Blanc and Ugni Blanc were of moderate and low quality white wine varieties (Tambe *et al.*,2008).

According to Suresh and Ethiraj (1987) and Joshi (1998) Cvs. Arka Kanchan, Arkavati, Thompson Seedless, Chenin Blanc, Sauvignon Blanc, and Perlette were suitable for making dry white table wines. Similarly, Arka Shyam, Beauty Seedless, Bangalore Blue and Bangalore Purple were suitable for making

dry red table wine, where as Arka Kanchan, Black Muscat and Convent Large Black for preparation of dessert wines (Negi and Randhawa,1980; Suresh *et al.*, 1985). Good quality dry white table wine could be obtained from cultivars Champion, Pearl of Csaba and Early Muscat (Kundu *et al.*,1980).

2.7 Varietal requirements for making different types of wine

Katyal and Gupta (1978) defined the different requirements for making wine (see 2.6). Ethiraj *et al.*(1983) from Bangalore suggested that characters like aroma, adequate sugar and acid content in berries, yield and resistance to pest and should be considered while selecting a grape variety for wine making. According to Robinson (1998), variety is the single most important factor, which determines about 90 percent of the flavour of the wine and is the key to appreciation and enjoyment of every wine.

Bammi (1968) claimed that dry table wines require grapes of low pH (3 to 3.35), high content of TSS (19 to 23⁰ B) and sweet dessert wines require grapes of relatively higher pH (3.3 to 3.6), higher TSS (24⁰ B) and medium acidity (0.5 to 0.6%). Vyas and Chakravorthy (1971) and Negi and Suresh (1972) were also of same opinion. According to Suresh and Ethiraj (1989) white table wines require a pH of 3.3, TSS of 19.5 to 23⁰ B and acidity of 0.7 percent; red table wines require pH of 3.4, TSS of 20.5 to 23.5⁰ B and 0.65 percent acidity; for sweet table wine require a pH of 3.4, TSS of 22.0 to 25.0⁰ B and 0.65 percent acidity and for dessert wines, varieties should have a pH of 3.4, TSS 23-26⁰ B and 0.5 percent acidity. Grape varieties having 22 to 24⁰ B, 0.5-0.6 percent acidity were found to be suitable for red dry table wine, while those having 20 to 22⁰ B and 0.6-0.8 percent acidity were found to be suitable for white dry table wines (Joshi, 1998).

Thus it is clear from the above that each type of wine require different composition for their preparation.

2.8 Classification of Wine

Majority of wines produced in the world are still wines, *i.e.*, without excess of carbon di-oxide and contain 8–14 percent alcohol. They are white, rose or red in colour and may contain sugar (sweet wine) or may not (dry wine). Wines made from different varieties of grape are classified in to groups based on either sugar or alcohol or both together. Wines from grapes could be red or white, dry or sweet, table or dessert.

Different scientists followed different criteria in classifying the grape wines. Jarczyk and Wzorek (1977) classified wines in to different type based on sugar content. The dry wines are practically free of sugars and contains 0 to 1 percent sugars, semi dry, sweet and very sweet wines contain 2 to 3, 8 to 11 and 7 to 12 percent sugars respectively. Ribereau–Gayon *et al.*(1998) classified wines as semi dry, sweet and syrupy sweet according to their sugar concentration. Semi dry wine contains 20g/lit of sugars, sweet wines contains 36 g/lit where as syrupy sweet wine contains sugars more than 36 g / lit.

Bammi (1968) classified dry table wine as those which contain less than 14 percent alcohol and have little or no unfermentable sugars whereas sweet dessert wine are those having 17- 20 percent alcohol with some unfermentable sugars.

Kadam (1997) classified wine on the basis of contents of alcohol and residual sugars, as dry table wines containing 9 to 11 percent alcohol and 0 to 1 percent residual sugars; semi dry table wines having 10 to 12 percent and 2 to 3 percent residual sugars; sweet dessert wine are there having 12 to 14 percent alcohol and 3 to percent residual sugars; and sweet dessert wine containing 13 to 18 percent alcohol and more than 8 percent residual sugars. Girdhari Lal *et al.*(1986) classified wines on the basis of alcohol content as light wine having 7 to 9 percent alcohol, medium wine having 9 to 16 percent alcohol and strong wine having 16 to 20 percent alcohol respectively.

Table 2.1 The recommended range of TSS, acidity and pH of juice for various types of wines

S.no	Type of Wine	TSS (⁰ B)	Titration Acidity (%)	pH
1	White Table	19.5 – 23.0	0.70	3.30
2	Red Table	20.5 – 23.5	0.65	3.40
3	Sweet Table	22.0 – 25.0	0.65	3.40
4	Dessert	23.0 – 26.0	0.50	3.60

(Chikkasubbanna, 1982)

CHAPTER - III

MATERIALS AND METHODS

The present investigation “Studies on growth, yield and wine production from different varieties of Grape (*Vitis vinifera* L.) “ was carried out during 2006-2008 at Grape Research Station, Rajendranagar (Experiment I) and Department of Horticulture, College of Agriculture, ANGRAU, Rajendranagar, (Experiment II and III), Hyderabad. The grapes produced from October pruning of 2006-07 (First year) and 2007-08 (Second year) were used in the present study.

3.1 Location and Weather condition

The experimental site was located at 18°45' North latitude and 77°85' East longitude at an altitude of 542.6 meters above mean sea level. It falls under arid sub-tropical climatic zone having an average annual rainfall of 800 mm. The Meteorological data was collected once in a week from the Meteorological Observatory situated at Agricultural Research Institute, Rajendranagar during the crop season from October 2006 to April 2008 and are furnished in Appendix-A & Appendix-B.

The weekly mean minimum and maximum temperature for the crop period *i.e.* from foundation pruning to end of harvest during the first year 2006-07 ranged from 17.0⁰c and 31.1⁰c with an average temperature of 24⁰c and mean relative humidity ranged from 36 to 84 % with a rainfall of 1.6 mm during the crop period, while during the second year 2007-08, it ranged from 16.3⁰c and 30.7⁰c with an average temperature of 23.5⁰c and mean relative humidity ranged from 38 to 82 % with a rainfall of 9.3 mm during the crop period (Fig. 3.1 and 3.2).

3.2 Materials

3.2.1 Grape Varieties

Thirteen wine grape varieties of which eight coloured and five white were evaluated during the year 2006-07 & 2007-08 to determine their suitability for wine preparation and quality. The varieties are Zinfandel, Cabernet Sauvignon, Shiraz, Ruby Red, Pusa Navrang, Bangalore Blue, Athens and Gulabi are the red varieties whereas, Symphony, Chenin Blanc, Sauvignon Blanc, Thompson Seedless and Italia are the white varieties. A brief description of these varieties are presented in the Appendix –C.

3.2.2 Cultivation

The varieties selected for the study were five years old grown on own roots, planted at 14 ft x 7 ft spacing and trained on an overhead bower. The soil of the vineyard is texturally classified as red sandy loam consisting sand 69.9 %, silt 8.2 % and clay 18.9 %. The chemical properties of these soils are pH 6.2, EC 0.16 dSm⁻¹, Organic carbon 1.60%, available N 350.0 kg ha⁻¹, available P 123.0 kg ha⁻¹, available K 680.0 kg ha⁻¹, Iron 35.50 mg kg⁻¹, Manganese 6.50 mg kg⁻¹, Copper 8.20 mg kg⁻¹ and Zinc 1.8 mg kg⁻¹.

3.2.3 Fertilizer application

Well rotten Farm yard manure @10kg per vine was applied twice before each pruning. A fertilizer dose of 500 kg N + 500 kg P₂O₅ + 1000 kg K₂O per hectare was applied at April and October pruning in splits according to the stages of vine as per the recommendations of Acharya N G Ranga Agricultural University.

3.2.4 Irrigation

Irrigation was provided through drip irrigation system. Two drippers each of 8 litres per hour discharge capacity were placed on either side of each vine 60 cm distance from the main trunk.

3.2.5 Weeding

Weeding was done by both manually and mechanically so as to maintain weed free conditions in the orchard.

3.2.6 Pruning

All the vines were pruned twice in a year *viz.*, foundation pruning during March- April leaving one or two buds to develop vegetative canopy and fore pruning was carried out during October-November in both the years (2006 and 2007) leaving 4-10 buds for fruiting depending on the variety.

S. no	Variety	No of buds retained / cane
1	Zinfandel	8
2	Cabernet Sauvignon	7
3	Gulabi	4
4	Shiraz	10
5	Bangalore Blue	6
6	Pusa Navrang	6
7	Athens	8
8	Ruby Red	5
9	Thompson Seedless	10
10	Chenin Blanc	8
11	Sauvignon Blanc	4
12	Italia	6
13	Symphony	5

3.3 EXPERIMENTAL DETAILS

For this investigation, three experiments were conducted during the years 2006-07 and 2007-08. The experiment and treatment details are presented below.

3.3.1 Experiment I: Study on growth and yield of different varieties of grape for wine production

The experiment was conducted with thirteen wine varieties of grape. Each variety was treated as a treatment and replicated thrice in a Randomized Block Design.

Treatments: 13

Coloured:

V₁- Zinfandel

V₂- Cabernet Sauvignon

V₃- Gulabi

V₄- Shiraz

V₅ – Bangalore Blue

V₆- Pusa Navrang

V₇- Athens

V₈- Ruby Red

White:

V₉- Thompson Seedless

V₁₀ – Chenin Blanc

V₁₁ – Sauvignon Blanc

V₁₂ – Italia

V₁₃ – Symphony

The observations on the growth parameters *viz.*, pruning weight, days taken for bud break, number of canes, cane diameter, shoot length, number of leaves, leaf area, days taken for 50% flowering and yield parameters *viz.*, number of bunches per vine, mean bunch weight, mean bunch length, number of berries, hundred berry weight, berry diameter, yield and heat unit requirement were recorded during the two cropping seasons (2006-07 and 2007-08) and data were analyzed statistically.

Growth Parameters

3.3.1.1 Pruning weight (Kg)

The fresh weight of the pruned canes at the time of October pruning was measured with the help of a weighing balance (Tulaman,H.T. 500 series). Three groups of vine vigour *viz.*, low, medium and high were designated on the basis of pruning weight as follows

- (i) Low vigour- Pruning weight less than 0.2 kg
- (ii) Medium vigour - Pruning weight 0.2 kg to 0.4 kg
- (ii) High vigour - Pruning weight more than 0.4 kg

(Havinal *et al.*,2008)

3.3.1.2 Days taken for bud sprouting after pruning

The number of days taken for bud sprouting from pruning was recorded in each treatment after the winter (October) pruning to know earliness or lateness of the variety. After October pruning, ten canes on each vine of each cultivar were tagged and observed for recording the days required for sprouting.

3.3.1.3 Number of Canes

The number of canes retained per vine after the October pruning was recorded.

3.3.1.4 Cane diameter (mm)

Mean cane diameter was recorded with vernier calipers by selecting ten canes randomly in each variety and expressed in millimeters.

3.3.1.5 Shoot length (cm)

Shoot length was recorded by selecting five shoots randomly from tagged canes and was expressed in centimeters.

3.3.1.6 Number of leaves per cane

Number of leaves per cane was recorded by counting the number of leaves per ten canes per vine.

3.3.1.7 Leaf area (cm²)

Leaf area was measured with the help of an Electronic leaf area meter (LI-3100, Lincoln, Nebraska USA) by selecting five leaves randomly from tagged canes and was expressed in square centimeters.

3.3.1.8 Days taken for 50 % flowering

After October pruning, ten canes on each vine of each cultivar were tagged and observed for recording the days required for 50% flowering and to know the variety with early flowering character.

3.3.1.9 Average number of bunches per vine

The mean bunch number was worked out on the basis of observations from a composite sample of ten canes chosen at random from every vine of each variety.

3.3.1.10 Mean bunch weight (g)

The mean bunch weight was worked out on the basis of observations from a composite sample of ten bunches chosen at random from every vine of each variety and expressed in grams .

3.3.1.11 Mean bunch length (cm)

The mean length of the bunches was derived by averaging the length of ten bunches randomly selected from each variety and expressed in centimeters.

3.3.1.12 Average number of berries per bunch

Number of berries per bunch was recorded by counting the number of fruits per five bunches per vine and averaged.

3.3.1.13 Hundred berry weight (g)

From each treatment hundred berries were randomly selected at harvest and their mean weight was recorded in grams.

3.3.1.14 Berry diameter (mm)

Mean berry diameter was recorded with the help of Vernier calipers at harvest by selecting ten berries randomly in each variety and was expressed in millimeters.

3.3.1.15 Fruit yield (kg/vine)

The number of bunches borne on the labeled spurs in each treatment was noted and weighed. The combined weight of these bunches was considered as the total yield per treatment and expressed in kilograms.

3.3.1.16 Number of Heat Units required for fruit ripening

The Heat units or degree days were calculated from the day of October pruning to harvest by using the following formula described by Rai *et al.* (2002).

$$DD = (T_{max} + T_{min})/2 - T_b$$

T_{max} & T_{min} are the maximum and minimum temperatures respectively.

T_b - is the base temperature below which fruit growth is arrested.

The base temperature for grape is taken as 10°C (Brar *et al.*, 1992).

The mean daily temperature was calculated from the maximum and minimum temperatures and the base temperature of 10°C was subtracted from this. The remaining temperature thus obtained is called 'Heat Unit' (HU), which is summed up over the period from October pruning to harvest to get heat unit required for maturity of grapes.

On the basis of heat unit requirements, the maturity period was categorized in to three groups as

- i) Early – Heat unit requirement less than 1700 degree -days
- ii) Medium – Heat unit requirement 1700- 1900 degree - days
- iii) Late – Heat unit requirement more than 1900 degree -days

3.3.2 Experiment II: Evaluation of different coloured and white varieties of grape for wine production

The experiment was conducted by preparing wine from eight coloured and five white varieties where in each variety was treated as a treatment

Varieties : 13

Coloured :

- V₁- Zinfandel
- V₂- Cabernet Sauvignon
- V₃- Gulabi
- V₄- Shiraz
- V₅ – Bangalore Blue
- V₆- Pusa Navrang
- V₇- Athens
- V₈- Ruby Red

White:

- V₉- Thompson Seedless
- V₁₀ – Chenin Blanc
- V₁₁ – Sauvignon Blanc
- V₁₂ – Italia
- V₁₃ – Symphony

The Physico-chemical analysis of Juice and wine were done as per the standard procedure and analyzed statistically in completely randomized block design with three replications.

3.3.3 Experiment III: Wine production by blending white varieties with coloured varieties of grape

The experiment was conducted by preparing wine by blending juice of white varieties with juice of coloured varieties with different proportions to study the effect of blending .The details of the treatments are given below.

Treatments – 24

- T₁- Thompson Seedless + Shiraz (2:1)
- T₂- Thompson Seedless + Shiraz (3:1)
- T₃ - Thompson Seedless + Bangalore Blue (2:1)

- T₄ Thompson Seedless + Bangalore Blue (3:1)
- T₅- Thompson Seedless + Ruby Red (2:1)
- T₆- Thompson Seedless + Ruby Red (3:1)
- T₇ - Chenin Blanc + Shiraz (2:1)
- T₈. Chenin Blanc + Shiraz (3:1)
- T₉- Chenin Blanc + Bangalore Blue (2:1)
- T₁₀. Chenin Blanc + Bangalore Blue (3:1)
- T₁₁ - Chenin Blanc + Ruby Red (2:1)
- T₁₂. Chenin Blanc + Ruby Red (3:1)
- T₁₃ - Sauvignon Blanc + Shiraz (2:1)
- T₁₄ - Sauvignon Blanc + Shiraz (3:1)
- T₁₅- Sauvignon Blanc + Bangalore Blue (2:1)
- T₁₆- Sauvignon Blanc + Bangalore Blue (3:1)
- T₁₇- Sauvignon Blanc + Ruby Red (2:1)
- T₁₈- Sauvignon Blanc + Ruby Red (3:1)
- T₁₉ - Italia + Shiraz (2:1)
- T₂₀ - Italia + Shiraz (3:1)
- T₂₁. Italia + Bangalore Blue (2:1)
- T₂₂. Italia + Bangalore Blue (3:1)
- T₂₃. Italia + Ruby Red (2:1)
- T₂₄. Italia + Ruby Red (3:1)

The Physico–chemical analysis of Juice and wine were done as per the standard procedure and analyzed statistically in complete randomized block design with three replications.

3.4 GENERAL PROCEDURE FOR WINE PREPARATION

Wine is an alcoholic product obtained by fermentation of fruit juices with yeast. The following is the general procedure for the preparation of a fruit wine as outlined by Joshi (1995).

3.4.1 Preparation of yeast culture

The yeast strain of *Sacharomyces cerevisiae var ellipsoideus* supplied by Denka consultancy, Hyderabad was used for the present study.

Fresh grape juice was diluted in the ratio of 1:1 (one litre of juice with one litre of distilled water) and was pasteurized in hot water bath at 85⁰C for 30 minutes. The container was removed from the water bath and placed on a wooden surface and was allowed to cool down to room temperature (30^o c).

A little quantity of pasteurized fruit juice from the container was poured in to the test tube containing the yeast culture under aseptic conditions and mixed. The mixture in turn was poured back into the container. The whole procedure was repeated until the whole of the yeast was not removable from the agar surface of the test tube. The container with a plug of cotton was kept in a warm place (20-25⁰C). The culture was ready for inoculation after 24 hours when a lot of bubbling was observed. The culture was added at the rate of 2% to the must for fermentation.

3.4.2 Preparation of Must

About 8 kg of grapes were harvested and berries were separated from the bunches and stalks were removed from the berries. These berries were washed with water to remove the extraneous matter present on the berries. Injured and rotten berries were discarded.

The berries were hand crushed, filtered through cheese cloth and clear juice was used for fermentation. Adjustment of total soluble solids was done to 24 °B by adding cane sugar and similarly p^H was also adjusted to 3.5 by adding tartaric acid. Addition of potassium meta bisulphite to the juice @ 100-150 mg per litre was done to inhibit the wild yeast and other spoilage microorganisms and also to prevent browning due to oxidation. This was treated as 'Must'.

3.4.3 Fermentation

The juice was fermented in a flask up to 3/4th of its volume and then pasteurized in hot water bath at 85⁰C for 30 minutes. The container was then

removed and cooled down to room temperature. The yeast culture was then added to the must under aseptic conditions and plugged with sterilized cotton and allowed for fermentation. The process of fermentation was monitored to the extent of bubbling.

The must extracted, after SO₂ treatment, was inoculated with two percent (v/v) yeast culture and left at 20+ 1° c for primary fermentation. It took nearly 7 days to complete the primary fermentation process for red wine and 10 days for white wines. The progress of fermentation was followed by measuring the fall in degree brix which was measured by Hand refractrometer (ERMA type).

3.4.4 Completion of fermentation

Fermentation was completed when no more bubbles were coming out and was also ascertained by stabilization of TSS for two successive days. TSS normally comes to 7 (or) 8⁰Brix from initial level of 24⁰B.

3.4.5 Filtration

After completion of fermentation, the yeast and other material settle down at the bottom of the container leaving clear liquid as supernatant. The supernatant liquid was then siphoned off and was filtered through a muslin cloth, and kept for cold stabilization for a week. Further, two or three more rackings were done at an interval of 15-20 days. During inter-racking period, no head space was left over in the bottle and corked tightly to prevent the conversion of wine into vinegar.

3.4.6 Clarification

After rackings, if the wine was not clear, it was clarified with aid of clarifying agents such as bentonite (150 ppm) to recover wine of crystal clear quality finish.

3.4.7 Siphoning/ Racking

Siphoning of clear liquid from the fermented must was done four times at fortnight intervals in order to get clear liquid. The wine was then transferred in to sterile bottles and corked tightly.

3.4.8 Pasteurization

After clarification, the clear wine was siphoned off and transferred to fresh sterile bottles, corked and subjected for pasteurization at 82° c for 20 minutes.

3.4.9 Maturation

After cooling the bottles were stored for maturation in BOD incubator at 10°C for ninety days. During maturation the wine was racked regularly.

Samples from the prepared clear wine were analyzed twice *i.e.* first before maturation and second after maturation period. Wine samples were also evaluated organoleptically after maturation with a panel of 5 judges for their quality and acceptability.

3.5 Physico-Chemical Analysis of Juice

The Grape juice was analyzed for the following quality parameters before fermentation.

3.5.1 Juice recovery (%)

This is the ratio of weight of juice obtained from 100 berries to the weight of 100 berries. This is expressed in percent.

$$\text{Juice Recovery (\%)} = \frac{\text{weight of juice obtained from 100 berries}}{\text{Weight of 100 berries}} \times 100$$

3.5.2 Total Soluble Solids (⁰Brix)

The Total Soluble Solids of the pulp and wine was determined by using ERMA hand refractometer and expressed as ⁰B (Ranganna, 1986).

3.5.3. Titrable Acidity (%)

Titration acidity in juice was determined by adopting procedure of AOAC method (1965) as detailed below.

In 100 ml conical flask, 10 ml juice was taken and made up to 100 ml with distilled water. Ten ml of this dilute was taken in another flask and two drops of phenolphthalein indicator were added to it and titrated against 0.1 N Sodium hydroxide till a permanent pink colour was obtained. The acidity of fruit juice was calculated using the following formula and expressed in terms of tartaric acid per 100 ml of juice.

$$\text{Tartaric acid (g) /100 ml juice} = \frac{\text{ml NaOH} \times \text{Normality of NaOH} \times 0.075 \times 100}{\text{Volume of sample (ml)}}$$

3.5.4. pH of the juice

pH of juice was determined by digital pH meter. The pH was calibrated at 25⁰C by using pH 4, 7 and 9.5 buffer tablets dissolved each in 100 ml distilled water. The calibration knob was pressed and pH was adjusted to 7. Electrode was immersed in pH 4 buffer solution and kept for 3 minutes, during which the buffer solution was shaken twice. After 3 minutes, the calibration knob was released, pH was adjusted to 4. Fine adjustment was made with the help of fine adjustment screw present at right side of pH meter. Likewise, the pH meter was calibrated to pH 4, 7 and 9.5 by using the respective buffer solutions. Then the wine sample was taken in a beaker and reading button was pressed. The electrode was immersed in wine and kept for 1 minute during which period wine sample was shaken twice. After 1 minute the reading button was released and the pH displayed was noted.

3.5.5 Sugars

Reducing sugars and total sugars in the juice of different varieties were estimated adopting the Lane and Eynon method (Ranganna, 1986). The reagents were prepared as specified in this standard method and work done is furnished below.

Standard invert sugar solution:

Sucrose of 9.5 g was taken in to volumetric flask and dissolved in 100 ml water. To it 10 ml of Hydrochloric acid (HCl) (5ml Conc. HCl + 5 ml water) was

added and allowed to remain stand for 3 days at an ambient temperature in dark room. Then the volume of invert solution made up to one litre with distilled water.

A quantity of 25 ml of standard invert solution taken in to 100 ml volumetric flask and 50 ml water was added and the solution was neutralized with 20% Sodium hydroxide (NAOH) using few drops of phenolphthalein indicator until the solution turned pink. Then the solution was acidified with 1N HCl until the disappearance of pink colour.

Fehling's solution factor

The Fehling's solutions (A and B) were mixed well in equal amounts. Exactly 10 ml of mixed solution was taken in to 150 ml conical flask to which 50 ml water was added. The standard invert solution as prepared above was taken in to burette. A quantity of 18 ml of invert solution added to mixed Fehling's solution and the conical flask containing these mixed solutions was placed over the flame burner until the solution turned brick red at boiling point and then for two minutes accurately on boiling, then added three drops of methylene blue indicator and completed the titration till the end point (solution turned brick red). The titre value obtained was used to derive the content of reducing and total sugars.

Reducing Sugars (%)

Ten ml of juice squeezed from the sample of fresh grapes was made up to 100 ml with distilled water using volumetric flask. This solution was neutralized with 20% NAOH using few drops of phenolphthalein indicator and acidified with 1N HCl until it made pink colour disappeared. To the neutralized solution 2 ml of 45% lead acetate was added, shaken well and kept to settle for 10 minutes. Then 2 ml of 22% potassium oxalate was added to remove excess lead and volume was made up to 250ml with distilled water and contents was filtered using Whatman No.1 paper. Reducing sugars in the lead free extract was then estimated by taking the solution in to the burette and titrated against mixed Fehling's solution (A and B).

10 ml of mixed Fehling's solution was taken in to 250 ml conical flask, added 50 ml of water and ran the burette in to flask to the required volume of sugar solution as prejudged incrementally to reduce the Fehling's solution which indicated by turning the solution to brick red colour on boiling. Then continued boiling for 2 minutes and added 2 to 3 drops of methylene blue indicator, titrated with sugar solution on heating until indicator was completely decolourized and formed brick colour precipitate as the end point of titration. The titre value obtained was used for calculation of reducing sugar content.

$$\text{Reducing sugar (\%)} = \frac{\text{Factor X Dilution X 100}}{\text{Titre value X Volume of the sample}}$$

Total sugars (%)

Total sugars in juice of different varieties were estimated adopting the Lane and Eynon method (Ranganna, 1986). Exactly 50 ml of lead free filtrate prepared was taken in to 100 ml volumetric flask. Add 10 ml of HCl to it and was remained stand for 24 hours at ambient temperature. Acid was neutralized with 20% NaOH using few drops of phenolphthalein indicator and acidified with 1N HCl until pink colour disappeared. Then the volume of invert solution was made up to 100 ml with distilled water. This solution was taken in to a burette and titrated against mixed Fehling's solutions as done for reducing sugars stated above. The aliquot was determined as invert sugars and the total sugar content was calculated as follows

$$\text{Total sugars (\%)} = \frac{\text{Factor X Dilution 1 X Dilution 2 X 100}}{\text{Titre value X Volume of sample (1) X Volume of sample (2)}}$$

3.6 Physico-Chemical Analysis of Wine

3.6.1 Titrable Acidity (%)

Titrateable acidity in wine was determined by AOAC method (1965) as detailed below.

Twenty five ml of wine sample was taken in to a small conical flask, heated to incipient boiling to remove CO₂ present in the wine. It was held for 3 seconds, swirled and then cooled.

In a 500 ml conical flask, 200 ml of distilled water was taken, boiled and neutralized with one ml of phenolphthalein indicator. Five ml of degassed sample was added to conical flask and used for titration. In a burette 0.1 N standard NaOH was taken and titrated against the contents in conical flask till the end point was reached *i.e.*,light pink stable colour appearance using well illuminated white background.

The titrable acidity in wine was calculated by using the formula and expressed as percent citric acid.

$$\text{Tartaric acid (g) /100 ml wine} = \frac{\text{ml NaOH} \times \text{Normality of NaOH} \times 0.075 \times 100}{\text{Volume of sample (ml)}}$$

3.6.2 Volatile acidity

The volatile acidity of wine samples was determined as described by Amerine & Ough (1974).

Procedure

Ten ml of wine sample was transferred to a sellier tube and tightly connected to a trap and condenser. The sample was steam distilled and 100 ml of the distillate was collected in to a 250 ml Erlenmeyer flask. The distillate was titrated against 0.1 N sodium hydroxide using phenolphthalein indicator.

The volatile acidity of the sample was calculated by using the following formula

$$\text{Acetic acid (gm/ 100 ml)} = \frac{(V) \times (N) \times (60) \times (100)}{1000 \times (v)}$$

Where

V= volume of sodium hydroxide used in titration (ml)

N = Normality of sodium hydroxide

v = volume of sample in ml.

3.6.3 Reducing sugars (%)

Reducing sugars were estimated by the method of Lane and Eyon (Ranganna, 1986).

Twenty five milli litres of de-alcoholised wine was pipetted in to 250 ml volumetric flask and 100 ml of distilled water was added. Two ml of 45% lead acetate solution was added to the flask for precipitation of colloidal matter. Two ml potassium oxalate (22 %) was added to this solution to precipitate the lead and the volume was made up to 250 ml with distilled water.

The contents were then filtered through What man No.1 filter paper. The extract was tested for its freedom from lead by adding a drop of potassium oxalate. The lead free solution was taken in a burette and titrated against 10 ml of standard Fehling's solution (mixture of 5 ml Fehling's A and 5 ml Fehling's B) using methylene blue as an indicator on heating mantle till brick red precipitate was noticed and was recorded as an endpoint.

The reducing sugars were calculated as per the formula and expressed in percent.

$$\text{Reducing sugars (\%)} = \frac{\text{Factor} \times \text{Dilution} \times 100}{\text{Titration value} \times \text{Weight of sample or volume of sample}}$$

3.6.4 Total sugars (%)

Total sugars were estimated following the method described by Lane and Eyon (Ranganna, 1986). For this, 50 ml lead free filtrate was taken in a 250 ml volumetric flask and to this 5 ml of concentrated HCl (1+1) was added, mixed well and kept for 24 hours at room temperature. This solution was then neutralized with 10 ml of 40% NaOH using phenolphthalein as an indicator till the pink colour persisted for at least few seconds. Then volume was made up to 250 ml. Total sugars were then estimated by taking this solution in a burette and titrated against standard Fehling's solution (mixture of 5 ml Fehling's A and 5 ml Fehling's B) using methylene blue as an indicator on heating mantle till brick red precipitate was noticed and was recorded as an end point.

The total sugars were calculated as per the formula given below.

$$\% \text{ Total sugar} = \frac{\text{Factor} \times \text{Dilution 1} \times \text{Dilution 2} \times 100}{\text{Titre value} \times \text{Volume of sample (1)} \times \text{Volume of sample (2)}}$$

as invert sugar

$$\text{Percent Sucrose} = (\text{Percent total invert sugar} - \text{Percent reducing sugar}) \times 0.95$$

$$\text{Percent Total sugar} = (\text{Percent reducing sugar} + \text{Percent sucrose})$$

3.6.5. Alcohol (%)

Alcohol content of wine was estimated by using spectrophotometer at 600 nm as per the procedure given by Natu *et al.* (1986).

Ethanol in the presence of strong acid like concentrated sulphuric acid (H₂SO₄) reacts with potassium dichromate (K₂Cr₂O₇) to give a green coloured substance which was measured in a spectrophotometer at 600 nm.

A standard graph was prepared using ethanol in the concentration ranging from 1 to 10 percent. One ml of freshly prepared potassium dichromate solution

was added to 1 ml aliquot. Four ml of precooled concentrated sulphuric acid was added along the sides of the tubes after keeping the tubes in a beaker having the ice cool water. The OD value was measured at 600 nm.

3.6.6 Total Phenols (mg/l)

Total Phenols in the wine was estimated by the procedure described by Sadasivam and Manickam (1996).

Phenols react with phosphomolybdic acid in Folin-ciocalteau reagent in alkaline medium and produce blue coloured complex (molybdenum blue) which was measured at 650 nm in the spectrophotometer.

Exactly 3 ml of sample [wine (0.2ml) + water (2.8ml)] was taken in a test tube, added with 0.5 ml of diluted (1:2) Folin-ciocalteau reagent and kept for 3 minutes at room temperature. After 3 minutes, 2 ml of Na₂CO₃ was added and mixed thoroughly. Tubes were placed in boiling water bath for 1 minute, cooled and absorbance was measured at 650 nm in spectronic-20 against a reagent blank. The reading was noted and total phenols were calculated as 0.8 OD = 37 µg from the standard graph and expressed as mg/ml of wine.

3.6.7 Tannins (%)

Tannins in wine was determined by the method given by Amerine and Joslyn (1951 a).

Ten ml of wine was taken into a volumetric flask, heated to remove the alcohol, cooled and made up to the original volume. Five ml of prepared sample was transferred to 800 ml beaker, to which 500 ml of water and 5 ml of indigo carmine solution were added. Then the contents were titrated with standard 0.1 N potassium permanganate solution, until the blue colour changed to green first, then few drops were added until green colour became golden yellow. This titre value was designated as 'a'.

A portion of the de-alcoholized sample was decolourized and detannized by shaking 25 ml of it with 10 grams of carbon (activated charcoal). This was filtered and 5 ml of it was transferred to 800 ml beaker, 500 ml of distilled water and 5 ml of indigo carmine solution were added. This was titrated with standard 0.1 N potassium permanganate solution kept in burette. This titre value was designated as 'b'.

Then $a - b = c$, the number of milliliters of potassium permanganate solution required for oxidizing the tannin and colouring matter in 5 ml of the wine. The amount of tannin and colouring matter as grams of tannin per 100 ml was calculated as per the following formula and expressed as percent tannins.

Percent tannins = $C \times \text{Normality of KMnO}_4 \times 0.0416 \times 100 / \text{Volume of wine}$

3.6.8 Flavonoids (mg/lit)

Flavonoids in the wine were determined by use of Formaldehyde to precipitate the flavonoid phenolic compounds as proposed by Ough and Amerine (1988).

To ten ml of wine sample, 5 ml of HCL:H₂O (1:4 v/v) solution and 5 ml of 37 % formaldehyde were added, left for 24 hours and filtered through 0.45um polyethersulphon membrane. The amount of flavonoid was calculated as the differences between total phenols and non flavonoids in wine and was expressed in mg GAE/lit.

3.6.9 Organoleptic evaluation

Sensory evaluation of wine was done for colour, aroma, flavour, taste, astringency and overall acceptability before and after maturation. A panel of 10 members was given with wine samples and evaluated on 20 point scale. The wine samples were graded on the hedonic scale given by Joslyn and Amerine (1964a).

Table 3.1. The hedonic scale followed is presented here under:

Quality	Hedonic scale	20 point scale
Excellent	7	18-20
Good	6	15-17
Fair	5	12-14
Ordinary	4	9-11
Poor	3	6-8
Bad	2	3-5
Very bad	1	1-2

The wines are graded by taking the means into consideration as per the hedonic scale for various quality attributes like colour, aroma, flavor, taste, astringency and overall acceptability.

3.7 Statistical analysis

Statistical analysis of the quantitative data of chemical parameters obtained from the experiment was done by Completely Randomized Design (CRD) as per the procedure outlined by Panse and Sukhatme (1967). The statistical analysis of the data obtained from sensory evaluation of the grape wine was done by Randomized Block Design (RBD) as given by Cockrane and Cox (1963).



Plate3a: White varieties of grapes used in the present experiment

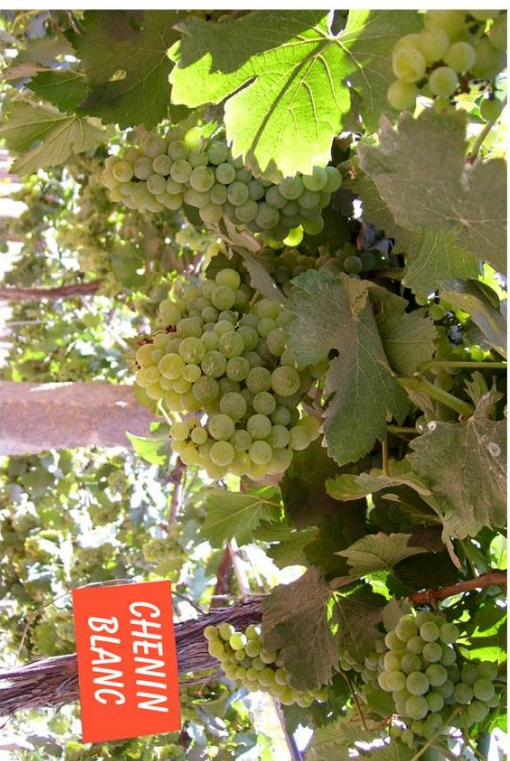


Plate3: White varieties of grapes used in the present experiment



Plate2a: Coloured varieties of grapes used in the present experiment



Plate2: Coloured varieties of grapes used in the present experiment



Plate1: Overall view of the experimental orchard

CHAPTER - IV

RESULTS AND DISCUSSIONS

An endeavour was made in this chapter to present the obtained results of the investigation with statistical interpretation and discussed the results substantiating them with the available information from earlier research work conducted on similar lines with physiological and biochemical reasons.

Wine is one of the fermented beverages, prepared from fruit juices by fermentation with micro organism like yeast. Grape has been the principal fruit used with preparation of wine. In fact, the word 'wine' signifies the fermented product from grapes only. It is considered as a health drink. Wine has been a part of the diet of man and is used as a medicine for centuries all over the world.

Wine production appears to have an ancient origin in India, particularly in the states of Jammu and Kashmir and Himachal Pradesh. Commercial cultivation of wine grapes in India has begun only since 1980's (Chadha and Shikhamany,1999).

Grapes have originated in temperate region. Hence, traditionally grapes are one of the most important fruit crops of temperate zone of the world, but presently its cultivation has been extended to tropical and sub-tropical regions of the world. The yield and fruit quality of grapes vary significantly with agro-climatic conditions under which it is grown. Many different climates exist in the tropics, resulting from variation in temperature, humidity, rainfall and its distribution. Good quality wine is produced in slightly elevated wet tropical areas of northern and eastern Thailand region. Similar climate prevails in the Deccan plateau of southern India, where a range of wine grape varieties were being grown, which are extensively used for wine production.

As the climate plays an important role in successful cultivation of grapes, selection for suitable variety for a particular use under a particular agro-climate is of paramount importance. Grape is an introduced fruit crop in India. Though its cultivation has been successful particularly in Southern states of India, the grape cultivation in tropical region is totally different from its natural habitat (*i.e.*, temperate zone) which shows definite influence on the growth performance, berry composition and eventually on fruit quality and products like raisins, juice and wine.

Practically all the grape cultivars grown in India are mainly for table purpose. Continuation of this practice in future may lead to serious marketing problems due to glut and lack of cold storage facilities etc. Further, the sweet table purpose grape types are not quite suitable for making good quality wines. To overcome this problem, there is a need to grow other types of grapes like wine grapes to develop Indian wine industry. This objective can be achieved by introducing wine grape varieties from different parts of the world and testing them along with our existing varieties and developed hybrids under different climatic regions for their suitability to the region and for making quality wines for acceptability in domestic as well as international markets. In view of the above, for the past few decades, several wine varieties were introduced and planted to develop wine industry. The information on their growth performance, composition and their suitability for making quality wines under varied climatic condition needs to be generated for selecting a suitable wine variety for different climatic regions (Patil *et al.*, 2007).

The major field of wine research in India included evaluation of grape varieties (both domestic and introduced) for their suitability to wine making. No scientific investigation has so far been made to find out suitable grape varieties for wine making and for commercial cultivation in Andhra Pradesh, an important state of grape growing in India, although a few such studies were made in Maharashtra (Patil *et al.*, 2007; Havinal *et al.*, 2008, Karibasappa and Adsule, 2008),

Punjab (Thakur *et al.*, 2008), Karnataka (Chikkasubbanna, 1982 ; Suresh *et al.*, 1985 & Patil and Patil, 2008) and West Bengal (Ghosh *et al.*, 2008).

In view of the above the present investigation was undertaken with the following objectives

1. To study the varietal performance of different wine varieties in respect of their growth and yield under semi-arid conditions of Hyderabad.
2. To study the wine recovery and quality parameters from different wine-grape varieties.
3. To study the effect of blending of different white varieties with coloured varieties on wine quality.

4.1. Experiment I: Studies on growth and yield of different varieties of grape for wine production

The performance of plant species in respect of growth, development and production is variable depending upon the agro-climatic conditions under which it is grown. This necessitates the performance studies of different plant species, particularly their varieties under different situations in order to choose a suitable one for that situation. Such studies are especially needed when plant species in respect of exotic species/varieties were introduced to another region. Keeping this in view, the present experiment was designed.

The variation in the values of different growth parameters may be attributed to their inherent genetic makeup; whereas the differences between seasons and years may be due to variation in the climatic factors and the response of varieties to such variations.

4.1.1. Pruning weight (kg/vine)

The results pertaining to the pruning weight of vine of both the seasons (Summer and Winter) in different varieties of grape for both the years (2006-07 and 2007-08) are presented in the Table – 4.1.

It is clear from the data that seasons and years have shown significant influence on the pruning weight in all the cultivars. Similarly, the cultivars showed significant differences among themselves in respect to pruning weight in both the seasons and years.

4.1.1.1. Summer pruning weight (kg/vine)

Significant variation was observed with respect to the summer pruning weight among the varieties, years while interaction effect was found to be non significant.

The pooled data signifies that among the varieties evaluated, Athens has recorded highest pruning weight (5.23 kg/ vine) closely followed by Cv. Shiraz (4.94 kg/vine) which were in the same order but superior to other varieties. Next in line was Ruby Red (4.26 kg/vine) which differed significantly from the above two cultivars and was at par with Italia (3.73 kg/vine). Lowest pruning weight was recorded by Cv. Zinfandel (1.03 kg/vine), while others recorded intermediate weight ranging from 1.78 to 3.41 kg/vine.

Between the two years, irrespective of the cultivars, the mean summer pruning weight was higher (3.47 kg/vine) in the year 2007-08, than 2006-07 (2.43 kg/vine). When the individual years are considered, during the first year of study (2006-07), highest pruning weight was recorded by the variety Athens (5.06 kg/vine) followed by Shiraz (4.56 kg/vine) while least weight was observed with Zinfandel (0.73kg/vine). Similar trend was noticed during the second year of study.

The interaction between years and cultivars was found to be non significant. However, cultivar Athens recorded highest summer pruning weight (5.06 and 5.40 kg/vine), whereas Zinfandel (0.73 and 1.33 kg/vine) produced least pruning wood in both the years of study.

4.1.1.2. Winter pruning weight (kg/vine)

It is evident from the Table-4.1 that significant variation existed with respect to winter pruning weight among the varieties and between the years.

The perusal of pooled data indicates that cultivar Shiraz (2.76 kg/vine) recorded highest pruning weight and was superior to other varieties. This was followed by cultivar Athens (2.21 kg/vine), which differed significantly from Shiraz, and was superior to others. Winter pruning weight was least in case of Zinfandel (0.46 kg/vine) followed by Sauvignon Blanc (0.64 kg/vine) and Chenin Blanc (0.78 kg/vine), and were in the same order. Rest of the cultivars recorded intermediate values for pruning weight between Shiraz and Chenin Blanc.

Significant difference between the years in respect to winter pruning weight was also observed. However, when the means of the years were considered, winter pruning weight was higher (1.62 kg/vine) in the year 2007-08 than that of 2006-07 (1.00 kg/vine).

During the first year, Cv. Shiraz recorded highest pruning weight (2.13 kg/vine) closely followed by Athens (2.03 kg/vine) while least winter pruning weight (0.23 kg/vine) was observed in Sauvignon Blanc closely followed by Zinfandel (0.26 kg/vine). In the year 2007-08, similar to that of first year, Shiraz has registered highest winter pruning weight (3.40 kg/vine) again followed by Athens (2.40 kg/vine) while Zinfandel recorded least pruning weight (0.66 kg/vine) followed by Chenin Blanc (0.83 kg/vine). Thus there is consistency in case of certain cultivars in both season and years of studies.

Interaction between varieties and years was found to be non significant.

The vigour of vine is expressed in terms of pruning weight and this character is an important growth attribute for distinguishing different grape varieties as vigorous and non vigorous based on growth rate (Shikhamany, 1983; Fawzi *et al.*, 1984; Satisha and Shikhamany, 1999; Benz *et al.*, 2006). The amount of pruning weight depends upon the vigour of the vine highly vigorous vines produce more pruning weight than less and medium vigorous varieties.

In the present investigation, summer pruning weight of different varieties of grape ranged from 1.03 to 5.23 kg/vine while winter pruning weight ranged from 0.46 to 2.76 kg/vine, highest being recorded with the variety Shiraz and lowest in

Zinfandel in both the seasons. The pruning weight was found to increase with the advance in the age of the crop. This difference in the pruning weight among the varieties may be attributed to the difference in the vigour of vine and in addition to this, assimilation of carbohydrates due to more number of canes, number of leaves produced and other growth parameters results in more dry matter production. Based on the above results, varieties can be classified as vigorous (Athens, Shiraz, Ruby Red); moderately vigorous (Italia, Bangalore Blue, Gulabi, Symphony, Pusa Navrang and Thompson Seedless); less vigorous (Zinfandel, Sauvignon Blanc and Cabernet Sauvignon). Pruning weight was found to have significant positive correlation with average number of bunches and yield per vine.

A wide range of pruning weight was reported by several workers 0.04 to 2.42 kg/vine (Kadu *et al.*, 2007), 0.44 to 2.93 kg/vine (Havinal *et al.*, 2008), 4.6 to 20.4 kg/vine (Shellie, 2007), 2.51 to 11.09 t ha⁻¹ (Karibasappa and Adsule, 2008), 0.91 to 3.78 kg/vine (Ratnacharyulu, 2010). However, pruning weight in the present study was less than those reported from South West Idaho (Shellie, 2007) which may be due to tropical conditions prevailing at Hyderabad. The values in the present study were in accordance with the above results.

4.1.2. Number of days taken for bud break

The data pertaining to days taken for bud break after winter pruning during 2006-07 and 2007-08 were presented in Table- 4.2. Significant variation was noticed among the varieties, years and interactions with an unaltered trend observed in both the years of study.

The perusal of the pooled data indicates that among the varieties, Pusa Navrang took significantly less number of days to bud break (8.15) and was however at par with Bangalore Blue (8.49) and Chenin Blanc (9.85). The latter was followed by Gulabi (10.09) and Sauvignon Blanc (11.56) and were in the same order. On the other hand, the variety Ruby Red took significantly more number of days to bud break (21.21) followed by Thompson Seedless (17.94) and Cabernet

Sauvignon (15.86). Rest of the varieties recorded intermediate values ranging from 13.96 to 15.36 days.

Significant influence on days to bud break after pruning was observed between the years. More number of days (14.69) were taken in the year 2007-08 than in 2006-07 (12.67) irrespective of the cultivars.

The number of days required for bud break significantly differed from year to year in respect of all varieties. In the year 2006-07, Ruby Red required highest number of days *i.e.*, 20.10 for bud break followed by Thompson Seedless (17.03) and both were at par. Least number of days were required by Pusa Navrang (7.20) closely followed by Bangalore Blue (8.06), Gulabi (9.06) and Chenin Blanc (9.10) which were in same order. The remaining cultivars recorded intermediate number of days for bud break.

Similar trend was observed in the year 2007-08, with slight difference. Ruby Red retained its consistency in requiring time for bud break by recording highest number of days (22.33) and was superior to all others. It was followed by Thompson Seedless (18.86) which in turn was followed by Cabernet Sauvignon (17.30) and both were at par, but superior over others. Cv. Bangalore Blue took least number of days (8.93) closely followed by Pusa Navrang (9.10) and Chenin Blanc (10.60) all were in same order. The rest of the varieties falls between these two extremes.

Interaction between years and cultivars was also significant. In both the years, Ruby Red took highest number of days for bud break, where as Pusa Navrang in 2006-07, showed early bud break (7.20) and Bangalore Blue in 2007-08 exhibited early bud break (8.93).

Bud burst is a varietal character as it marks the beginning of seasonal growth and it is strongly influenced by temperature. Bud bursting time is not easily predictable because its relationship with temperature is very complex. The period of bud sprouting varies with the year and variety. Cvs. Pusa Navrang, Bangalore Blue and Chenin Blanc were the earliest ones to show bud break requiring less than

ten days. Whereas Ruby Red needed more than 20 days for bud break. Based on this, the varieties can be classified into early, mid and late bursting varieties (Bharat, 1997; Mandelli *et al.*, 2003).

Early varieties : Pusa Navrang, Bangalore Blue, Chenin Blanc and Gulabi.

Mid season varieties: Sauvignon Blanc, Symphony, Shiraz, Zinfandel, Italia and Cabernet Sauvignon.

Late varieties : Ruby Red, Thompson Seedless and Athens.

The data on the parameter clearly indicates that prevailing temperature after pruning affects the time required for bud break in the same variety and the influence of temperature is more than that of variety. Italia at Hyderabad took more than 15 days for bud break and at Venezuela another tropical country, took less than 12 days for bud break (Pina and Bautista, 2004). Further, lowest number of days taken for bud break was registered during the first year of studies over the second year. This may be due to ideal climatic conditions prevailing during the first year of study *i.e.* warmer climatic conditions observed during the bud break period and also may be due to consecutive higher levels of stored carbohydrate reserves. Such conclusion can also be drawn from earlier studies (Rajaram, 1964; Muthukrishnan, 1969; Patil, 1968; Kulwal, 1968; Shinde and Patil, 1978; Bharat, 1997; Valor and Bautista, 1997; Seif and Abd Ei Samad, 2000; Pina and Bautista, 2004). Mandelli *et al.* (2003), classified Cabernet Sauvignon as a mid seasons variety in Brazil, which is inline with the present result wherein Cabernet Sauvignon is grouped under mid season variety.

Some of the research findings on bud burst were reported on varietal variation in number of days taken for bud break *viz.*, Early (5 days in Bangalore Blue (Muthu Krishnan, 1969); 7 days (Pusa Navrang) to 13 days (Concord) (Ratnacharyulu, 2010); 9.4 days in Chenin Blanc (Valor and Bautista, 1997), Mid group (12 days in Anab-e- shahi (Rajaram, 1964); 12 days in Italia (Pina and Bautista, 2004); Late group (12 days in Bangalore Purple, 13 days in Ruby Red and

22 days in Hur (Bharat, 1997); 14 (Gulabi) to 23 days (Pandhari sahebi) (Shinde and Patil, 1978; Kulwal, 1968). The results of the present study are in confirmity with the above findings.

4.3. Number of Canes per vine

Table 4.3.furnishes the data recorded on number of canes per vine from which the following observations are made. Significant variation was observed among the varieties during both the years while it was found to be non significant with respect to their interactions.

With regards to varieties, Cv. Shiraz produced significantly maximum number of canes per vine (54.93) closely followed by Chenin Blanc (53.89) and both were in same order. Cv. Cabernet Sauvignon produced next higher number of canes (47.94) which differed significantly from the above two cultivars and superior to others. Where as Cv. Thompson Seedless recorded the least number of canes (32.91) followed by Italia (34.40), Bangalore Blue (34.61) and Gulabi (35.03), and were in same order but statistically differed from others. The remaining cultivars produced intermediate number of canes per vine.

Significant variation in the number of canes during the different years among the different cultivars was also vivid from the Table.4.3. Significantly lesser number of canes (38.72) were recorded in 2006-07 where as, higher number of canes (44.68) were produced in 2007-08. When the individual years are considered, in the year 2006-07, significantly highest number of canes per vine was observed with Chenin Blanc (52.56) closely followed by Shiraz (50.50) and were in same order and superior to other varieties. Thompson Seedless registered least number of canes (30.76) followed by Italia (31.30).The number of canes produced by rest of the cultivars were in between these extremes.

Contrary to the above, in 2007-08, maximum number of canes was noticed in Shiraz (59.36) closely followed by Chenin Blanc (55.23), and were in same order. On the other hand Thompson Seedless with least number of canes (35.06)

followed the same trend as that of previous year closely followed by Bangalore Blue (36.66) and Italia (37.50).

The interaction between the varieties and years did not exert significant influence.

4.1.4. Cane diameter (mm)

Data on diameter of cane expressed in (mm) were presented in Table-4.4. The data indicated that varieties, years have exerted significant variations while interactions showed non significant influence on cane diameter.

The perusal of pooled data indicates that irrespective of the years, the varieties exhibited significant differences in thickness (diameter) of the canes among themselves. Highest cane diameter was observed in Italia (18.60mm) closely followed by Ruby Red (18.14mm), Athens (16.94mm) and Bangalore Blue (16.88mm) and were in same order. On the other side, Cv. Zinfandel produced thinnest canes (10.93mm) closely preceded by Cabernet Sauvignon (12.66 mm) and both were in same order. Rest of the varieties were in the range of 13.83 to 16.73mm.

Significant difference was noticed with respect to the cane diameter between the years studied. The mean cane diameter was maximum during the second year (16.24 mm) when compared to the first year (14.69 mm). During the first year, maximum diameter of cane was recorded by the variety Italia (16.90 mm) closely followed by Ruby Red (16.83 mm) where as, minimum was noticed with the variety Zinfandel (9.54mm). Similar trend was noticed in the second year of investigation.

The interaction effect of years and varieties exhibited non significant influence on cane diameter.

Besides, pruning weight, the vine vigour can also be judged by the number of canes produced per vine and diameter (Fawzi *et al.*, 1984). The production of canes and their dimension depends upon vigour of the vine, which inturn depends

upon the extent of stored food material in the vine. Vigorous varieties having greater stored food material, produce higher number of canes. It appears that varieties which produced less than 40 canes per vine like Thompson Seedless, Italia, Bangalore Blue, Gulabi and Sauvignon Blanc are less vigorous and those which produced more than 50 canes per vine like Chenin Blanc and Shiraz are highly vigorous and the rest are of medium vigorous type. In the present investigation, the number of canes varied from 32.91 to 54.93 while diameter of cane ranged from 10.93 to 18.60 mm. This difference in number of canes may be due to differences in vigour of the variety. Number of canes found to increase progressively in all the varieties with increase in the age of crop, caused by increased leaf area and vine canopy. Several scientists have recorded similar observations on the number of canes per vine in different cultivars from 3.67 to 41.73 (Kadu *et al.*, 2007) 17.30 to 52.44 (Havinal *et al.*, 2008), 32.33 to 104.00 (Ratnacharyulu, 2010) and cane diameter of 12.61 to 16.21 mm (Reddy *et al.*, 1992) and 4.9 to 6.9 mm (Havinal *et al.*, 2008). Havinal *et al.*, 2008 reported 52.44 canes per vine in case of Chenin Blanc from Maharashtra which is nearly similar to that of the same variety (53.90) at Hyderabad. However, Cabernet Sauvignon produced higher number of canes (47.95) at Hyderabad than at Ahmadabad (30.20), which may be due to difference in the climate at both places and greater response of Cabernet Sauvignon to climate. The results of the present study are in accordance with the above findings.

4.1.5. Shoot length (cm)

The data regarding the Shoot length in different varieties of grape for the two years were furnished in Table-4.5. Significant variation was observed among the varieties and years.

The pooled data reveal that the shoot length was significantly maximum in Athens (79.16 cm) closely followed by Gulabi (77.00 cm) and Thompson Seedless (75.16 cm) which were at par. whereas least shoot length was recorded in case of Bangalore Blue (53.33 cm) preceded by Ruby Red (60.66 cm) which were

independent of each other. The remaining cultivars recorded shoot length in the range of 61.22 cm in Italia to 72.66 cm in Cabernet Sauvignon.

With respect to the years, shoot length was less (65.94 cm) in the first year of experiment than that of second year (68.15 cm). During the first year, maximum shoot length was observed in the variety Athens (77.33cm) followed by Thompson Seedless (74.66 cm) and Gulabi (74.00 cm) and the latter two were on par to each other, while minimum was recorded by the variety Bangalore Blue (49.00 cm). In the second year of study (2007-08), same pattern of shoot length was observed in respect of short and longest shoot lengths *i.e.* Athens recorded maximum shoot length (81.00 cm) followed by Gulabi (80.00cm) and minimum was noticed in Bangalore Blue (57.65 cm).

The interaction effects of varieties and years was found to be non significant.

The vigour of vine can also be judged by means of shoot length besides pruning weight and number of canes. Generally length of the shoot depends upon the vigour of the variety and extent of pruning. Highly vigorous varieties generally produce longer shoots. However, this does not appear to be true in the present trial. In the present study, it was observed that shoot length varied from 53.33 to 79.16 cm. Highly vigorous varieties (Chenin Blanc and Shiraz) produced comparatively shorter shoots than less vigorous varieties. Thus it appears that the difference may be due to variety, rather than the vigour of the variety. Since the severity of pruning is similar in respect of all varieties screened, the variation in shoot length of different varieties due to extent of pruning may also be ruled out. This difference in shoot length might be attributed to the number of buds retained on the cane after pruning.

4.1.6. Number of leaves

The data recorded on number of leaves were furnished in Table-4.6. A perusal of the data reveals significant effect with respect to the varieties, years and interaction on number of leaves per vine.

Among the different varieties studied, maximum number of leaves per vine was recorded in Ruby Red (23.66) closely followed by Athens (22.33) and both were in same order and superior to others. Cvs. Sauvignon Blanc and Chenin Blanc are next in line recording 18.66 and 18.50 leaves per plant respectively and were at par. However, less number of leaves were observed with Bangalore Blue (9.83), which was independent of the other cultivars.

With respect to the years, there was progressive increase in the number of leaves with increase in the age in all the varieties. The number of leaves increased from 15.07 in the first year to 18.45 in the second year. In the year 2006-07, Athens produced maximum number of leaves (21.00) closely followed by Ruby Red (20.66) and were at par, but superior to others. Minimum number of leaves were produced by Bangalore Blue (9.00) preceded by Italia (10.00) and Gulabi (11.00) and were at par to each other.

In the year 2007-08 unlike in the previous year, Ruby Red registered significantly highest number of leaves (26.66) followed by Athens (23.66) and both were independent of each other and superior to rest of the cultivars. Significantly lowest number of leaves was registered by Bangalore Blue (10.66) as in the previous year, but was independent to others.

The interaction between varieties and years indicated significant influence. In both the years, Bangalore Blue recorded minimum number of leaves (9.00 and 10.66) while Athens (21.00) recorded maximum number in the year 2006-08 and Ruby Red in the year 2007-08 recorded maximum number of leaves (26.66).

4.1.7. Leaf area (cm²)

The data pertaining to the leaf area in different varieties of grape for both the years were presented in the Table- 4.7. Significant variability was recorded among the varieties and the years but with similar trend was noticed in both the years.

The perusal of pooled data reveals that maximum leaf area was recorded in the variety Bangalore Blue (112.53 cm²) which was significantly superior to rest of the varieties. This was followed by Ruby Red (91.94 cm²), Pusa Navrang (82.56 cm²) and Athens (72.13 cm²). The latter was however, at par with Symphony (70.93 cm²), Thompson Seedless (70.93 cm²), Gulabi (66.50 cm²) and Sauvignon Blanc (64.78 cm²) while, minimum mean leaf area was recorded in Chenin Blanc (42.21 cm²) which in turn was comparable with Zinfandel (46.29 cm²).

When the years are taken into consideration, mean leaf area was found to decrease from first year to second year (74.40 to 63.00 cm²). In 2006-07, maximum leaf area (122.73 cm²) was noticed in Bangalore Blue which was superior over all others. Next in line was Ruby Red (99.26 cm²) which was superior over other cultivars. Minimum leaf area (45.96 cm²) was recorded in Chenin Blanc preceded by Zinfandel (48.66 cm²). The rest of the cultivars recorded intermediate values between two extremes.

In the year 2007-08, similar trend was observed. Maximum leaf area (102.33 cm²) and minimum leaf area (38.46 cm²) was observed in Bangalore Blue and Chenin Blanc respectively.

The varietal and years interaction effects did not show any significant influence on this trait.

Leaves are the sites of photosynthesis, more the number of leaves on the plant more will be the photosynthesis. In the present study leaf number varied from minimum of 9.83 to a maximum of 23.66 and the leaf area ranged from a minimum of 42.21 cm² in Chenin Blanc to a maximum of 112.53 cm² in cultivar Bangalore Blue. This may be due to the difference in number of canes and vigour of the vine and also may be attributed to inherent varietal character. It was also evident from the data that varieties having less number of leaves had recorded maximum leaf area and vice versa this might be due to translocation of more nutrients to the leaf growth which ultimately results in higher leaf area. The present results are in

conformity with the findings of Kadu *et al.*(2007); Shirsath (1965); Chadha and Randhawa (1974).

4.1.8. Days taken for 50 % flowering

The data recorded on days taken for 50% flowering was furnished in Table 4.8 which indicated that the experiment was significant in respect of varieties, years while it was found to be non significant with their interaction.

The different varieties screened here have shown statistical differences among themselves in both years and in their mean number of days taken for 50% flowering. The pooled data signify that Pusa Navrang took significantly less number of days to flowering (25.36) and was on par to Chenin Blanc (26.24) and Bangalore Blue (27.63). The next best variety was Symphony (28.55). On the other hand maximum number of days was taken by Italia (44.37) which was on par with Thompson Seedless (43.56) and Ruby Red (43.39). Remaining varieties recorded intermediate values from 34.54 to 38.23 days.

The number of days taken for 50% flowering significantly varied between the years, being more in the second year of experiment (38.00) than in the first year (32.79). In the year 2006-07, Italia took more number of days for 50% flowering (42.00) closely followed by Thompson Seedless (41.60) and Ruby Red (41.26) which were in the same order. Where as Pusa Navrang (23.16), followed by Chenin Blanc (23.16) and Bangalore Blue (24.83) recorded minimum days for flowering and were at par with each other.

The picture in 2007-08 in similar to that of the first year. In this year highest number of days to 50% flowering was recorded by Italia (46.74) closely followed by Thompson Seedless (45.53) and Ruby Red (45.53) which were at par whereas Pusa Navrang (27.56) closely preceded by Chenin Blanc (29.33) took less number of days.

The interaction effects was found to be non significant. However, cultivar Pusa Navrang took less number of days while Italia took more number of days for 50% flowering in both the years.

Early flowering is an important attribute, as opening of panicles in shortest possible time is most desirable character in grape. The number of days taken for 50% flowering in grape varies with the genetic base of cultivar and environmental conditions (G x E interaction). Bright warm weather results in early flowering than rainy and cool weather (Weaver, 1976). This is most useful in assessing the maturity and early harvesting of berries providing ease to harvest fruit in one or two pickings to reduce the cost of picking. Early flowering resulting in early harvesting is required, particularly in North India, where harvesting often coincides with early monsoon rains, resulting in loss of produce due to diseases etc.

In the present study, time taken for 50 % flowering varied from 25.36 to 44.37 days. Based on the results, varieties can be classified as early blooming (Pusa Navrang, Chenin Blanc, Bangalore Blue and Symphony) mid (Shiraz, Gulabi, Zinfandel, Athens, Cabernet Sauvignon and Sauvignon Blanc) and late blooming (Italia, Thompson Seedless and Ruby Red). All the varieties took less number of days to flowering during the second year compared to first year, this may be due to difference in the bud burst duration and also to the prevailing climatic conditions. The number of days for 50% flowering was also influenced by the number of degree days or heat units. Under sub-tropical conditions of Punjab a months time was required for different grape cultivars (Jawanda *et al.*, 1965). Whereas under tropical conditions of Bangalore, the varieties Gulabi and Bangalore Blue needed 47.0 and 33.5 days respectively to reach 50% flowering. Several workers reported range for 50 % flowering from 33.5 to 47.0 days (Jawanda *et al.*, 1965); 19 to 25 days (Nalwadi *et al.*, 1972); 16 to 30 days (Bharat, 1997); 12 to 23 days (Randhawa and Sharma, 1960). The results of the study are in line with the above reports. The number of leaves, leaf area has no relationship and are not associated with flowering. This is a special trait with polygenic in expression and environment plays a very important role.

Bunch characteristics

4.1.9. Mean number of bunches per vine

The presented data in Table- 4.9. on the number of bunches per vine revealed the following results.

The mean number of bunches per vine varied significantly among the cultivars. Chenin Blanc showed maximum number of bunches (113.78) and was significantly superior over others followed by Shiraz (97.75) and Pusa Navrang (95.53) in descending order, and both were in same order, but superior to others. Whereas Cv. Thompson Seedless showed minimum number of bunches (37.26) preceded by Italia (38.74) and were at par. The rest of the cultivars showed intermediate values ranging from 45.70 in Gulabi to 87.74 in Cabernet Sauvignon.

Years have also shown significant influence on the number of bunches. An increase in mean number of bunches from 62.65 in 2006-07 to 71.63 in 2007-08 irrespective of the cultivars was observed. All the cultivars have shown this increase except Cv. Athens in which the number of bunches decrease from 61.06 in 2006-07 to 59.90 in 2007-08.

In 2006-07, significantly highest number of bunches was observed with Chenin Blanc (101.30) which was superior over others. Significantly lowest number of bunches was observed with Thompson Seedless (34.00) closely preceded by Italia (35.73) and both were in same order but differed from others. The rest of the cultivars recorded the number of bunches per vine in between the two extremes of maximum and minimum number.

In 2007-08 also, similar trend was noticed in the number of bunches per vine. Chenin Blanc produced significantly highest number of bunches per vine (126.26) and was superior over others and Thompson Seedless recorded minimum number (40.53) respectively.

The interaction effect on the number of bunches per vine was non significant.

4.1.10. Mean bunch weight (g)

Data on mean weight of the bunch (g) as recorded during 2006-07 and 2007-08 in respect of different cultivars was depicted in Table-4.10 from which it was clear that the parameter was responded significantly to the factor *i.e.*, varieties while it was found to be non significant with years and their interactions.

When the varietal means were considered for evaluation, it was observed that maximum bunch weight was recorded in Italia (331.61 g) followed by Thompson Seedless (307.79 g) but both were independent to each other and superior to the rest of varieties. The next best variety was Athens (154.89 g) and was at par with Zinfandel (149.29 g). Minimum weight of the bunch was observed in Cabernet Sauvignon (88.06 g) closely preceded by Gulabi (89.59 g), Symphony (98.38 g) and Sauvignon Blanc (98.83 g) and all these were at par. The bunches in case of remaining cultivars weighed intermediately ranging from 104.86 g in Pusa Navrang to 138.26 g in Chenin Blanc.

The years have not shown significant effect on weight of bunches. In the first year of experiment (2006-07) Italia has produced heaviest bunches (335.56 g) closely followed by Thompson Seedless (311.93 g) and the Cv. Cabernet Sauvignon has produced bunches with minimum weight (91.76 g) followed by Gulabi (92.46 g) and Symphony (99.53 g) whereas the rest of the cultivars produced bunches of medium weight between the two extremes.

In the second year of the trial, Italia continued to produce heaviest bunches (327.66 g) followed by Thompson Seedless (303.66 g). Similarly Cabernet Sauvignon continued to produce bunches with lighter weight (84.36 g) this year also.

The interaction effects did not exert significant influence on the bunch weight.

4.1.11. Mean bunch Length (cm)

Significant variation among the varieties, years and non significant influence in their interaction are shown by the statistical analysis of the data on the mean bunch length (Table-4.11).

The mean data of varieties irrespective of the years has indicated that the length of bunch varied significantly among the cultivars. Maximum bunch length was recorded in Thompson Seedless (17.90cm) which was superior to others. Next in line was Italia (17.00 cm) which was followed by Shiraz (12.33 cm) and were independent to each other. The length of the bunch was least in Sauvignon Blanc (6.66 cm) closely preceded by Symphony (7.04 cm) and both were at par. The latter was comparable with Gulabi (7.56 cm). The remaining cultivars recorded intermediate values for the length of the bunches ranging from 8.86 cm to 11.08 cm.

The yearly effect on length of the bunch was significant. Average length of the bunch showed slight decrease from the first year (10.95 cm) to second year (10.11 cm) in all the cultivars except with Cvs. Bangalore Blue and Gulabi.

When the individual years were taken into account, it was observed that in 2006-07, maximum length of bunch was recorded in Cv. Thompson Seedless (19.60 cm) which was at par with Italia (18.80 cm) and were superior to others. Minimum length of the bunch was observed in Sauvignon Blanc (6.80 cm) closely preceded by Symphony (7.36 cm) and Gulabi (7.36 cm) and were at par. Similar results were recorded during the second year of the trial.

The interaction effect of varieties and years was found to be non significant. Among the varieties, Thompson seedless recorded longest bunches followed by Italia whereas, smallest bunches were recorded by Sauvignon Blanc.

Bunch and berry attributes contribute much to the yield of vines and these are specific to each variety. Heavier the bunches with heavier berries, more the yield of grape varieties. However, they differ in different varieties due to nutrition, place of cultivation etc., Bunch characteristics *viz.*, number of bunches, bunch

weight and bunch length were used in describing different grape varieties by several workers (Hedrick, 1908; Bioletti, 1938, Singh and Singh, 1940; Joshi, 1961; Shirsath, 1965; Kashyap *et al.*, 1988; Shanmugavelu, 1989). The bunch characteristics have significant correlation with the fruit yield.

Number of bunches per vine differs significantly with the variety, nutrition of the vine and probable site of growing. In the present study, the number of bunches varied from 37.26 to 113.78 with maximum recorded in the variety Chenin Blanc and minimum in Thompson Seedless respectively. The productivity of bunches, bunch weight and length appears to be a genetic phenomenon, but the climate and soil nutrient status also contribute to certain extent. This difference in the number of bunches per vine may be attributed to varietal character due to more number of canes or immaturity of canes in different varieties. Similar line of work was registered by Kadu (2002) and Havinal (2007). A wide range in number of bunches was reported by several workers *i.e.*, 8 to 88 (Anonymous, 1984a); 9.30 to 33.43(Kadu *et al.*,2007); 17.35 to 93.10 (Karibasappa and Adsule, 2008); 58.33 to 142.00 (Ratnacharyulu, 2010); 131 to 162 (Walker *et al.*, 2000). The outcome of the present study is in agreement with the above references.

Bunch weight is an important yield attribute. Bunch weight in the present study found to ranged from 88.06 to 331.61 g with maximum being with the variety Italia and minimum with the variety Cabernet Sauvignon. The differences in the bunch weight in different varieties may be attributed to inherent genetic character of the variety, difference in number of canes, number of berries per bunch and berry size and also vine canopy size where the high bunch weight was observed in the varieties which had large canopy size (Walker *et al.*, 2000; Havinal *et al.*, 2008). Several workers reported a range of bunch weight from 28.49 to 317.00 g (Kadu, 2002); 41 to 430 g (Bhujbal, 1972); 44.9 to 431.1 g (Daulta *et al.*, 1972); 60.5 to 194 g (Ghosh *et al.*, 2008); 65.5 to 251.5 g (Karibasappa and Adsule, 2008); 75.7 to 280g (Kumar and Rajan, 2008); 88 to 310 g (Richard *et al.*, 1999);

97.33 to 161.33 g (Ratnacharyulu, 2010). These results of the present study are with the findings of the above workers.

In the present investigation, length of bunch ranged from 6.66 cm (Sauvignon Blanc) to 17.90 cm (Thompson Seedless). A range of bunch length from 10.1 to 15.4 cm (Ghosh *et al.*, 2008); 12.0 to 19.2 cm (Richard *et al.*, 1999); 13.7 to 21.7 cm (Thakur *et al.*, 2008). This type of results on bunch characteristics in different varieties were also reported by Richard *et al.*, (2000), Kadu (2002) and Havinal (2007).

Berry characteristics

4.1.12. Number of berries per bunch

Statistical analysis of the data presented in Table-4.12 on the number of berries per bunch as influenced by varieties and years has revealed significant influence.

The pooled data indicate that among cultivars, Pusa Navrang recorded highest number of berries per bunch (87.16) closely followed by Thompson Seedless (82.75) and both were statistically at par. The next best variety was Italia (78.85). On the other hand, lowest number of berries per bunch was recorded by Gulabi (31.73) which was independent to other varieties. This was preceded by Bangalore Blue (39.95) and Sauvignon Blanc (44.41) which were in same order. The rest of the varieties recorded number of berries ranging from 51.03 in Symphony to 69.34 in Chenin Blanc.

Years exhibited significant difference. The number of berries per bunch was slightly more in the second year (62.91) than in the first year (60.59). However, the cultivars Zinfandel, Cabernet Sauvignon, Shiraz, Athens and Thompson Seedless showed reduction in the number of berries in the second year whereas others showed increased in different magnitudes.

In the year 2006-07, Pusa Navrang registered significantly highest number of berries (86.93) closely followed by Thompson Seedless (84.27) with which it was at par. Lowest number of berries was recorded with Gulabi (30.66) closely preceded by Bangalore Blue (37.70) and both were in same order. The results of second year trial were similar to that of first year.

The interaction effects among the varieties and years were found to be non significant. However, irrespective of the years, the variety Pusa Navrang recorded higher number of berries per bunch followed by Thompson Seedless while minimum was found with the variety Gulabi.

4.1.13. Hundred Berry Weight (g)

The data on the hundred berry weight are presented in Table-4.13. It is clear from the table that there was significant difference among the varieties and years but not in case of interaction between varieties and years.

Mean hundred berry weight was significantly maximum in Italia (414.21 g) which was superior over others and was followed by Thompson Seedless (323.13 g) which was superior to rest of the varieties. The next best variety was Gulabi (281.21 g) which was at par with Bangalore Blue (275.56 g). Significantly minimum hundred berry weight was recorded with Pusa Navrang (123.19 g) preceded by Cabernet Sauvignon (135.21 g) and both were at par. Rest of the varieties recorded hundred berry weight ranging from 198.51 to 251.38 g.

The effect of years on hundred berry weight was significant. However, mean hundred berry weight in year 2006-07 (245.28 g) was greater than that of 2007-08 (230.69 g). During the first year, Italia (424.70 g) recorded maximum hundred berry weight followed by Thompson Seedless (336.16 g). The weight of hundred berries was least with Pusa Navrang (126.33 g) and Cabernet Sauvignon (144.83 g). Similar results were also recorded with respect to hundred berry weight in the second year of the investigation.

The interaction effect of varieties and the years found to be non significant. Regardless of the years, the variety Italia registered highest hundred berry weight followed by Thompson Seedless and minimum in the variety Pusa Navrang.

4.1.14. Berry diameter (mm)

The data on diameter of the berries are furnished in Table- 4.14. The different treatments *viz.*, varieties, years and their interaction significantly influenced the diameter of the berry.

The perusal of pooled data indicate that berry diameter has shown significant variations among the different varieties. Significantly maximum diameter of berries was recorded in Italia (17.93 mm) closely followed Gulabi (16.51 mm) which fall in same order and superior to other cultivars. Next in line was Zinfandel (15.28 mm) which was on par with Ruby Red (15.21 mm). Minimum berry diameter was recorded in Pusa Navrang (10.75 mm), closely preceded by Shiraz (11.63 mm), Chenin Blanc (12.15 mm), and Sauvignon Blanc (12.23 mm) and were at par with each other. The rest of the varieties produced medium sized berries varying from 13.24 to 14.03 mm in diameter.

Significant difference was noticed with respect to diameter of berry between the years. However, the size of the berry was less in 2007-08 than that in 2006-07. Except in case of Shiraz and Athens in all other cases the size of the berry was less in the second year.

In the first year, berry diameter varied from 11.40 mm to 18.40 mm. Highest diameter of berries was recorded by Italia (18.40 mm) followed by Gulabi (17.16 mm) which were in same order. Whereas smallest berries were produced by Pusa Navrang (11.40 mm) preceded by Shiraz (11.53 mm), Chenin Blanc (12.70 mm) and all these fall in the same order.

In the second year, almost similar trend of berry diameter was observed particularly varieties producing diameter of berries. Berries of Cv. Italia produced maximum berry diameter (17.47 mm) and was superior over others but was on par

with Gulabi (15.86 mm). However, this year smallest berries were produced by Pusa Navrang (10.10 mm) preceded by Sauvignon Blanc (11.13 mm).

The interaction effect of varieties and years on berry diameter found to be significant. Irrespective of the years, the variety Italia recorded higher diameter of berry followed by the variety Gulabi whereas Cv. Pusa Navrang recorded least diameter.

Berry characteristics include number of berries, hundred berry weight and diameter of berry which varies according to the variety and appears to be a varietal character, nevertheless it is influenced by environmental as well as nutritional factors.

In the present study, number of berries ranged from a minimum of 31.73 in Gulabi to a maximum of 87.16 in Pusa Navrang cultivar respectively. The difference in the number of berries per bunch may be attributed to the difference in the size of the berry and diameter of the berry. These results are in agreement with the findings of Kadu *et al.*(2007)and Ratnacharyulu (2010).

Hundred berry weight is also an important yield trait which also varies according to the variety. It was found to range from 123.19 to 414.21 g in different cultivars studied in the present experiment. Based on the hundred berry weight, the varieties can be classified as those having highest berry weight (Italia, Thompson Seedless, Gulabi Bangalore Blue and Athens) and lowest (Pusa Navrang, Cabernet Sauvignon, Shiraz and Chenin Blanc) while the remaining varieties (Symphony, Sauvignon Blanc, Zinfandel and Ruby Red) fall in medium berry weight. The variation in the berry weight might be due to variation in the diameter of the berries and also due to number of berries per bunch. Wide range of hundred berry weight was reported by several workers , 45 to 398 g (Daulta *et al.*, 1972); 104 to 275 g (Ramkumar *et al.*, 2002); 106 to 403 (Ratnacharyulu, 2010); 110 to 160 g (Richard *et al.*, 1999); 130 to 480 g (Thakur *et al.*, 2008); 150 to 300 g (Ghosh *et al.*, 2008);198 to 269 g (Masoodi *et al.*, 1991); 208 to 755 g (Sharma *et al.*,1993). The values of the present study were in confirmity with the above findings

In the present study, diameter of the berry varied widely among the varieties from 10.75 mm to 17.93 mm. The variety Pusa Navrang recorded minimum diameter of berry while the variety Italia showed maximum, this may be attributed to presence of more number of berries in the former than the latter. Several workers reported a wide range of berry diameter ranging from 10 mm (Cabernet Sauvignon) to 19 mm (Bangalore Purple) Kadu *et al.* (2007); 10.0 mm (Ruby Red) to 20.7 mm (Cardinal) reported by (Thakur *et al.*, 2008). The results are in agreement with the reports of Richard *et al.* (1999); Ratnacharyulu (2010) etc.

4.1.15. Fruit yield (kg/vine)

The quantity of value added products from the crop and economic returns largely depend on fruit yields. It is customary to record yields in varietal trials and compare them for the ultimate evaluation and selection of high yielder. Yields not only depend on varieties, but also on several other factors, besides prevailing agro-climatic condition, where the crop is raised. With this view, yields of different grape cultivars were recorded during both the years of trial and the recorded data on this parameter were furnished in Table-4.15.

The statistical analysis of the data in the Table indicated significant variations among the varieties and years and a non significant influence of interaction on fruit yield.

The perusal of pooled data indicates that maximum fruit yield was recorded with the variety Chenin Blanc (16.81 kg/vine) followed by Italia (13.53 kg/vine) and Shiraz (13.48 kg/vine) which were at par. The latter was followed by Thompson Seedless (11.53 kg/vine) which was however, comparable to Pusa Navrang (10.78 kg/vine). On the other hand, minimum fruit yield was observed in the variety Sauvignon Blanc (4.51 kg/vine) comparable with Gulabi (4.94 kg/vine). Rest of the varieties were in the range from 6.03 to 9.91 kg/ vine.

Significant difference was noticed with respect to fruit yield in both the years. When the mean yields of both years are compared, it was observed that mean yield showed significant increase in the second year over the first year.

During the first year, the yield difference among the varieties was significant. In this year Chenin Blanc (15.23 kg/vine) recorded significantly highest yield but was at par with cultivars like Shiraz (12.80kg/vine) and Italia (12.50 kg/vine). Minimum yield was recorded in case of Sauvignon Blanc (4.38 kg/vine) closely preceded by Gulabi (4.53 kg/vine) with which it was at par. The yields of the remaining cultivars were intermediate.

During the second year also significantly highest yields were contributed by Chenin Blanc (18.40 kg/vine) followed by Italia (14.56 kg/vine) and Shiraz (14.16 kg/vine) and were at par. The lowest yield was observed with Sauvignon Blanc (4.64 kg/vine) preceded by Gulabi (5.36 kg/vine).

Interaction between varieties and years showed non significant influence. However, irrespective of the years, the variety Chenin Blanc recorded highest yield per vine while the variety Sauvignon Blanc showed the lowest yield.

The ultimate goal of any grower is the yield, which is the most important factor from commercial point of view. Yield is variable among the different varieties of a crop and is inherent. However, it depends on the age of the plant, nutrition, cultural practices adopted, on pest and disease incidence and finally place of cultivation *i.e.*, climate of the area. Yield also varies from year to year in the same variety and also when grown at different locations. These facts have been brought about clearly in the present investigation. Wide range of yield among different varieties of grape screened at different location has been reported from India and abroad (Daulta *et al.*, 1972; Thatai *et al.*, 1987; Kadu, 2002; Ramkumar *et al.*, 2002; Ghosh *et al.*, 2008; Shellie, 2007; Karibasappa and Adsule, 2008; Havinal *et al.*, 2008 and Ratnacharyulu, 2010) which support the results of the present study at Hyderabad. The difference in the yield per vine in different grape cultivars might be due to differences in weight of the bunch, number of bunches, weight of the berries and age of the vines besides their successful adoption to the varying agro-climatic conditions under which they are cultivated (Thatai *et al.*, 1987; Havinal *et al.*, 2008).

In the present investigation the yield ranged from 4.51 to 16.81 kg/vine. The variety Chenin Blanc recorded maximum while Sauvignon Blanc showed the minimum yield. Based on this, varieties can be classified as high yielders ranging from 16.81 to 10.78 kg/vine (Chenin Blanc, Italia, Shiraz, Thompson Seedless and Pusa Navrang) ; medium yielders ranging from 9.91 to 7.31 kg/vine (Zinfandel, Athens, Cabernet Sauvignon and Symphony); and low yielders ranging from 6.74 to 4.51 kg/vine (Ruby Red ,Bangalore Blue, Gulabi and Sauvignon Blanc). Pusa Navrang yielded 21.5 kg/vine at Lucknow whereas at Hyderabad it yield 10.78 kg/vine. This difference may be due to variation in the climate of both places. Lucknow comes under sub-tropical zone whereas Hyderabad comes under semi-arid tropical zone. Ghosh *et al.*, 2008 from West Bengal reported Pusa Navrang as highest yielder (12.2 kg/vine) among the eight grape cultivars screened.

Thus it is clear that the prevailing climate of the location has a substantial bearing on yield. Yearly effect on yield is also effective, a little higher yield was recorded with second year of study irrespective of the variety. The yield potential of a grape variety is inherent subject to adoption to varying agro-climatic conditions of different locations.

4.1.16. Heat unit requirement

Optimum stage of maturity of fruits is an important factor that influences the quality of wine. The stage of maturity can be judged by heat summation, besides others like days for bud burst and days for anthesis, colour of the stem, transparency of the berries and TSS etc. Hence, heat unit requirement for maturity in different cultivars was worked out based on the base temperature of grape under semi arid conditions of Hyderabad and were presented in Table-4.16.

The results in the table indicated that significant influence of the variety, years and interactions on the heat unit requirement. The pooled data implies that Italia required maximum number of heat units (2207.46 degree days) closely followed by Ruby Red (2119.96 degree days). Italia however was statistically

superior to other cultivars except Ruby Red with which it was at par. The latter was comparable with Thompson Seedless (2040.16 degree days) and Cabernet Sauvignon (2031.64 degree days). Minimum number of heat units were required by Pusa Navrang (1726.24 degree days) closely preceded by Chenin Blanc (1764.11 degree days), Bangalore Blue (1815.79 degree days), Symphony (1816.30 degree days) and all fell in the same order. The rest of the cultivars recorded intermediate values ranging from 1859.70 to 1989.72 degree days respectively.

Years also had influenced the heat unit requirement of different grape cultivars. However, there was less requirement of heat units in the first year than in second year. In the first year of study, Ruby Red recorded higher number of heat units (1984.23 degree days) followed by Italia (1969.73 degree days) while lowest was noticed in Pusa Navrang (1720.36 degree days). During the second year, Italia registered maximum heat units (2445.20 degree days) followed by Ruby Red (2255.70 degree days) and minimum was recorded by the variety Pusa Navrang (1732.13 degree days).

Interaction effect on the heat unit requirement was significant. The Cv. Pusa Navrang recorded minimum number of heat units in both the years while Ruby Red in the first year and Italia during the second year recorded higher heat units.

Plant growth and development is proportional to the biological time or thermal time, which can be defined as the integral part of the product of the time and temperature above a threshold level. The concept of heat units is simply to predict phenological stages and has been used to forecast the main stages of plant development.

Varieties exhibit inherent differences in their heat unit requirement. Each variety has a specific heat summation requirement which however, varies under the influence of place of cultivation and time. This has been observed to be true in the present study.

According to Bammi (1968) most of the grape growing areas in India received heat units of 4000 to 4800 degree days in grape from the start of growth to

maturity of berries. The requirements of heat units also differed with earliness or lateness of the variety. Makhija *et al.*, (1984) observed that early maturing varieties (Pearl of Csaba) required 1600 degree days, mid season variety (Black Muscat) required 2080 degree days and late season variety (Alam Wick) required 2250 degree days under Delhi conditions and concluded that early maturing varieties required less heat units than the late maturing varieties. Similar observations were made by Thakur *et al.*, 2008.

The requirement of heat units differs from place to place for the same variety. Bangalore Blue required 3562 degree days to attain maturity at Coimbatore (Palaniswamy *et al.*, 1965) whereas it required 1815.79 heat units at Hyderabad in the present study. The heat unit requirement in case of Italia varied from 1727-1840 degree days in different months over a base temperature of 12°C in Brazil (Murakami *et al.*, 2002). In Egypt, Thompson Seedless required 8566 and 12591 heat units for the start and the end of the bud break whereas it required 2040.16 heat units in the present investigation at Hyderabad.

In the present study, heat unit requirement in different cultivars of grape varied from 1726.24 to 2207.46 degree days having recorded maximum by the variety Italia and minimum by the variety Pusa Navrang respectively. Based on this data, varieties can be classified as early maturing (Pusa Navrang, Chenin Blanc, Symphony and Sauvignon Blanc), mid maturing (Gulabi, Bangalore Blue, Shiraz and Zinfandel) while late maturing varieties (Cabernet Sauvignon, Athens, Thompson Seedless, Ruby Red and Italia). The variation in heat unit requirements among the different grape varieties was attributed to the variation in the date of maturity (Thakur *et al.*, 2008). The variation in the heat unit requirement with the variation in the date of maturity was also reported in Ber (Singh *et al.*, 1998); Mango (Shinde *et al.*, 2001) and Litchi (Rai *et al.*, 2002).

Several scientists have reported wide range of heat units from 1600 to 2250 degree days (Makhija *et al.*, 1984); 890.1 to 1491.7 degree days (Thakur *et al.*, 2008). Different cultivars require different heat unit requirement *viz.*, 3562 degee

days in Bangalore Blue (Palaniswamy *et al.*, 1965); 2000 degree days in Thompson Seedless and 3284 degree days in Gulabi (Rameshwar, 1993) 1295 degree days in Cabernet Sauvignon (Santos *et al.*, 2007). The results are in accordance with the above findings.

Experiment-II Wine Production from different coloured and white varieties of Grape

Physico Chemical Properties of Juice

Wine is prepared from grape juice. Hence it is necessary to know the physico-chemical characters of the juice. Further, for wine making, specific chemical parameters requirements are essential. Different types of wines have different values of TSS, acidity and pH. Hence it is a pre requisite to analyse the bio-chemical properties of juice and wine.

4.2.1. Juice Recovery (%)

The quantity of the wine is directly related to the juice recovery from the berries, hence it becomes necessary to have the information about juice recovery percent from different cultivars of grape to assess their suitability in wine making. With this objective in view, data was collected on juice recovery percentage and are presented in Table- 4.17.

Statistical analysis of the data indicated significant variation among the varieties while the influence of years and interaction was non significant.

The perusal of pooled data indicates that maximum mean juice recovery was observed in the Cv. Chenin Blanc (78.38 %), closely followed by Cv. Pusa Navrang (77.75 %), and both were in the same order. The latter was on par with Shiraz (74.80 %) which in turn was comparable with Sauvignon Blanc (72.49%) and Cabernet Sauvignon (72.36%). Minimum mean juice recovery was recorded in cultivar Gulabi (54.26%) preceded by variety Italia (56.33%) and both were in the same order. But the juice recovery percent was moderate in some cultivars *viz.*, Sauvignon Blanc, Cabernet Sauvignon, Thompson Seedless, Symphony and Zinfandel.

With respect to the years, there was no significant difference between the two years of study. However, during the first year of trial, Chenin Blanc (80.43%) showed maximum juice recovery followed by Pusa Navrang (79.90%) whereas minimum recovery was observed with Gulabi (55.53 %). Similar trend was noticed with respect to juice recovery during second year also.

The interaction between varieties and years was found to be non significant.

The ultimate quantity of wine depends largely on the amount of juice recovered from the berries. The quantity of juice recovery from the berries in turn depends on pulpiness (Selvaraj *et al.*, 1975; Jindal, 1990), size and seediness of berries (Selvaraj *et al.*, 1975).

Patil *et al.*, (2007) observed higher juice recovery in white grapes than in red varieties, which was in line with the observations of the present study wherein the white varieties yielded higher juice recovery except Italia. Among the coloured varieties, Pusa Navrang yielded maximum juice recovery followed by Shiraz and Gulabi yielded minimum juice recovery while in case of white varieties Chenin Blanc recorded highest juice recovery percent while Italia registered least.

These results are in agreement with the findings of several researchers in different grape cultivars *viz.*, 75.56 % in Cabernet Sauvignon and 60.55 % in Thompson Seedless (Pawar, 2002); 76.00 % in Pusa Navrang and 62.67 % in Ruby Red (Ratnacharyulu, 2010).

4.2.2. Total soluble solids in juice (°B)

The important constituent of wine is ethyl alcohol, a product of fermentation of sugars of fruit juice. Therefore, sugars are essential in adequate quantities in fruit juice for fermentation and also for production of quality wine. TSS forms a guide for producing different types of wines besides, the need for amelioration of fruit juice in order to have optimum content for wine making. In this context it becomes pre-requisite to measure the content of sugars, which are generally expressed as Total Soluble Solids (TSS) in Brix. TSS of the juice

measured in different grape cultivars included in the study were furnished in the Table-4.18.

Perusal of the data indicates that mean maximum TSS was recorded in Cv. Shiraz (21.95 °B) which was highly significant and superior over the rest of the cultivars. This was followed by Cabernet Sauvignon (18.91°B), Chenin Blanc (18.81°B), which were in the same order. Minimum mean TSS content was observed in Italia (15.43 °B) closely preceded by Gulabi (15.63 °B) and Symphony (16.06 °B) and all were on par with each other. However, the cultivars Ruby Red (16.91°B), Thompson Seedless (16.95°B), Bangalore Blue (17.01°B), Pusa Navrang (17.16°B), Athens (17.21°B) and Sauvignon Blanc (17.50°B) did not differ statistically.

With regard to the years, the mean TSS content was significantly less in 2007-08 (17.05 °B) than that in 2006-07 (17.97°B). In 2006-07, Cv. Shiraz showed highest TSS content (22.30 °B) and was superior over others. This was followed by Chenin Blanc (19.50 °B), Cabernet Sauvignon (19.06 °B) and Zinfandel (18.70 °B) which were at par with each other. Minimum TSS content was recorded by Italia (15.66 °B) preceded by Gulabi (16.06 °B) and Symphony (16.46 °B) and all were statistically in same order. The rest of the cultivars showed intermediate values and were non significant.

Similar to 2006-07, in the year 2007-08, Shiraz showed highest TSS (21.60 °B) and was superior over others. This was followed by Cabernet Sauvignon (18.76 °B), Chenin Blanc (18.16°B) which were superior over the rest of the cultivars. Whereas, Italia showed minimum TSS of 15.20 °B, closely preceded by Gulabi (15.20°B) and Symphony(15.66°B) and were at par. The rest of the cultivars showed intermediate TSS values ranging from 16.20 (Athens) to 17.63°B (Zinfandel).

The interaction effect of cultivars and years was also significant. In both the years, Cv. Shiraz recorded maximum value of TSS (22.30°B and 21.60°B) while

Italia (15.66°B) in 2006-07 and Gulabi (15.20°B) in the second year showed minimum TSS content and were in the same order.

TSS is an important substrate for getting quality wine. According to Ethiraj and Suresh (1987), TSS range of 19.5 -23.0 °B and 20.5-23.5 °B is optimum for making white and red table wines respectively. According to the above specification none of the white or coloured varieties screened are suitable for making wine, except Shiraz which recorded 21.95 °B TSS in coloured varieties. The low TSS in the varieties tested may be due to the cooler temperatures, during berry development. The cool temperatures were reported to reduce the sugar levels in berries (Karibasappa *et al.*, 2006). On the contrary, hot conditions during ripening period increases the sugar levels in grape.

Variation in TSS among the varieties was reported earlier (Selvaraj *et al.*, 1975; Suresh *et al.*, 1985; Chikkasubbanna *et al.*, 1990; Singh, 1995; Gaurav *et al.*, 2000; Patil *et al.*, 2007; Ghosh *et al.*, 2008; Havinal *et al.*, 2008; Karibasappa and Adsule, 2008). In the present study Shiraz has recorded highest TSS (21.95°B) among the coloured varieties and Chenin Blanc in white varieties (18.81°B). Karibasappa and Adsule (2008) reported 18.5°B TSS in Chenin Blanc from Pune, which supports the results of present study. TSS recorded in case of Cabernet Sauvignon (18.91°B) which was less than that (22.6°B) reported by Havinal *et al.*, (2008) from Maharashtra may be due to the difference in prevailing climatic conditions between the two places. The differences in TSS in different grape cultivars may also be due to difference in maturity period and heat unit requirement (Masoodi *et al.*, 1991; Singh, 1995; Havinal *et al.*, 2008).

TSS content of grapes grown in different parts of the country varies considerably. For example 'Thompson Seedless' grapes grown in states of Andhra Pradesh, Karnataka and Maharashtra were higher brix (> 20 °B) whereas the same variety grown in Haryana, Punjab and Tamil Nadu have less brix (12.15°B). Grapes with low TSS are not preferred for wine making.

4.2.3. Titrable acidity of juice (%)

Organic acids (tartaric, malic and citric acids etc) determine the total titrable acidity and play an important role in evaluating the sensory properties of wine, particularly the tartness, colour and keeping quality. The mean values of titrable acidity in different cultivars during both season (2006-07 and 2007-08) were presented in Table-4.19 and the results are described below.

A perusal of the data presented in the Table indicates that among the different cultivars screened, Chenin Blanc showed mean maximum titrable acidity (0.92%) in juice and was significantly superior over the rest of the cultivars. It was followed by Bangalore Blue (0.84%) and Italia (0.80%) and both were statistically in same order. Mean minimum titrable acidity (0.51%) was observed by Ruby Red, which statistically differed from other cultivars. This was preceded by Thompson Seedless (0.59%), Cabernet Sauvignon (0.60 %), Symphony (0.62 %) and Gulabi (0.66%) which did not differ from each other statistically. The rest of the cultivars recorded titrable acidity in the range of 0.67 % in Zinfandel to 0.76% in Shiraz.

Years have also exerted significant influence on titrable acidity in grape juice, but the difference between the yearly means was not impressive, though there was statistical difference between the two. Titrable acidity was slightly more (0.72%) in the second year than in the first year (0.68 %).

During 2006-07, maximum titrable acidity was observed in Chenin Blanc (0.91%) closely followed by Bangalore Blue (0.82%) and Italia (0.80 %) and all the three were in same order. Minimum titrable acidity was noticed in Ruby Red (0.48%) closely preceded by Thompson Seedless (0.55%), Cabernet Sauvignon (0.58 %) and Symphony (0.60%) and were in same order. The rest of the cultivars recorded values of titrable acidity between these two extremes.

Similar trend was noticed during 2007-08. Maximum titrable acidity was recorded in Chenin Blanc (0.93%), a slight increase over the previous year. It was

closely followed by Bangalore Blue (0.86%) and Italia (0.81%). Minimum titrable acidity was recorded in Ruby Red (0.54%) closely followed by Cabernet Sauvignon (0.62%), Thompson Seedless (0.64%) and Symphony (0.65%) and all these cultivars were statistically at par. Intermediate values for titrable acidity were observed in rest of the cultivars.

The influence of interaction of varieties and years was also significant. In both years Chenin Blanc showed maximum titrable acidity (0.91% and 0.93%), while Ruby Red showed minimum titrable acidity (0.48% and 0.54%).

Acidity of grape berries is one of the criteria that determines the suitability of a grape variety for wine making, as the flavour of the wine depends upon the optimum acidity of the grapes (Ethiraj and Suresh, 1978). Further, requirement of acidity in juice varies for different types of wines. Bammi (1968) stated that dry table wines require high acidity of 0.6 to 0.9%, while sweet dessert wines require 0.5 to 0.6 % acidity. High or low acid grapes are not suitable for wine making (Ethiraj and Suresh, 1978). As per the above norms, almost all the varieties of the present study are suitable for making dry table wines except Ruby Red, Thompson Seedless and Cabernet sauvignon which are suitable for sweet dessert wines.

The acidity ranged from 0.51% in Ruby Red to 0.84% in Bangalore Blue among the coloured varieties and 0.59% in Thompson Seedless to 0.92 % in Chenin Blanc among the white varieties. Thakur *et al.* (2008) reported highest total acidity in Ruby Red (1.45%) which was much higher than in the present investigation. The content of acidity seems to be affected by the prevailing temperature during the development and ripening of berries. Cool and mild temperature increases the production of acids particularly malic and tartaric acids, while hot conditions lowers the acid level in grapes (Karibasappa *et al.*, 2006). Higher levels of acidity was recorded in all the varieties during the year 2007-08 as compared to 2006-07. This might have been due to the lower temperatures prevailing during that period at Hyderabad.

4.2.4. pH of grape juice

The pH of the grape juice depends on the variety, season etc. It is required for the growth and development of yeast and affects colour, taste and appearance of wine. The data pertaining to pH of juice were presented in the Table- 4.20. It is obvious from the data that varieties showed significant influence while years and interactions did not exhibit any significant influence on the pH of the grape juice.

Among the different cultivars tested, for their growth performance and suitability for wine making, cultivar Athens registered highest pH of 3.53 and was closely followed by Thompson Seedless (3.51), Sauvignon Blanc (3.48), Symphony (3.48), Zinfandel (3.46), Cabernet Sauvignon (3.46) and Gulabi (3.45) which were statistically in the same order. Minimum pH was registered in Italia (2.96) which was statistically different from other cultivars and was preceded by Bangalore Blue (3.03) and Pusa Navrang (3.03) with which it was at par.

The yearly effect was not significant. In the first year, however highest pH (3.60) in the juice was recorded by Athens and minimum pH was shown by Bangalore Blue (2.96). In the second year, Chenin Blanc had maximum pH of 3.56 and Italia had recorded minimum pH of 2.93. The pH of juice in the rest of the cultivars ranged from 3.00 to 3.56 in 2006-07 and 2.96 to 3.56 in 2007-08.

With regard to interaction between the varieties and years, the effect was found to be non significant.

pH of the grape juice plays an important role in the occurrence of malolactic fermentation, prevention of microbial spoilage, stability of soluble proteins, solubility of potassium bi-tartrate and calcium tartarate and colour stability in (red) wine (Morries *et al.*, 1984). pH is very important factor in the biological process of fermentation and is responsible for retention of flavouring substances in wine.

For good wine stability, Morris *et al.*(1984) prescribed an upper limit of pH as 3.4 and 3.5 for white and red wines respectively. A pH of 3.3 and 3.4 in grapes was suggested as optimum for making white and red table wines respectively (Ram Srinivas *et al.*, 1998). A pH greater than 3.6 makes wine unstable (Amerine and Ough, 1980). Wines made from low pH grapes will be inferior in quality (flabby) and those from high pH will be tart and metallic (Mullins *et al.*, 1992).

Vyas and Gandhi (1971) and Sharma (1997) reported range of pH from 3.2 to 3.5 respectively in various grape varieties under sub tropical conditions of North India. Selvaraj *et al.*, (1975) reported pH range of 3.2 to 3.7 in different cultivars from Tropical Bangalore. pH ranged from 3.07 to 4.95 in different wine grape cultivars from Pune (Karibasappa and Adsule, 2008). In the present study, pH ranged from 3.03 (Bangalore Blue and Pusa Navrang) to 3.53 (Athens) among coloured varieties while from 2.96 (Italia) to 3.51 (Thompson Seedless) among the white varieties.

According to the pH norms prescribed by Ram Srinivas *et al.*(1998), almost all the varieties screened are suitable for making wines except Italia.

4.2.5. Total sugar content of juice (%)

The data recorded on total sugar content of juice as furnished in Table-4.21. indicated that the experiment was significant in respect of varieties, years and their interaction.

Irrespective of the years, the varieties exhibited significant differences in total sugars in juice. Highest total sugar content was observed in Shiraz (19.28 %) closely followed by Chenin Blanc (19.07%) which were at par. Next in line was Pusa Navrang (18.21%) and was at par with Cabernet Sauvignon (17.89 %). On the other hand, Cv. Italia had minimum total sugar content (13.14%) closely preceded by Gulabi (15.37%) and Bangalore Blue (15.45%), the latter two were at par.

With respect to the years, the mean total sugar content was significantly less (16.31%) in 2007-08, than that of 2006-07 (17.08%). In 2006-07, Cv.Shiraz

showed highest total sugar content (19.79%) and was superior to other cultivars. This was followed by Chenin Blanc (19.49%) and Pusa Navrang (19.21 %). Minimum total sugar content was observed in Italia (13.72%) preceded by Bangalore Blue (15.52%) and Gulabi (15.57 %) and all were statistically in same order. The rest of the cultivars recorded intermediate values.

Similar trend was observed in the year 2007-08. Maximum sugar content (18.78%) was recorded in Shiraz followed by Chenin Blanc (18.66%) and minimum was observed in Italia (12.57%) and Gulabi (15.18%) respectively. The Cvs.Cabernet Sauvignon (17.43%), Pusa Navrang (17.22%), and Zinfandel (17.09%) were the next, showing maximum total sugar content and were in same order but superior to other cultivars.

The interaction between varieties and years showed significant influence. Shiraz recorded highest total sugar content in juice (19.79% and 18.78%) while Italia (13.72 % and 12.57%) recorded least content in both the years.

4.2.6. Reducing sugar content of juice (%)

Significant influence of varieties, years and their interaction was observed as per statistical analysis of the data on reducing sugars of juice in different grape cultivars (Table- 4.22).

The mean data of varieties, irrespective of the years has indicated that the reducing sugars content varied significantly among the cultivars. Maximum reducing sugar content of 15.38 % was recorded in Shiraz which was closely followed by Chenin Blanc (15.21%) and both were in the same order but superior over other cultivars. Next was Cabernet Sauvignon (14.27%) which was at par with Zinfandel (13.79%). The reducing sugar content was least in Pusa Navrang (7.84 %) preceded by Italia (10.48%), Gulabi (12.26%) and Ruby Red (12.64 %) and all these differed significantly with each other. The remaining cultivars recorded intermediate values ranging from 12.69 % to 13.43 %.

The reducing sugar content was significantly differed between the years. However, reducing sugar content of the juice without reference to the cultivars showed slight decrease from the first year (13.14%) to second year (12.58%).

When the individual years were taken into account, it was observed that in the year 2006-07, maximum reducing sugar content was recorded in cultivar Shiraz (15.78%) which was at par with Chenin Blanc (15.54%) and both were superior to other cultivars. Minimum reducing sugar content (8.27%) was observed in Pusa Navrang preceded by Italia (10.94%). The rest of the cultivars recorded intermediate values ranging from 12.42% in Gulabi to 14.64% in Cabernet Sauvignon.

In the second year of the trial, Shiraz (14.98%) recorded higher reducing sugar content and was statistically in same order with Chenin Blanc (14.88%) but significantly superior to the rest. Cabernet Sauvignon (13.90 %), Zinfandel (13.63%) and Bangalore Blue (13.00%) were in same order but differed statistically with the above cultivars. Pusa Navrang showed consistency in producing lowest content (7.41%) this year also and was in same order with Italia (10.02 %).

Interaction between the varieties and years showed significant influence. Cv. Shiraz had higher reducing sugar content while Pusa Navrang recorded minimum content in both the years.

The predominant reducing sugars present in grapes are glucose and fructose, accounting for about 99% of the total carbohydrates in grape juice. Other sugars present are sucrose, raffinose, stachyose, maltose and galactose (Jindal, 1990). In the present study, reducing sugars in juice in different cultivars ranged from 7.84% to 15.38% with minimum in the variety Pusa Navrang and maximum in Shiraz. Interestingly, Pusa Navrang though having higher total sugar content (18.21%) recorded least content of reducing sugars (7.84%), attributable to the inherent varietal character.

A large variation in the content of total and reducing sugars of grape was reported earlier, 10.94% to 27.00% and 9.10 % to 22.20 % (Jindal, 1990; Masoodi *et al.*, 1991; Hristov, 1991; Mane, 1995), 15.80% to 24.15% and 14.15% to 23.80% (Sandhu *et al.*, 1988; Sharma *et al.*, 1993).

Physico chemical properties of wine

4.2.7. Total soluble solids of wine (⁰B)

The data recorded on total soluble solids of wine both before and after aging in different grape cultivars during 2006-07 and 2007-08 were presented in Table- 4.23.

Total soluble solids of wine before aging (⁰B)

With respect to the TSS of wine before aging, among all the varieties, Italia has recorded highest TSS content (10.93⁰B) followed by Cv.Ruby Red (10.33⁰B) and Gulabi (10.33⁰B) both were in the same order and lowest TSS was recorded by Cv. Shiraz (7.93⁰B) which was on par with Chenin Blanc (8.19⁰B). The latter was preceded by Cabernet Sauvignon (8.56⁰B) and Pusa Navrang (8.84⁰B) and both differed statistically with each other, while others recorded intermediate values ranging from 8.99⁰B to 9.76⁰B.

Significant difference was observed between the years with respect to TSS of wine before aging. Mean TSS content was higher (9.57⁰B) in 2007-08, than that of 2006-07 (9.27⁰B). During the first year of study, maximum TSS was observed in the variety Italia (10.80⁰B) followed by Ruby Red (10.26⁰B) while minimum was noticed by the variety Shiraz (7.08⁰B) which was at par with Chenin Blanc (8.06⁰B). Unlike in the first year, during second year, Cv. Italia recorded highest TSS content (11.06⁰B) followed by Gulabi (10.46⁰B) while lowest was registered by Shiraz (8.06⁰B) preceded by Chenin Blanc (8.33⁰B).

Interaction between varieties and years was found to be significant. Cultivar Italia registered highest TSS in wine while least was recorded by Shiraz in both the years.

Total soluble solids of wine after aging (⁰B)

With regard to TSS of wine after aging, significant variations was observed among the cultivars and years. The pooled data indicates that Cv.Shiraz (6.88 ⁰B) recorded lowest TSS and was closely preceeded by Chenin Blanc (7.10 ⁰B) and Cabernet Sauvignon (7.45 ⁰B) which differed statistically with each other. TSS content was highest in case of Italia (10.01 ⁰B) followed by Ruby Red (9.33⁰B) and both were independent to each other. All the other cultivars showed intermediate values for TSS between Shiraz and Ruby Red.

Significant difference between the years in respect to TSS of wine after aging also observed. However, when the means of the years were considered, TSS content was lower (8.20 ⁰B) in 2006-07 than that of 2007-08 (8.50 ⁰B). During the year 2006-07, maximum TSS in wine was registered with Italia (9.93⁰B) followed by Ruby Red (9.13⁰B) and Sauvignon Blanc (9.13⁰B) while minimum was noted in Shiraz (6.83⁰B). Similar trend was observed in the results of the second year trial.

The interaction between years and cultivars was significant. Cultivar Shiraz showed minimum TSS content in wine (6.83⁰B & 6.93⁰B) while maximum with Italia (9.93⁰B and 10.10⁰B).

Total soluble solids is an important factor in making quality wine. The final TSS of wines depends upon the utilization of sugars by the yeast cells. Reduction in the TSS is an indicator for the completion of fermentation process. The sugars are metabolized to obtain energy. The ethanol and CO₂ are the bye products of yeast fermentation. A complete utilization of sugar during fermentation is desirable to obtain higher alcohol level in the final wine product. It can be judged by a large decrease or even complete disappearance of TSS in final wine product. The decrease in TSS in initial stage is attributed to the higher fermentability of juice which may be due to more availability of sugar in the initial stage (Nishino *et al.*, 1985). Thus a maximum reduction in TSS is favourable for quality wine preparation (Pawar, 2002). Similar findings were earlier reported by Othman *et al.*(1992) .

It was evident from the Table that TSS of wine in all the varieties found to decrease after fermentation process. This decrease in TSS of wine after fermentation process (*i.e* before aging) might be due to utilization of sugars by yeast for its growth and multiplication. Further, reduction in TSS of wine was observed after aging, this may be due to availability of insufficient sugars at the later stages of fermentation (Tritton, 1938).

In the present investigation, TSS of wine in different cultivars after aging ranged from 6.88 to 10.01^oB. Minimum TSS was registered with the variety Shiraz followed by Chenin Blanc and Cabernet Sauvignon while maximum was observed by the variety Italia. Hence it can be concluded that the varieties have shown significant variability in TSS content of wine, lower content might be due to utilization of more sugars for production of alcohol. A range of TSS from 9.65 to 11.34^oB and 9.60 to 10.00^oB in wine was reported earlier by Vikas Kumar (2010) and Shankar *et al.*, (2006). The results are in conformity with the findings of above workers.

4.2.8. Titrable acidity of wine (%)

Grape juice and wine contains mainly organic acids like tartaric, malic and citric acids. These acids play an important role on the quality of wines particularly the tartness, colour and keeping quality. The data on total titrable acidity of wine of different grape varieties under study were recorded for two years both before and after aging are presented in Table- 4.24. which indicate that the experiment was significant in respect of varieties and years while non significant in case of their interaction.

Titrable acidity of wine before aging

Significant variability was observed among the varieties and years with respect to the titrable acidity of wine before aging.

With respect to the varieties, the pooled data indicates that the cultivar Chenin Blanc had recorded maximum titrable acidity (0.85%) which was significantly superior to the other varieties and was followed by Bangalore Blue

(0.78%) and Italia (0.69 %). The latter was however, comparable with Shiraz (0.65%). Cultivars Athens (0.63 %), Pusa Navrang (0.60 %) and Gulabi (0.60%) were in the same order. On the other side, minimum titrable acidity was recorded in the variety Ruby Red (0.38 %) followed by Cabernet Sauvignon (0.46%) which in turn was on par with Sauvignon Blanc (0.49%), Symphony (0.50%) and Thompson Seedless (0.51%).

With respect to the years, mean titrable acidity recorded was higher in the second year (0.61%) than that of first year (0.56%). In the year 2006-07, maximum titrable acidity of wine was observed with the variety Chenin Blanc (0.81%) followed by the variety Bangalore Blue (0.78%) and Italia (0.67%), while minimum was recorded by the variety Ruby Red (0.30%) closely followed by the Cabernet Sauvignon (0.41%).

In the 2007-08 year, similar results were reported as that of the previous year. The variety Chenin Blanc recorded maximum titrable acidity (0.90%) followed by the variety Bangalore Blue (0.79%) and Italia (0.71%) where as minimum was noticed by the variety Ruby Red (0.46 %) followed by Cabernet Sauvignon (0.51 %) and Symphony (0.51 %).

The interaction effect of varieties and years was found to be non significant.

Titrable acidity of wine after aging

It is evident from the Table that titrable acidity of wine in all the cultivars found to decrease over aging. Significant variations were noticed among the varieties, years while it was non significant among the interactions.

Irrespective of the years, the varieties responded significantly with respect to titrable acidity content of wine. The perusal of pooled data reveals that titrable acidity of wine after aging was found to be maximum in the variety Chenin Blanc (0.79%) which was significantly superior over the rest of the varieties and was followed by the variety Bangalore Blue (0.69 %) and Italia (0.62 %) which were however in the same order. Minimum content of titrable acidity was found with the

variety Ruby Red (0.34%) which was comparable with the varieties *viz.*, Cabernet Sauvignon (0.40%), Sauvignon Blanc (0.42%), Thompson Seedless(0.43%) and Symphony(0.43%).

Yearly effect was significant. During the first year, maximum titrable acidity of wine was observed with the variety Chenin Blanc (0.76 %) followed by Bangalore Blue (0.67 %) while minimum was noticed by the variety Ruby Red (0.31%). Similar trend was also noticed in the second year of trial.

Acidity is an important attribute as it imparts taste and flavour to the wine besides protecting the wine from spoilage (Sim and Morris, 1984). The acids are important in maintaining pH low enough to inhibit the growth of many undesirable bacteria, thus giving advantage to wine yeasts. Bammi (1968) stated that dry table wines require high acidity of 0.6-0.9 percent while sweet dessert wines require 0.5-0.6 percent. It was reported that varieties with high acidity content in wines are suitable for dry table wine preparation and vice versa (Suresh *et al.*, 1983). A wide range of titrable acidity was reported by several workers 0.64 to 0.69 % (Patil, 1994), 0.31 to 0.65% (Suresh *et al.*, 1985).

The titrable acidity of wine showed decreased from that of the juice, this might be due to precipitation of tartaric acid as potassium acid tartarate during fermentation process. (Kundu *et al.*, 1980; Chikkasubbanna, 1982, Padshetty *et al.*, 1982; Sharma, 1987).

Amount of acidity differed between the years which may be due to the effect of variety and season (Rankine *et al.*,1971). Kliewer (1967) and Mattick *et al.*, (1972) observed that *Labrusca* types (eg. Bangalore Blue) showed relatively higher acidity as compared to *Vinifera* types. Aging has profound effect on the titrable acidity content in wines. It reduces the acidity content of wine. This significant decrease in titrable acidity content in wines after aging might be due to combining of acids with alcohols to form esters, adding aroma to the wines (Singh

Nagi and Manjrekar, 1976) or may be due to precipitation of potassium tartarate (Kundu *et al.*, 1980 and Padshetty *et al.*, 1982).

In the present study, titrable acidity of wine in different cultivars after aging ranged from 0.34 to 0.79 % with highest being recorded by the variety Chenin Blanc followed by Bangalore Blue and lowest in Ruby Red. Based on the titrable acidity content, varieties are categorized as wine with high acidity content (Chenin Blanc, Bangalore Blue, Italia and Athens); wine with medium acidity content (Pusa Navrang, Gulabi, Shiraz and Zinfandel) and with low acidity content in wines (Ruby Red, Cabernet Sauvignon, Sauvignon Blanc, Thompson Seedless, and Symphony). Hence it can be concluded that the varieties with high acidity range are suitable for the dry table wine preparation while those containing lower acidity content are suitable for sweet dessert wines production.

4.2.9. Volatile acidity of wine (%)

The results pertaining to the volatile acidity of wine in different varieties of grape before and after aging for the two years are presented in the Table- 4.25.

Volatile acidity of wine before aging

Significant variability was observed among the varieties while years and interaction showed non significant influence on this parameter.

With respect to the varieties, irrespective of the years, maximum volatile acidity was recorded with the variety Ruby Red (0.073%) which was significantly superior to the other varieties but at par with Gulabi (0.063%) and Bangalore Blue (0.061%), while minimum was observed in the variety Symphony (0.014%) which was comparable with the variety Chenin Blanc (0.015%) and Sauvignon Blanc (0.020%). Other varieties recorded volatile acidity between 0.029 to 0.055%.

Years have not shown significant influence on volatile acidity of wine in both the years of study. Volatile acidity content in wine was higher in the second year (0.042%) compared to first year (0.039%). In 2006-07, maximum volatile acidity was found with the variety Ruby Red (0.071%) followed by Gulabi

(0.062%) and Bangalore Blue (0.060%) while minimum was noticed by the variety Symphony (0.013%) which was comparable with Chenin Blanc (0.014%). Similar trend was noticed with respect to volatile acidity of wine before aging during the second year.

The interaction effect of varieties and years was non significant.

Volatile acidity of wine after aging

The volatile acidity of wine in all the cultivars decreased upon aging. Significant variability was observed among the varieties but non significant between the years of study and their interactions.

The perusal of pooled data indicates that significantly higher content of volatile acidity after aging was observed with the variety Ruby Red (0.065%) followed by Gulabi (0.055 %) and Bangalore Blue (0.053 %) and all these were at par with each other. The latter was however comparable with the variety Athens, Pusa Navrang, Cabernet Sauvignon and Zinfandel. On the other hand, minimum content was recorded with the cultivar Symphony (0.010%) which was at par with the variety Chenin Blanc (0.011%) Sauvignon Blanc (0.015%) and Thompson Seedless (0.023%).

During first year of trial, maximum volatile acidity was found with the variety Ruby Red followed by Gulabi and Athens while minimum was noticed by the variety Symphony preceded by Chenin Blanc. Similar results were recorded in the second year of trial.

The interaction effect of varieties and the years showed non significant influence.

Volatile acidity refers to the volatility of the acid with steam and is normally expressed in terms of acetic acid. It is a common practice to assess the volatile acid content of wine, as it is an indicator of the soundness of wine. Volatile acids in wine are acetic acid, butyric and propionic acid. The amount of acetic acid produced during alcoholic fermentation is usually less than 0.03 g/ml. The higher concentration indicates spoilage due to bacterial contamination. According to the

Indian standards for wine constituents, a wine should not contain volatile acidity as acetic acid more than 1g/litre of wine (Bhalerao, 2001).

In the present investigation, volatile acid content of wines in different varieties after aging varied widely from 0.010 to 0.065% .The values of volatile acidity of wine in all the varieties are found to lie within the standard limits. Among the varieties, Ruby Red recorded maximum volatile acidity followed by Gulabi while minimum volatile acidity was found with the variety Symphony and was found to be comparable with all the white varieties except Italia (as per the Indian Standards for wine constituents).

The significant decrease in volatile acidity of wine upon aging in all the varieties might be due to the formation of esters by the reaction of ethyl alcohol and volatile acids (Amerine *et al.*, 1972a). The outcome of the results is in accordance with the findings of Suresh *et al.*(1985), Flanzky *et al.*, (1987) and Kadu *et al.* (2007).

4.2.10. Total sugar content of wine (%)

The data on total sugar content of wine before and after aging in different grape cultivars for the two years are furnished in the Table- 4.26.

Total sugar content of wine before aging

Significant variation was observed among the varieties and years while it was non significant with respect to their interactions.

With respect to the varieties, the pooled data reveal that total sugar content of wine was significantly maximum in the variety Ruby Red (6.44%) which was superior over the rest of the varieties closely followed by Italia (6.33%) and both were in the same order. Next in line was Gulabi (5.55%) which was at par with Pusa Navrang (5.46%), Thompson Seedless (5.45%), Bangalore Blue (5.40%) and Athens (5.39%), while the lowest total sugar content in wine was registered by the variety Shiraz (4.37%) and was comparable with the variety Chenin Blanc (4.39%). Rest of the varieties showed a range between 4.78 to 5.33 %.

During the first year of trial, the variety Ruby Red recorded maximum total sugar content in wine, followed by Italia and Gulabi while minimum total sugar percent of wine was noticed with the variety Shiraz which was on par to Chenin Blanc. Unlike in the first year, during the second year, the variety Ruby Red recorded maximum total sugars in wine followed by the variety Italia whereas minimum total sugar percent of wine was noticed in the variety Shiraz followed by Chenin Blanc respectively.

The interaction effect of varieties and years was non significant.

Total Sugar content of wine after aging

Total sugar content of wine found to decrease in all the grape cultivars after aging irrespective of years. Significant variation was observed among the varieties and years while it was non significant with respect to the interactions.

The perusal of pooled data indicates that among the varieties tested, total sugar content of wine was maximum in the variety Italia (5.23%) which was superior over the rest of the varieties closely followed by Ruby Red (5.19%) and both were in the same order. Next in line was Gulabi (4.89%) which was at par with Pusa Navrang (4.86%). While the lowest total sugar content in wine was registered by the variety Cabernet Sauvignon (3.09%) closely preceded by Shiraz (3.18%) and Chenin Blanc (3.18%) which were in the same order. Rest of the varieties showed intermediate values ranging from 3.58 to 4.53%.

Significant effect was observed between the years. Mean total sugar content of wine was maximum in the second year *i.e.*, 2007-08 (4.20%) than that of the first year (4.00%). In the first year (2006-07), maximum content of total sugars was recorded by the variety Ruby Red (5.16%) followed by Italia (5.03%) and minimum content was observed with Cabernet Sauvignon (3.06%) preceded by Shiraz (3.10%). Rest of the varieties showed intermediated values between the two extremes. Similar trend was recorded in the second year of investigation.

Interaction effect between varieties and years was found to be non significant.

4.2.11. Reducing Sugar content of wine (%)

The results pertaining to the reducing sugar content of wine in different varieties of grape before and after aging for the two years were shown in the Table-4.27.

Reducing Sugar content of wine before aging

Significant variation was observed among the varieties and years with respect to the reducing sugar content of wine, while it was non significant with their interactions.

The perusal of pooled data indicates that maximum reducing sugar content was recorded by the variety Italia (4.89%) which was significantly superior to the other varieties and was followed by Thompson Seedless (4.21%). The latter was followed by Ruby Red (4.20%) Sauvignon Blanc (4.14%), Symphony (4.11%), Athens (4.11%) and Gulabi (4.11%), all of which fall in the same order. Shiraz recorded lower reducing sugar content (2.45%) preceded by Cabernet Sauvignon (2.75%) and Chenin Blanc (3.13%). Rest of the varieties recorded reducing sugar content in the range of 3.24% to 3.66%.

Significant variation was observed with respect to reducing sugar content between the years. However, mean reducing sugar content was higher during the second year (3.87%) than that of first year (3.58%). During the first year, maximum content of reducing sugar in wine was recorded with the variety Italia (4.46%) followed by Thompson Seedless (4.13%) and Sauvignon Blanc (4.13%) which were in same order, while minimum was noticed in the variety Shiraz (2.10%) preceded by Cabernet Sauvignon (2.40%). In the Second year of study, Italia showed highest content of reducing sugars (5.33%) followed by Thompson Seedless (4.30%) and Ruby Red (4.30%) while least content was shown by the variety Shiraz (2.80%) preceded by Cabernet Sauvignon (3.10%).

Interaction effect was found to be non significant.

Reducing sugar content of wine after aging

A decrease in the reducing sugar content of wine was observed in all the varieties upon aging. Significant variation was noticed among the varieties and years while interactions effect was non significant.

The pooled data shows that the cultivar Symphony (3.34%) recorded significantly maximum reducing sugar content in wine and was at par with Italia (3.33%), Sauvignon Blanc (3.30%) which were in the same order. Next in line was Ruby Red (3.13%) which was at par to Athens (3.03%). On the other side, lowest reducing sugar content was noticed in Cabernet Sauvignon (1.53%) closely preceded by Chenin Blanc (1.54%) and they were at par to each other. Rest of the varieties showed intermediate values ranging from 1.76 to 2.68%.

Yearly effect was also significant. Mean reducing sugar content was higher in the second year (2.65%) than that of first year (2.42%). In the first year, higher content of reducing sugars was observed with the variety Italia followed by Symphony, while lower content was noticed with the variety Cabernet Sauvignon which was on par to Shiraz and Chenin Blanc. In the second year, Sauvignon Blanc recorded maximum content of reducing sugars in wine followed by Symphony and minimum was observed in the variety Chenin Blanc preceded by Cabernet Sauvignon.

The interaction effect of varieties and years was non significant.

Sugars are converted into alcohol and carbon dioxide in the process of fermentation. In the present investigation, Symphony recorded maximum total and reducing sugar content followed by Italia while Cabernet Sauvignon and Chenin Blanc are found to have minimum content of reducing sugar in the wine. Higher amounts of sugar content in wine might be due to improper utilization of sugars by the yeast cells for their growth during fermentation.

During aging, wine so produced by fermentation of sugars acquire appreciable quality attributes to make it more palatable. The total and reducing sugars found to decrease in all the cultivars upon aging due to conversion of sugars

into various by products like aldehydes, acetals, esters, tartaric acid and malic acids during aging as reported by Joslyn and Amerine (1964b). Reduction of total sugars due to the maillards reaction during aging was also reported by Zoecklein *et al.* (1995). Similarly, decrease in TSS, total sugars and reducing sugars was also reported by Sharma and Joshi (2003) during aging of straw berry wine. A wide range of reducing sugars and total sugars in the grape wine was reported by several scientists *viz.*, 5.84 to 6.09% and 6.40 to 6.81% (Patel, 1994), 5.80 to 6.17% and 6.37 to 6.72% (Pawar 2002).

4.2.12. Alcohol content of wine (%)

Ethyl alcohol is the predominant constituent of alcoholic fermentation. The yield of alcohol mainly depends on the initial sugar concentration present in the juice. The alcohol content of the wine samples made from different grape varieties are furnished in the Table-4.28.

Alcohol content of wine before aging

Significant variation was observed among the varieties and years while it was non significant with respect to their interactions.

With respect to the varieties, the pooled data indicates that maximum alcohol content was recorded in the variety Shiraz (11.43%) which was significantly superior over others and was closely followed by Chenin Blanc (11.30%). Next in line was Cabernet Sauvignon (10.88%) followed by Zinfandel (10.38%). On the other hand, minimum content was noticed by the variety Italia (7.79%) preceded by Ruby Red (8.05%). Rest of the varieties showed intermediate values ranging from 8.49% in Pusa Navrang to 9.81% in Sauvignon Blanc.

Years have shown significant influence on the alcohol content of wine. Mean alcohol content was maximum during the first year (9.85%) compared to second year (9.44%).

During the first year of trial, Shiraz recorded maximum content of alcohol followed by Chenin Blanc and Cabernet Sauvignon while Italia recorded minimum. Similar trend was observed in the second year also.

Interaction effect was found to be non significant.

Alcohol content of wine after aging

An increase in the alcohol content of wine in all the varieties of grape studied was observed upon aging. However significant variability was observed among the varieties and years.

The perusal of pooled data indicates that maximum alcohol content in the wine after aging was recorded by the variety Shiraz (12.25%) which was significantly superior to the other varieties and was closely followed by Chenin Blanc (12.08%), Cabernet Sauvignon (11.48%), Zinfandel (10.86%) and Athens (10.43%). However Athens was at par to Thompson Seedless (10.43%) and Sauvignon Blanc (10.29%). Minimum content of alcohol in wine was found in the variety Italia (8.78%) preceded by Ruby Red (9.21), which in turn was on par with Pusa Navrang (9.36%). Remaining varieties showed a range between 9.68 to 10.03%.

Years have exerted a significant influence on this parameter. The alcohol content was higher during the first year (10.66%) than that of second year (10.04%).

The interaction effects of varieties and years were found to be non significant.

In the present investigation, the alcohol content in different varieties ranged from 8.78% (Italia) to 12.25% (Shiraz). The yield of alcohol depends upon several factors such as initial sugar content, amount of by products formed and amount of sugar used by yeasts etc (Amerine *et al.*, 1972a). The variation in alcohol content of wine prepared from different varieties of grapes might be due to variation in amounts of sugar present in their berries.

Utilization of sugars by yeast and converting them into carbon dioxide and ethyl alcohol in anaerobic condition was reported by Carl (1979a). A wide range of alcohol content in the wine were reported by several workers 7.4 to 11.9 % (Suresh and Negi 1975), 11.2 to 12.6% (Suresh *et al.*, 1983); 12.6 to 15.5% (Suresh *et al.*, 1985), 7.3 to 8.2% (Patel 1994), 7.6 to 8.2% (Pawar, 2002), 9.75 to 10.68 % (Patil, 2005) 7.4 to 11.9 % (Suresh and Negi, 1975), 11.2 to 12.6 % (Suresh *et al.*, 1983). The results of the present investigation are in agreement with the above findings.

4.2.13. Tannin content of wine (%)

Tannins are a complex group of poly phenolic compounds of diverse origin and chemical structure, but have several common properties such as bitterness, taste and antiseptic properties. The results pertaining to tannin content of wine from different varieties of grape before and after aging for both the years were presented in the Table- 4.29.

Tannins content of wine before aging

Significant variation was observed among the varieties and years while it was found to be non significant with respect to their interactions.

With respect to the varieties, the pooled data indicates that Ruby Red recorded significantly maximum content of tannins in wine (0.067%) and was superior over the other varieties and was closely followed by Pusa Navrang (0.063 %) and Gulabi (0.058%) which did not differ statistically from each other. The latter was at par with Cabernet Sauvignon (0.055%) and Athens (0.052). Minimum content of tannins was found in case of Chenin Blanc (0.007%) which was preceded by the remaining white varieties except Italia and all were in the same order. Other varieties showed a range between 0.022 to 0.042%.

Mean tannin content of wine among the varieties was higher in the second year (0.039%) than that of the first year (0.034%). During the first year of trial, higher amount of tannins was observed in the variety Ruby Red (0.064%) closely

followed by Pusa Navrang (0.058%) and Gulabi (0.055%), while lower content was noticed in the variety Chenin Blanc (0.006%) which was however, comparable with all other white varieties except Italia. More or less similar trend was noticed during the second year.

The interaction effect of varieties and years with respect to tannin content was found to be non significant.

Tannin content of wine after aging

Reduction in the tannin content of wine was observed among the varieties upon aging in both the years.

Significant differences was noticed among the varieties with respect to tannin content but the years and interaction of years and varieties did not show significant influence.

The perusal of pooled data indicates that Ruby Red (0.060%) recorded significantly maximum tannin content closely followed by Pusa Navrang (0.055%) and Gulabi (0.053%) which were in the same order. Next in line was Athens (0.045%) and Cabernet Sauvignon (0.043%) which were at par to each other. White varieties have recorded lower tannin content and among them Chenin Blanc (0.004%) recorded lower content and was on par with Sauvignon Blanc (0.008%), Symphony (0.009%) and Thompson Seedless (0.010%).

Non significant difference was noticed between the two years studied. In the year 2006-07, maximum tannin percent was observed with the variety Ruby Red (0.058%) followed by Gulabi (0.053%), Pusa Navrang (0.052%) and minimum in Chenin Blanc (0.003%). In the 2007-08 year, maximum was noticed with Ruby Red (0.063%) followed by Pusa Navrang (0.058%) and minimum was noticed in the variety Chenin Blanc (0.005%).

Interaction effect was found to be non significant.

Tannins are a group of phenolic compounds present in wine which determine the astringency of wine. Tannin content of wines from coloured varieties

was higher than those of white varieties, due to extraction of more tannins from skin and seeds of coloured varieties and in white varieties, juice was fermented without skin and seeds (Sharma, 1987).

In the present investigation a wide range of tannin content of wine after aging was noticed in wine from 0.004 to 0.060%. Maximum tannin content was observed in the variety Ruby Red while lowest in the variety Chenin Blanc. The differences in the amount of tannins between the varieties could be attributed to the characteristics of the varieties (Bisson and Ribereau- Gayon, 1978). Among the coloured varieties, Ruby Red recorded higher content while Bangalore Blue recorded minimum. This suggested that most of the tannins are not retained after fermentation in the wine made from *Labrusca* grapes *i.e.*, Bangalore Blue (Ough and Singleton, 1968). Similarly, among the white varieties higher tannin content was noticed in Italia and lowest in Chenin Blanc, this might be attributed to the higher pulp content extracted in the juice of Italia.

A wide range of tannin content of 0.05 to 0.40 % in white wines and 0.40 to 1.2% in red wines was reported by Gollmick *et al.*, (1991). The decrease in tannin content upon aging may be due to its oxidation and precipitation with proteins (Zoecklein *et al.*, 1995) and also may be due to binding of tannins with phenols resulting in polymerization and precipitation thereafter (Beridze,1948 and Ribereau Gayon and Stone Street, 1964).

4.2.14. Total Phenol content of wine (mg/l)

The data pertaining to total phenol content of wine in different varieties of grape before and after aging during 2006-07 and 2007-08 are presented in the Table – 4.30.

Total Phenol content of wine before aging

Total phenol content of wine varied significantly among the varieties and years while interactions showed non significant effects.

The pooled data reveals that significantly higher amounts of total phenols were recorded in coloured varieties than that of the white varieties. Among them

Pusa Navrang (1696.49 mg/l) recorded significantly maximum content and was closely followed by Ruby Red (1666.50 mg/l) and Gulabi (1559.16 mg/l). The latter was at par with Athens (1557.50 mg/l). While the lowest content was noticed in Cabernet Sauvignon (1084.16 mg/l). On the other hand, among the white varieties, Italia recorded maximum content of total phenols (527.33 mg/l) and the variety Chenin Blanc showed minimum content (236.5 mg/l) which was comparable with Sauvignon Blanc (247.33 mg/l).

During the first year, in the coloured varieties, Pusa Navrang recorded maximum content of total phenol followed by Ruby Red while the variety Cabernet Sauvignon recorded minimum content. Among the white varieties, Italia recorded highest content and Chenin Blanc recorded the least tannin content. More or less similar trend was noticed in the second year of trial.

The interaction between the varieties and years showed non significant influence.

Total Phenol content of wine after aging

Total phenol content of wine was found to decrease in all the cultivars upon aging. Significant variation was observed among the varieties and years with similar trend observed in both the years and non significant influence with respect to years and interactions was noticed.

The perusal of pooled data indicates that coloured varieties showed higher contents than white ones. Maximum total phenol content was recorded in Pusa Navrang (1652.83 mg/l) closely followed by Ruby Red (1619.5 mg/l). Next in line was Gulabi (1535.16 mg/l) which was on par with Athens (1510.83 mg/l). In white varieties, Italia recorded maximum content (511.49 mg/l) followed by Thompson Seedless (422.16 mg/l) and Chenin Blanc (213.33 mg/l) recorded minimum content.

Yearly effect was significant. Maximum content was recorded in the second year than the first year.

Interaction effect was found to be non significant.

Phenolic compounds possess several essential wine properties influencing colour stability of wine besides influencing mouth feel, depth and astringency (St. Cricq *et al.*, 1988). They are also responsible for bitterness and astringency in wine.

In the present investigation, phenolic compounds varied from a minimum of 213.33 mg/l in the Cv. Chenin Blanc to a maximum of 1652.83 mg/l in Cv. Pusa Navrang. It was evident from the results that coloured varieties recorded higher total phenol content than that of white ones. This might be due to the presence of monomeric anthocyanins and other phenols in the coloured varieties which are lacking in the white ones (Venkataramu *et al.*, 1980).

A wide range of total phenol content of 1000-4000 mg/l in red varieties and 50- 2500 mg/l in white varieties was reported by several scientists (Joseph *et al.*, 1963 and Salunkhe *et al.*, 1990); 0.016-0.032 % (Patel, 1994); 0.02–0.04 % (Pawar, 2002). The results obtained in the study are in conformity with the above workers.

The phenolic compounds in the wine decreased upon aging process. The decrease in phenols was desirable, as it improves the palatability of wine and prevents colour deterioration (Patel *et al.*, 1978), due to the formation of quinoxide from poly phenols in a short time which might be precipitated from wine and that prevents colour discolouration (Patel *et al.*, 1978) or it might be due to the combination of total phenols with aldehydes and subsequent polymerization or may be due to the precipitation with added or natural proteins (Amerine and Cruess, 1960).

4.2.15. Flavonoid content of wine (mg/l)

The results pertaining to flavonoid content of wine in different grape varieties before and after aging for both the years are presented in the Table 4.31.

Flavonoid content of wine before aging (mg/l)

The Perusal of data indicates that significant variability was observed among the varieties studied while non significant influence was noticed with respect to years and their interactions.

The pooled data indicates that higher content of flavonoid was recorded by the coloured varieties than the white varieties. Among the coloured varieties, significantly higher content of flavonoid was found in the variety Pusa Navrang (964.14 mg/l) followed by Ruby Red (851.49 mg/l) which differed statistically with each other. The latter was followed by Cabernet Sauvignon (821.32 mg/l) which was at par. While minimum was noticed in the variety Athens (553.99 mg/l) which was however comparable with Zinfandel (567.35 mg/l). Other three varieties showed a range between 632.28 mg/l to 762.66 mg/l. On the other hand, among the white varieties, maximum flavonoid content of wine was recorded in Italia (281.85 mg/l) which was significantly superior over others. Remaining white varieties recorded lower values wherein, Chenin Blanc (145.8 mg/l) recorded significantly least content and was comparable with the remaining white varieties.

There was no significant variation regarding the flavonoid content of wine between the years. During the first year, maximum content of flavonoid was recorded in the wine made from Pusa Navrang (944.62 mg/l) followed by Ruby Red (830.66 mg/l) while minimum was recorded in Chenin Blanc (143.60 mg/l). Similar trend was observed during the second year of investigation.

Interaction effect of varieties and years was non significant.

Flavonoid content of wine after aging

A decrease in the content of flavonoid was observed among all the varieties after aging of wine in both the years of study.

The perusal of pooled data indicates that among the coloured varieties, significantly higher content of flavonoid was found in the variety Pusa Navrang (922.42 mg/l) followed by Ruby Red (823.33 mg/l) and both differed statistically. The latter was followed by Cabernet Sauvignon (783.50 mg/l) with which it was at par. While minimum content was noticed in the variety Zinfandel (525.30 mg/l) which was comparable with Athens (529.55 mg/l). Other three varieties had content ranging between 591.16 mg/l to 720.83 mg/l. Among the white varieties, maximum flavonoid content of wine was recorded in Italia (257.94 mg/l) which was superior

over others. Remaining white varieties recorded lowest values wherein, Chenin Blanc (122.33 mg/l) recorded significantly lower content and was comparable with the remaining white varieties.

The yearly and the interaction effect of varieties and years showed non significant influence on the content of flavonoids in the wines after aging.

According to Neri and Boulton (1996), flavonoids in particular the derivatives of flavanol and flavones groups which are involved in co-pigmentation, accounts for half of the colour of red wine. In the present study, flavonoid content in wine ranged from 121.34mg/l to 922.42mg/l. It was also observed that unlike the total phenol content, flavonoid content was maximum in coloured varieties when compared to white varieties. The red wines had significantly higher flavonoid content in juice of coloured grapes due to higher extraction of anthocyanin from skins of crushed grapes, which are kept along with fermenting juice for a few days at the time of (red) wine preparation, as described by Ribereau-Gayon *et al.*, (1998).

Flavonoid concentration in white wines ranged from 10 to 50 mg/l while in red wines it may reach 800mg/l (Joshi,1997). Interestingly, Glories (1999) and Ravi kumar (2008) detected flavonoids in red grapes but not in white grapes. The results are in same agreement with the reports of the above scientists.

4.2.16. Organoleptic evaluation of wine

After the aging, evaluation of different wine samples was done according to the hedonic scale. There are significant differences among the treatments for all the quality attributes (Table -4.32).

The appearance of the wine was graded as fair. The highest score of 17.73 (good) for appearance was obtained by Shiraz followed by Chenin Blanc (16.66) and the lowest score of 10.66 (ordinary) was obtained by the variety Italia. Rest of the varieties showed intermediate scores ranging from 11.85 to 16.35.

The aroma of the wine was graded as fair. The highest score of 16.35 (good) for aroma was accorded by Cabernet Sauvignon followed by Shiraz with score of 15.75 (good) and the lowest score 10.96 (ordinary) was accorded by Italia. Remaining varieties scored in the range of 11.18 in Gulabi to 15.23 in Zinfandel.

The flavour of the wine was graded as fair. The highest score of 16.46 (good) for flavour was accorded by Chenin Blanc and was followed by Shiraz with 15.41 (good) and the lowest score of 10.43 (ordinary) was accorded by Ruby Red. The scores of the flavor in the rest of the varieties ranged from 11.26 in Italia to 15.23 in Sauvignon Blanc.

The taste of the wine was graded as fair. The highest score of 17.30 (good) for taste was gained by Shiraz followed by Cabernet Sauvignon (16.55) which inturn was on par with Chenin Blanc (16.53) and the lowest score of 10.11 (ordinary) was gained by Italia. The scores of the taste in different varieties showed intermediate values from 11.45 to 16.55.

The colour of the wine was graded as fair. The highest marks of 16.55 (good) for colour was scored by Shiraz closely followed by Cabernet Sauvignon (16.08) and the lowest marks of 10.23 (ordinary) scored by Ruby Red. Score of other varieties ranged from 10.55 in Italia to 16.08 in Cabernet Sauvignon.

The overall acceptability of the wine was graded fair. The highest score of 14.18 (fair) for overall acceptability was obtained by Shiraz and the lowest score of 10.50 (ordinary) was obtained by Italia. Rest of the varieties recorded intermediate score values ranging from 10.66 to 13.36.

The average quality of wine was fair (13.81). The highest score of 16.15 for average quality was obtained by Shiraz followed by Chenin Blanc (15.41) which was comparable with the variety Cabernet Sauvignon (15.40) and the lowest score of 10.67 was obtained by Italia. The remaining varieties obtained score range from 11.25 in Ruby Red to 14.68 in Zinfandel.

Wine is a fermented product prepared from the fresh fruit juice and its acceptability by the consumers is assessed by organoleptic evaluation (Patil and Patil, 2006). Evaluation of product (*e.g.* wine) was done by selected panel of 5 members. For evaluation, 20 point scale is taken in to consideration based mainly on the appearance, colour, aroma, taste, flavour and overall acceptability (Amerine and Ough, 1980). After taking the average means of quality attributes under each treatment, the wine were categorized based on hedonic scale grade and they were graded accordingly.

In the present investigation, average score of wine samples of different grape cultivars ranged from a minimum of 10.67 in Italia to 16.15 in cultivar Shiraz. Based on the average score, wine made from different varieties are graded as Good (Shiraz, Chenin Blanc and Cabernet Sauvignon), Fair (Zinfandel, Athens, Sauvignon Blanc, Symphony, Bangalore Blue, Thompson Seedless and Pusa Navrang) and Ordinary wines (Gulabi, Ruby Red and Italia).

Experiment III: Wine production by blending white varieties with coloured varieties

Blending is one of the most important operations in food technology. It is one of the oldest techniques having origin in the ancient art of cooling and brewing. 'Blending' is defined as the intimate intermingling of two or more physically or chemically dissimilar groups of matter, resulting in some pre-defined state of intimacy of complete uniformity. The blending of fruit drinks is an economic requisite to utilize some fruit varieties which may not have otherwise favourable characteristics including cost and product preparation. Secondly, the objective is to supplement appearance, nutrition and flavour. Thirdly, one could simply think of new product development through blending. Fourthly, it facilitates to utilize lesser known fruits profitably. Two or more fruit juices / pulp may be blended in various proportions for preparation of RTS drinks *etc.*, (Deka *et al.*, 2001).

The chemical composition of many fruit juices is not balanced from an organoleptic point of view and to avoid chemical alteration such as neutralizing or increasing acidity, juice of varying compositions are blended together to provide the desired balance of sweetness and sourness. Strong aromatized juice can well be appreciated only on dilution. Juices counteract the acids of one another and regulate brix: acid ratio. By blending, it is possible to bring out the latent flavour of the ingredient juice and the resultant blend due to multiplicity of flavour and colour is outstandingly unique. Hence, blends are more invigorating and nutritious. Blending fruit juices has some advantages like providing a variety of new flavour and better nutritional balance. With this objective, wines were prepared by blending juice of white varieties with coloured varieties in two different proportions. White varieties used in the present study are Sauvignon Blanc, Chenin Blanc, Thompson Seedless and Italia while coloured ones include Shiraz, Ruby Red and Bangalore Blue in two different ratios *i.e.*, 2:1 and 3:1 respectively. The results of bio chemical properties of juice and wine of different blends were discussed below.

Physico Chemical Properties of juice of different blends

4.3.1. Total soluble solids of juice of blends (°B)

In grapes, a large portion of the soluble solid is sugar. The sugar content of the juice is often expressed in terms of °Brix. Glucose and fructose are fermentable sugars. During the course of fermentation, the yeast converts these sugars to alcohol and carbon dioxide. The amount of alcohol produced is related to the amount of sugar initially present in the juice; thus, by controlling the amount of sugar in the juice, one can control the amount of alcohol in the resulting wine. TSS forms a guide for producing different types of wines besides, the need for amelioration of fruit juice in order to have optimum content for wine making. The data pertaining to TSS of the juice of different blended grape cultivars included in the study were furnished in the Table-4.33. The statistical analysis of the experiment was significant in respect of treatments, years and their interaction.

The Perusal of pooled data indicates that treatment T₇ has recorded maximum TSS (21.46°B) which was significantly superior to the rest of the cultivars closely followed by T₁ (21.29 °B) and both were statistically at par. The latter was comparable with T₃ (20.70 °B). Minimum TSS content was observed with T₂₄ (16.46°B) which was independent over the others. The rest of the treatments recorded intermediate values ranging from 17.20 to 20.60 °B.

With regard to the years, the mean TSS content was significantly less in 2007-08 (18.47 °B) than that in 2006-07 (19.19 °B). In 2006-07, treatments T₁ and T₇ recorded highest TSS content (21.26 °B) and were at par. This was followed by T₉ (21.13 °B). Minimum TSS content was recorded by T₂₄ (15.93 °B) preceded by T₂₃ (16.53 °B). The rest of the treatments showed intermediate contents.

During the year 2007-08, T₇ showed highest content of TSS (21.66 °B) followed by T₁ (21.33 °B) and T₃ (21.00 °B) which were superior to the rest of the treatments. Whereas, T₂₄ showed minimum TSS (17.00°B) closely preceded by T₁₇ (17.53 °B). The rest of the treatments showed intermediate contents of TSS ranging from 17.66 to 20.86 °B.

The interaction effect of treatments and years was found to be significant. In both the years, treatment T₇ recorded maximum value of TSS while T₂₄ showed minimum TSS content. With respect to the ratios, 2:1 had maximum TSS than 3:1.

Total soluble solids is an indirect measure for sugars, as they are the prime source of alcohol. In the present study, significant variability was observed among the treatments with respect to the TSS of the juice varying from a minimum content of 16.46 °B to a maximum of 21.46 °B. The data also indicates that blending of white varieties with the coloured cultivar Shiraz has resulted in maximum TSS when compared to that of Ruby Red and Bangalore Blue. This may be due to presence of higher TSS content in Shiraz among the coloured ones. Similar results on blending were reported by Pawar (2002) and Patil *et al.*(2007) from Rahuri, Maharashtra.

4.3.2. Titrable acidity of juice (%)

The data pertaining to total titrable acidity of juice in different blended treatments are furnished in the Table-4.34. It is evident from the statistical analysis, that the experiment was significant with respect to the blending treatments and interactions and non significant between the years.

Among the blending treatments, significantly maximum titrable acidity was recorded with T₁₂ (1.66 %) followed by T₂₄ (1.55%) and T₁₁ (1.53%) which differed with each other. The latter was followed by T₁₇ (1.45%) which was on par with T₁₈ (1.41%), T₂₃ (1.40%) and T₁₀ (1.39%). On the other hand, minimum titrable acidity was observed with T₃ (0.64%) which was comparable with T₁₅ (0.66 %) and T₄ (0.69%). The other treatments showed a range between 0.72 to 1.33%.

However, no significant variation was observed between the two years of trial. When the individual years are considered, during the first year, T₁₂ recorded maximum titrable acidity (1.73%) followed by T₂₄ (1.60%) while minimum was recorded with T₁₅ (0.63%) closely preceded by T₃ (0.64%) with which it was at par. Similar to the first year, in the second year, T₁₂ registered maximum titrable acidity followed by T₁₁ (1.55%) whereas lowest was recorded in T₃ (0.65%).

Interaction effect of blending treatments and years showed significant variation. Among the different treatments, T₁₂ recorded maximum titrable acidity while T₁₅ in the first year and T₃ during the second year showed minimum titrable acidity content.

Next to sugars, organic acids are the most abundant solids present in grape juice. They are a very important component of juice and wine. They are responsible for the tart taste and have a marked influence on wine stability, colour, and pH. The principal organic acids found in grapes are tartaric, malic, and to a small extent, citric acid. Grapes are one of the rare fruits that contain tartaric acid. It is present as free acid and a salt, such as potassium bitartrate. Bitartrate is an important constituent since it affects pH and stability of the wine.

In the present study titrable acidity of juice in different treatments ranged from 0.64 to 1.66%. The data on titrable acidity also represents that among the different varieties blended, varieties blended with Bangalore Blue had higher content of acidity while those blended with Ruby Red showed minimum content. This may be due to the presence of high acidity content in Bangalore Blue. Among the two proportions tested, 3:1 showed higher content of titrable acidity.

4.3.3. pH of juice

The data pertaining to pH of juice are presented in the Table 4.35. It is obvious from the data that significant influence was exerted by the treatments and years while the interactions did not exhibit any statistical difference between the blends and years.

The pooled data indicate that higher pH was recorded in the treatment T₁₅ (4.13) closely followed by T₉ (4.10), T₂₁ (4.10), T₁₆ (4.08), T₁₃ (4.06) and T₂₂ (4.01) and all were at par with each other. On the other hand, lowest pH was in the treatment T₁₂ (3.48) preceded by T₁₁ (3.55) with which it was at par. pH ranged from 3.61 to 4.00 in the rest of the blends.

Significant variation was noticed between the two years. Mean pH was higher in the first year (3.89) than in the second year (3.81). In the first year, highest pH in the juice was recorded by T₁₃(4.23) followed by T₁₅ (4.13) and minimum pH by T₈ (3.50). Whereas in the second year, T₂₁ has recorded maximum pH (4.16) and T₁₂ has recorded minimum pH (3.40). Rest of the treatments showed intermediate values between the two extremes.

Interaction effect however was found to be non significant.

In the present investigation, pH of juice ranged from a minimum of 3.48 to a maximum of 4.13. White varieties which were blended with coloured Ruby Red recorded highest pH value while those blended with Bangalore Blue showed lowest value.

4.3.4. Total Sugar content of juice in blended varieties (%)

The data recorded on total sugar content of juice in blends as furnished in Table- 4.36 which indicated that the experiment was significant in respect of treatments, years and their interaction.

The perusal of pooled data signifies that higher total sugar content of juice was found in the treatment T₇ (20.03%) closely followed by T₁ (19.20%) and T₂ (17.86%) which differed with each other. Minimum total sugar was observed with T₂₂ (13.65%) preceded by T₂₀, T₁₆, T₂₁, and were at par. Remaining treatments found to range from 13.91 to 17.24%.

Significant variation was noticed between the two years. Mean total sugar content was higher during the first year (15.74%) than the second year (15.46%). In the first year, highest total sugar content in the juice was recorded by T₇ (20.20%) followed by T₁ (19.37%) and minimum total sugar content was observed by T₂₂ (13.90%). Whereas in the second year, similar trend was noticed with respect to total sugar content of juice. Rest of the treatments showed intermediate values between the two extremes.

Interaction effect was found to be non significant.

4.3.5. Reducing sugar content of juice in blended varieties (%)

The data recorded on reducing sugar content of juice in blends is furnished in Table- 4.37. Statistical analysis of the data indicated that the experiment was significant in respect of treatments, years and non significant in their interaction.

The perusal of pooled data reveals that higher reducing sugar was recorded in the treatment T₇ (16.92%) closely followed by T₈ (14.68) which inturn was followed by T₁₃, T₁₁, T₁₄, T₁, T₁₂ and T₂ and all were in the same order. Lowest reducing sugar was observed with the treatment T₂₂ (10.89%) preceded by T₂, T₄,

T₁₆, T₂₀, T₂₄, T₃, T₁₅, T₁₀ and T₁₈ and all were at par. Remaining treatments showed a range of reducing sugars from 12.09 to 13.41%.

Significant variation in the content of reducing sugars was noticed between the two years. Mean reducing sugar was higher in the first year (13.10%) than the second year (12.49%). In the first year, highest reducing sugar in the juice was recorded by T₇ (17.07%) followed by T₈ (16.78%) and minimum reducing sugar content was recorded by T₂₂ (10.89%). However in the second year, similar trend was noticed with respect to reducing sugar of juice. Rest of the treatments showed intermediate values between the two extremes in both the years.

The interaction between blending treatments and years failed to influence reducing sugar content significantly.

Sugars are the primary source of alcohol. In the present investigation, reducing sugar content of juice in different blended treatments varied from 10.89 to 17.07%. Variation in the reducing sugar content was also indicated with different coloured varieties. White varieties which were blended with Shiraz recorded highest reducing sugar content while those blended with Ruby Red showed lowest content. Among the two proportions, 2:1 recorded maximum content of sugars when compared to 3:1.

Physico chemical properties of wine

4.3.6. Total soluble solids in blended wine (⁰B)

The data recorded on total soluble solids of wine in different treatments during 2006-07 and 2007-08 both before and after aging are presented in Table-4.38.

Total soluble solids in blended wine before aging

Statistical analysis of the data indicated that treatments, years and interactions have shown significant influence on the total soluble solid content in wine. The perusal of pooled data indicates that significantly lower TSS was recorded in T₇ (7.26⁰B) closely preceded by T₈ (7.48⁰B) which were independent

to each other. Next in line was T₁ (7.73⁰B) and T₂ (7.99⁰B). Higher content of TSS was registered with T₂₁ (10.66⁰B) which was at par with T₂₁ (10.66⁰B) and T₁₆ (10.48⁰B). Rest of the treatments recorded intermediate values ranging from 8.59 to 10.46⁰B.

Yearly effect of this parameter was significant. When the TSS means of years were considered, the content was highest in the second year (9.64⁰B) than first year (9.09⁰B). During the year 2006-07, maximum TSS of wine was noticed with T₁₅ and T₂₁(10.46⁰B) followed by T₂₂ (10.40⁰B) while minimum was recorded with T₇ (6.60⁰B). In the second year, similar trend was observed with respect to TSS of wine in different blended treatments.

Interaction effect between the treatments and years found to be significant. The treatment T₇ recorded maximum T₂₁ recoded minimum total soluble solids in both the years.

Total soluble solids in blended wine after aging

It was observed from the results shown in the Table that TSS of wine decreased upon aging. Significant variation was observed among the treatments and years while interaction effect was found to be non significant.

The perusal of pooled data reveal that among the treatments, minimum TSS was recorded with T₇ (6.60⁰B) closely preceded by T₈ (6.83⁰B) which were at par. This was followed by T₁ (7.26⁰B) and T₂ (7.49⁰B) and were independent to each other. On the other hand, highest TSS was recorded with T₂₁ (10.29⁰B) followed by T₁₅ (10.21⁰B), T₂₂ (10.13⁰B) and T₁₆ (10.11⁰B) and were in the same order. The TSS content of blends in rest of the treatments varied from 7.76 to 9.94⁰B.

Significant difference between the years in respect to TSS of wine was also observed. However, when the means of the years were considered, TSS content was lower (8.61⁰B) in 2006-07 than that of 2007-08 (9.05⁰B). During the year 2006-07, maximum TSS in wine was registered with T₂₁ (10.13⁰B) followed by T₁₅ (10.03⁰B) and T₂₂ (10.00⁰B) while minimum was noted in T₈ (6.13⁰B) preceded

by T₇ (6.20⁰B). In the second year, maximum TSS was recorded with T₂₁ (10.46⁰B) followed by T₁₅ (10.40⁰B) while minimum was recorded with T₇ (7.00⁰B).

The interaction between years and treatments was found to be non significant.

Total soluble solids is an important factor in making quality wine. The final TSS of wine depends upon the utilization of sugars by the yeast cells. Reduction in the TSS is an indicator for the completion of fermentation process. Thus a maximum reduction in TSS is favourable for quality wine preparation (Pawar, 2002). Similar findings were earlier reported by Othman *et al.* (1992).

In the present investigation, TSS of wine in different blended treatments after aging ranged from 6.60 to 10.29⁰B. Minimum TSS was registered with the treatment T₇ followed by T₈ while maximum was observed in T₂₁. Hence it can be summarized that among the different blends, white varieties blended with Shiraz showed greater decline in TSS than those blended with Bangalore Blue while wine prepared from blending of white varieties with Ruby Red showed higher content of TSS. Among the two proportions evaluated, white varieties blended with Shiraz in the ratio of 2:1 recorded minimum TSS of wine over 3:1, while with Bangalore Blue 3:1. Thus, the ratio of blends varied with the variety with which white varieties were blended.

4.3.7. Titrable acidity in blended wine (%)

Grape juice and wine contains mainly organic acids like tartaric, malic and citric acids. These acids play an important role on the quality of wines particularly the tartness, colour and keeping quality. The data on total titrable acidity of wine of different treatments under study were recorded for two years both before and after aging were presented in Table- 4.39.

Titrable acidity in blended wine before aging

Significant variation was observed among the treatments. However, years as well as interactions have not exerted significant influence.

With respect to the blended treatments, T₂₄ has recorded maximum titrable acidity (1.43%) which was significantly superior to the other treatments. It was followed by T₁₂ (1.38%) with which it was at par. The latter was however comparable with T₁₁ and T₁₈ (1.28%). Minimum titrable acidity was recorded in the T₃ (0.51 %) followed by T₄ (0.53%) and T₉ (0.54%) which were in the same order. Rest of the treatments recorded intermediate values of acidity ranging from 0.64 to 1.25%.

The titrable acidity was not influenced significantly by the years. In the year 2006-07, maximum titrable acidity in wine was recorded with T₂₄ and T₁₂ (1.33%) followed by T₁₁ (1.26 %) while minimum was observed by T₉ (0.50 %) closely followed by T₃ (0.51%). Remaining treatments recorded acidity in the range from 0.53 to 1.26%. Similar trend was observed in the second year of the trial.

The interaction effect of treatments and years was non significant.

Titrable acidity in blended wine after aging

Significant variation was observed among the different blended treatments and years. However, interaction of treatments and years failed to influence the parameter significantly. Aging of blended wines resulted in reduction of acidity in both the years.

The perusal of pooled data indicate that T₁₂ recorded maximum titrable acidity (1.23%) which was significantly superior over the other treatments followed by T₂₃, T₂₄, T₁₁, T₁₈, T₁₇, T₂₀, T₈ and T₁₉ which were at par. Minimum titrable acidity was recorded in T₃ (0.42%) preceded by T₉, T₁₀, T₄ and T₁, and all were in the same order. Rest of the treatments recorded intermediate values ranging from 0.66 to 1.01%.

Mean titrable acidity was higher during the second year (0.91%) than that in the first year (0.82%). In the year 2006-07, maximum titrable acidity of wine was observed with T₂₄ (1.21%) and was followed by T₂₃ (1.17%) while minimum acidity was recorded by T₉ (0.41 %) closely followed by the T₃ (0.42%). Rest of

the treatments showed a range of acidity from 0.53 to 1.26%. Unlike in the first year, T₁₂ recorded higher titrable acidity followed by T₁₁ whereas least content was noticed in T₃.

The interaction effect of treatments and years was found to be non significant.

It is evident from the table that titrable acidity content in different blended treatments after aging varied from 0.42 to 1.23%. Interestingly, it was observed that the white varieties blended with Bangalore Blue recorded maximum titrable acidity while those blended with Ruby Red showed least content. Of all the treatments, T₁₂ recorded maximum content of titrable acidity and between the two proportions, irrespective of the cultivars, 3:1 ratio showed higher acidity.

4.3.8. Volatile acidity content in blended wine (%)

The content of volatile acidity in wine plays an important quality parameter which determines the acceptance and soundness of wine. The data pertaining to the volatile acidity of wine in different treatments before and after aging for the two years are presented in the Table- 4.40.

Volatile acidity content in blended wine before aging

Significant variation was observed among the treatments and years while it was non significant in their interactions.

The pooled data indicate that irrespective of the years, maximum volatile acidity was recorded with T₂₂ (0.046%) which was significantly superior to the other treatments but was on par with T₂₁ (0.044%), T₂₄ (0.042%) and T₂₀ (0.041%). Minimum content was observed in T₁₃ (0.017%) which was comparable with T₇, T₁₄, T₈, T₁₁ and T₁₇. The content varied from 0.023 to 0.039% in the rest of the blends.

Significant variation was observed with respect to volatile acidity of wine in both the years of study. In 2006-07, maximum volatile acidity was found with T₂₂ (0.045%) followed by T₂₁ (0.042%). Minimum was noticed in T₁₃ (0.016%) which

was comparable with T₁₄ (0.018%). Similar trend was noticed in volatile acidity of wine before aging during the second year.

The interaction effect of treatments and years was found to be non significant.

Volatile acidity content in blended wine after aging

The volatile acidity of wine in all the treatments decreased upon aging. Significant variation was observed among the treatments but was non significant in case of years of study and interactions. Similar trend was noticed among the treatments in both the years of investigation.

The perusal of pooled data indicates that significantly higher content of volatile acidity after aging was observed with T₂₂ (0.041%) which was significantly superior to the other treatments and was on par with T₂₁ (0.039%), T₂₄ (0.038%), T₂₃ (0.037%) and T₂₀ (0.036%) while minimum was observed in T₁₃ and T₇ (0.012%) which was preceded by T₁₄, T₈, T₁₁ and T₁₇. Other treatments showed values between 0.019 to 0.034% respectively.

With regard to the years and interaction, non significant influence was recorded.

According to the Indian standards for wine constituents, a wine should not contain volatile acidity as acetic acid more than 0.1% in wine (Bhalerao, 2001). In the present investigation, volatile acid content of wines in different treatments after aging varied widely from 0.012 to 0.041%. The values of volatile acidity of wine in all the treatments were within the standard limits. Significant decrease in volatile acidity of wine upon aging in all the treatments might be due to the formation of esters by the reaction of ethyl alcohol and volatile acids (Amerine *et al.*, 1972a).

Further, among the different blending treatments evaluated, wine produced from the blends of Italia showed higher content of volatile acidity. Further, among the coloured varieties blended, Ruby Red recorded maximum volatile acidity content over Bangalore Blue and Shiraz. With respect to the different proportions, treatments blended with 3:1 ratio recorded maximum content than 2:1 ratio.

4.3.9. Total sugar content in blended wine (%)

The data on the content of total sugars of wine before and after aging in different blended varieties for the two years are presented in the Table- 4.41.

Total sugar content in blended wine before aging

Significant variation was observed among the blends and years but with respect to their interaction it was found to be non significant.

The perusal of pooled data indicates that significantly higher content of total sugars was observed with T₂₁ (6.10%) which was significantly superior to the other treatments. However, it was followed by T₃ (5.87%) which was comparable with T₂₂ (5.83%) while minimum content was observed in T₇ (3.38%) preceded by T₈, and T₁₃ which were in the same order. The contents of total sugars ranged between 3.81 to 5.68% in the rest of the blends.

The quantity of total sugars between the years showed significant level. However, in 2006-07, maximum total sugar content was found with T₂₁ (6.02%) which was followed by T₃ (5.78%) and T₂₂ (5.70%) and minimum content was noticed by T₇ (3.22%) preceded by T₁₃ (3.54%). The contents of total sugars showed similar trend in the following year (2007-08).

The interaction effect of treatments and years was found to be non significant.

Total sugar content in blended wine after aging

Irrespective of the blends, a reduction in the content of total sugar was observed after aging. Among the treatments, upon aging reduction in the total sugar content was observed. Significant variation was observed among the treatments and years but not in case of their interactions.

As in case of wines before aging, total sugar content of wine after aging was significantly higher with T₂₁ (5.53%) which was superior over the other treatments. It was followed by T₂₂ (5.33%) which inturn was on par with T₂₃ (5.24%).

Minimum content was observed in T₇ (2.25%) preceeded by T₈ (2.31%) and both were at par. The contents varied from 2.63 to 4.98% in other blends.

With respect to the years, significant variation was observed between the two years of study. In 2006-07, maximum total sugar content was found in T₂₁ (5.64%) followed by T₂₂ (5.27%) and minimum was noticed in T₈ (2.14%) preceeded by T₇ (2.16%) which were in the same order. Similar trend was observed during the second year of investigation.

The interaction effect of blended treatments and years was found to be non significant.

4.3.10. Reducing sugar content in blended wine (%)

The data on the content of reducing sugar of blended wine before and after aging in different blended wines for the two years are furnished in the Table- 4.42.

Reducing sugar content in blended wines before aging

The content of reducing sugars varied significantly among the different blended wines and between the years. However, it failed to reach significant level in case of their interactions.

A perusal of pooled data indicates that significantly higher content of reducing sugars was observed with T₂₁ (5.43%) which was superior over the other blended treatments followed by T₂₂ (5.07%) and T₂₃ (4.92%). Minimum was observed in T₇ (2.04%) which was preceeded by T₈ (2.20%) and both were independent to each other. Other blends showed a range of contents from 2.52 to 4.68 %.

Yearly influence on the content of reducing sugars in blends was significant. Higher content was recorded in the second year (3.89%) than the first year (3.64%). In 2006-07, maximum reducing sugar content was found in T₂₁ (5.33%) followed by T₂₂ (5.01%). Minimum was noticed by T₇ (2.02%) preceeded by T₈ (2.17%). Second year showed similar trend.

The interaction effect of treatments and years was found to be non significant.

Reducing sugar content in blended wine after aging

Aging caused reduction in the content of reducing sugar in all the blends. The different wine blends showed significant variation. However, the years and interaction did not exert any significant influence on this parameter.

As in the case of wines before aging, reducing sugar content of wine was significantly higher in T₂₁ (4.80%) which was superior over the other blends followed by T₂₃ (4.45%). Minimum was observed in T₇ (1.84%) which was preceded by T₈ (1.91%) and both were at par. The contents varied between 2.24 to 4.27% in rest of the blends.

When the years are taken in to account, it was observed that the variation in the content of reducing sugars was not significant. Maximum content of reducing sugar was found in T₂₁ in both the years (4.79 and 4.81%) followed by T₂₃ (4.28 and 4.63%) and minimum was in T₈ (1.80 and 1.89%) preceded by T₇ (1.88 and 1.95%).

The interaction effect of treatments and years was found to be non significant.

The sugars are metabolized to obtain energy required for fermentation. The ethanol and CO₂ are the by products of yeast fermentation. A complete utilization of sugar during fermentation is desirable to obtain higher alcohol level in the final wine product. Higher amounts of sugar content in wine might be due to improper utilization of sugars by the yeast cells for their growth during fermentation. The total and reducing sugars decreased in all the blends upon aging due to conversion of sugars into various by products like aldehydes, acetals, esters, tartaric acid and malic acids during aging (Joslyn and Amerine, 1964b).

From the above results, it is evident that the white varieties blended with coloured Cv. Shiraz showed minimum content of sugars in wine when compared to another coloured Cv. Bangalore Blue while those blended with Ruby Red recorded

maximum content of sugars in blended wine indicating meagre utilization of sugars for production of alcohol.

4.3.11. Alcohol content in blended wines (%)

The data recorded on alcohol content of blended wine before and after aging in different blended wines for the two years are included in the Table-4.43.

Alcohol content in blended wine before aging

Blended wines showed significant variation in the quantum of alcohol in wines before aging in both the years but interaction did not attain significant level.

The pooled data indicates significantly higher content of alcohol in T₇ (11.87%) which was superior over the other treatments. It was closely followed by T₁ (11.38%). The next best treatment was T₁₂ (10.58%). Minimum content was observed in T₂₁ (7.99%) preceded by T₂₂ (8.12%), both differed with each other. Other treatments recorded intermediate values varying from 8.16 to 10.41%.

Significant variation was observed in content of alcohol of blended wine in both the years of study. Higher content was recorded during the first year (9.40%) than the second year (9.24%). However, in both the years similar trend was followed among the treatments wherein maximum alcohol content was found in T₇ (11.97 and 11.77%) and minimum was noticed in T₂₁ (8.03 and 7.95%).

The interaction effect of treatments and years was found to be non significant.

Alcohol content in blended wine after aging

The content of alcohol in different blended wines has increased upon aging. The variation is statistically significant among the blends and years. However, not in case of interactions.

As in the case of blended wines before aging, alcohol content of wine was significantly higher in T₇ (12.04%) which was superior over the other treatments followed by T₁ (11.51%) while minimum was observed in T₂₁ (8.11%) preceded

by T₂₂ (8.22%) and both were statistically at par. Other treatments recorded alcohol content ranging from 8.34 to 10.74%.

With respect to the years, significant variation was observed between the two years of study. Maximum alcohol content was found in T₇ in both the years (12.11 and 11.97%) followed by T₁ (11.59 and 11.44%) and minimum was recorded by T₂₁ (8.20 & 8.02%) preceded by T₂₂ (8.33 and 8.11%) in both the years.

In the present study, alcohol content in blended wines after aging ranged from 8.11 to 12.04%. Wines blended with Shiraz recorded higher amounts of alcohol than that with Bangalore Blue and Ruby Red. This may be attributed to the compatible nature of Shiraz over the other varieties.

4.3.12. Tannin content in blended wine (%)

Tannins are a complex group of poly phenolic compounds which imparts bitterness, taste and antiseptic properties. The data recorded on content of tannin wine in different blended wines before and after aging for both the years are presented in the Table- 4.44.

Tannins content in blended wine before aging

The various blended treatments showed significant influence on the content of tannins in blended wines. However, years and interaction did not show such significant influence.

With reference to the different blending treatments, the pooled data reveal significant higher content of tannins in T₂₁ (0.050%) which was superior over the other treatments followed by T₂₂ (0.037%) which was however comparable with T₉ (0.034%). Minimum content was observed in T₈ (0.011%) closely preceded by T₇ (0.012%), T₁₂ (0.015%) and T₂ (0.017%) and were in the same order. Other treatments recorded intermediate values between the two extremes.

Although, the years have not shown significant influence, in both the years of study. Regarding the individual years, in both the years similar trend was

followed among the treatments wherein maximum tannin content was found with T₂₁ (0.049 and 0.051%) and minimum in T₈ (0.010 and 0.013%).

The interaction effect however did not exert any significant influence on the content of tannin in blended wines before aging.

Tannins content in blended wine after aging

A decrease in the tannin content was noticed in different blended treatments upon aging. Blended treatments were significant whereas years and interaction were found to be non significant.

Significantly maximum content of tannins was recorded by T₂₁ (0.044%) which was superior over the other treatments. It was followed by T₂₂ (0.030%). Minimum content was observed in T₈ (0.007%) closely preceded by T₇, T₁, T₆, T₅, T₁₁ and T₄ and all were in the same order. Rest of the treatments recorded intermediate values between the two extremes.

Significant variation was not observed with respect to tannin content of wine in both the years of study. In both the years similar trend was followed among the treatments wherein maximum tannin content was found in T₂₁ (0.043 and 0.045%) and minimum was in T₈ (0.006 and 0.008%).

The interaction effect between treatments and years was found to be non significant.

It is evident from the results that tannin content varied significantly among the different treatments. The white varieties blended with coloured Cv.Shiraz registered minimum content of tannins in wine while those blended with another coloured Cv.Ruby Red showed maximum tannin content in their corresponding blended wine. Among the two ratios tried, 3:1 showed minimum content of tannin in all the treatments when compared to 2:1.

4.3.13. Total Phenol content in blended wine (mg/l)

Phenolic compounds are a group of substances that are structurally diverse and are present in various amounts. They play a vital role in determining the wine's

colour and flavour. The results pertaining to total phenol content of wine in different blended wines of grape before and after aging for both the years were furnished in the Table- 4.45.

Total Phenol content in blended wine before aging

Blended treatment showed significant influence, however their content of total phenol was not significantly influenced either by years or interactions.

With respect to the treatments, the pooled data indicates higher content of tannins in T₂₁ (599.66 mg/l) which was superior over the other treatments followed by T₂₂ (584.45 mg/l) and both were at par. Minimum content was observed in T₁₄ (245.16 mg/l) closely preceded by T₁₃ (259.16 mg/l) and T₈ (262.33mg/l) and all were in the same order. Other treatments recorded intermediate values ranging from 280.33 in T₁₈ to 551.97 mg/l in T₂₃.

The content of total phenol in blended wines showed non significant variation between the years. In both the years however similar trend was followed among the treatments wherein maximum total phenol content was recorded in T₂₁ (592.33 and 607.00mg/l) and minimum in T₁₄ (240.66 and 249.66 mg/l).

The interaction effect did not exert significant influence on this parameter.

Total Phenol content in blended wine after aging

A marked decrease in the total phenol content was noticed in different blended treatments upon aging. Blending treatments were significant, but not between the years and interactions.

A perusal of pooled data reveals significantly maximum content of tannins with T₂₁ (570.89 mg/l) which was superior over the other treatments followed by T₂₂ (544.05 mg/l). Minimum content was observed in T₈ (228.32 mg/l) preceded by T₁₄ (232.66 mg/l), T₁₈ (239.49 mg/l) and T₁₃ (243.99 mg/l) and these were in the same order. Other treatments recorded intermediate values between the two extremes.

After aging, variation in the content of total phenol of blended wine was not significant during the two years of study. In both the years, similar trend was followed among the treatments wherein maximum content was found with T₂₁ (535.11 and 553.00 mg/l) and minimum in T₁₄ (222.33 and 243.00 mg/l).

The interaction effect was found to be non significant.

It is evident from the results that total phenol content varied significantly among the different treatments. Among the coloured varieties, Shiraz when blended with white varieties registered minimum content of total phenol in the blend, while the blend of Ruby Red with white variety showed maximum content of total phenol in the wine. Among the two ratios tried, 3:1 showed minimum content of total phenol in all the treatments when compared to 2:1.

4.3.14. Flavonoid content of wine in blended treatments (mg/l)

Flavonoid compounds are a group of phenolic substances that play a vital role in determining the wine's colour and flavour. The data pertaining to flavonoid content of wine in different blended wines of grape before and after aging for both the years were furnished in the Table- 4.46.

Flavonoid content in blended wines before aging

Treatmental influence on the content of flavonoids was significant. However, years and interactions failed to significantly influence this parameter.

With respect to the treatments, the pooled data indicates significantly higher content of tannins in T₂₁ (272.81 mg/l) which was superior over the other treatments closely followed by T₂₃ (260.98mg/l) with which it was at par. The latter was however comparable with T₂₂ (250.49 mg/l). Minimum content was observed in T₈ (108.20 mg/l) closely preceded by T₇ (112.53 mg/l) T₁₂ (112.80 mg/l) and T₁₁ (123.65mg/l) and all were in the same order. Other treatments recorded intermediate values ranging from 124.75 to 238.52 mg/l.

The content of flavonoid in blended wines was not influenced by years as well as interaction. The content showed similar trend was followed among the treatments wherein maximum flavonoid content was recorded with T₂₁ followed by T₂₃ and minimum was noticed in T₈.

The interaction effect did not exert any significant influence.

Flavonoid content in blended wines after aging

The content of flavonoid decreased significantly in different blended treatments upon aging, while it was found to be non significant between the years and their interactions.

As in the case of the blends before aging, flavonoid content of wine after aging in different blended treatments followed same trend in recording higher and lower flavonoid content. The perusal of pooled data reveals significantly higher content of flavonoids in T₂₁ (264.75mg/l) which was superior to the other treatments followed by T₂₃ (247.86 mg/l). Whereas minimum content was observed in T₈ (99.05mg/l) closely preceded by T₁₂ (104.73mg/l) and T₇ (105.62mg/l) which were in the same order. Rest of the treatments recorded intermediate values between the two extremes.

Significant variation was not observed with respect to flavonoid content of wine in both the years of study. Similar trend was followed among the treatments in both the years wherein maximum content was found with T₂₁ (261.22 and 268.29 mg/l) and minimum was noticed by T₈ (95.34 and 102.77 mg/l).

The interaction effect was found to be non significant.

It is evident from the results that flavonoid content varied significantly among the different treatments. The white varieties blended with Shiraz registered minimum content of flavonoid in wine while those blended with Ruby Red showed maximum content in their corresponding wine. Among the two ratios tried, 3:1 showed minimum content of flavonoid in all the treatments when compared to 2:1.

4.3.15. Organoleptic evaluation of wine in blended treatments

Evaluation of blended wine was done by a panel of 5 members. For evaluation, 20 point scale was taken in to consideration mainly based on the appearance, colour, aroma, taste, flavour and overall acceptability. There were significant differences among the treatments for all the quality attributes (Table - 4.47).

The appearance of the wine was graded as fair. The highest score of 17.18 (good) for appearance was obtained by T₇ followed by T₁ (16.53) and the lowest score of 11.66 (ordinary) was obtained by the variety T₂₁. Rest of the treatments showed intermediate scores ranging from 12.35 to 15.36.

The aroma of the wine was graded as fair. The highest marks of 16.25 (good) for appearance was scored by T₇ followed by T₁ (15.41) and the lowest marks of 10.26 (ordinary) scored by the treatment T₂₃. Rest of the treatments showed intermediate scores ranging from 10.63 to 14.98.

The flavour of the wine was graded as fair. T₇ recorded highest score of 16.55 (good) for appearance followed by T₁₂ (16.08) and the lowest score was recorded by the treatment T₁₅ of 11.55 (ordinary) preceded by T₂₃ (11.63). Rest of the treatments showed intermediated scores ranging from 12.23 to 15.73.

The taste of the wine was graded as fair. The highest score of 17.30 (good) for taste was recorded by T₇ followed by T₁ (16.53) which inturn was at par with T₁₂ (16.25) and the lowest score of 12.01(fair) recorded by T₂₁. Rest of the treatments showed intermediated scores ranging from 12.13 to 15.71.

The colour of the wine was graded as fair. The highest score of 17.83 (good) for colour was recorded by T₇ followed by T₄ (16.95) which inturn was at par with T₁₂ (16.25) and the lowest score of 12.63 (fair) recorded by T₂₁. The score of the rest of the treatments ranged from 13.10 to 15.56.

The overall acceptability of the wine was graded fair. The highest score of 18.31 (excellent) for overall acceptability was awarded to T₇ followed by T₁ (17.41) and the lowest score of 11.55 (ordinary) was awarded to T₂₁.

After taking the average means of quality attributes under each treatment for consideration the wine were categorized based on hedonic scale grade and graded accordingly. The average quality of wine was fair (14.10). The highest score of 17.23 (good) for average quality was obtained by T₇ followed by T₁ (16.32) and the lowest score of 11.96 (ordinary) was secured by T₂₃. The remaining treatments scored marks ranging from 12.14 to 15.50.

In the present investigation, average score of wine samples of different blended wines ranged from a minimum of 11.96 in T₂₃ to 17.23 in T₇. Based on the average score, wine made from blended wines can be graded as Good (T₇, T₁, T₁₂, T₄ and T₁₃), while rest of the blends produced fair quality wine except T₂₃ which showed ordinary quality.



ZINFANDEL



CABERNET SAUVIGNON



GULABI



SHIRAZ



BANGALORE BLUE



PUSA NAVRANG



ATHENS



RUBY RED

Plate4: Wine samples of different coloured varieties of grapes



THOMPSON SEEDLESS



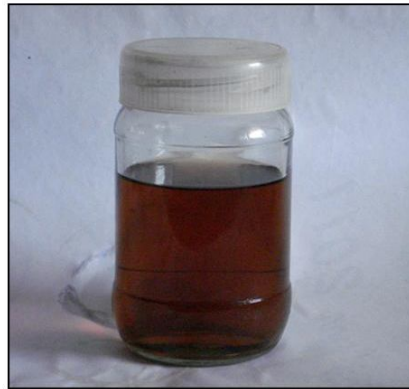
CHENIN BLANC



ITALIA



SAUVIGNON BLANC



SYMPHONY

Plate5: Wine samples of different white varieties of grapes



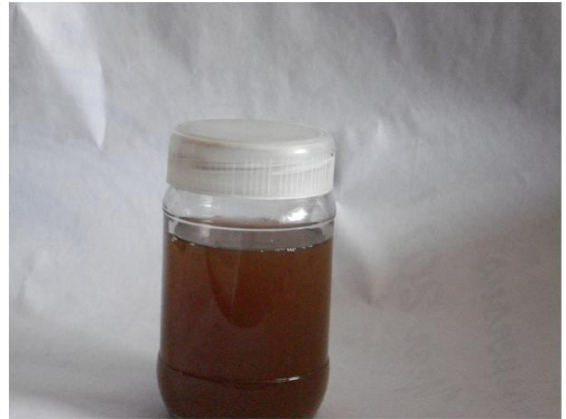
Plate10: Overall view of the wine samples for organoleptic evaluation



Plate11: Organoleptic evaluation of wine of different cultivars of grape by panel of judges



Thompson Seedless + Shiraz 2:1



Thompson Seedless + Shiraz 3:1



Thompson Seedless + Ruby Red 2:1



Thompson Seedless + Ruby Red 3:1



**Thompson Seedless +
Bangalore Blue 2:1**



**Thompson Seedless +
Bangalore Blue 3:1**

Plate7 : Wine produced from blending of Thompson Seedless with Shiraz, Ruby Red, Bangalore Blue in two different ratio (2:1 and 3:1)



Chenin Blanc + Shiraz 2:1



Chenin Blanc + Shiraz 3:1



Chenin Blanc + Ruby Red 2:1



Chenin Blanc + Ruby Red 3:1



**Chenin Blanc +
Bangalore Blue 2:1**



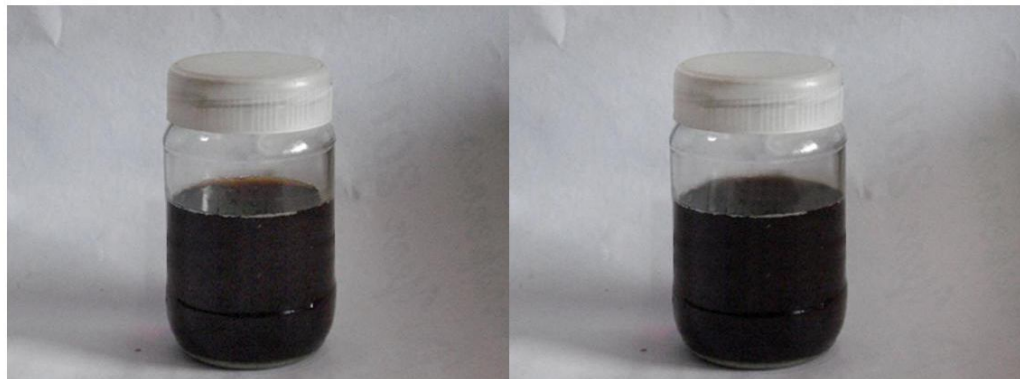
**Chenin Blanc +
Bangalore Blue 3:1**

Plate8: Wine produced from blending of Chenin Blanc with Shiraz, Ruby Red, Bangalore Blue in two different ratio (2:1 and 3:1)



Sauvignon Blanc + Shiraz 2:1

Sauvignon Blanc + Shiraz 3:1



**Sauvignon Blanc +
Ruby Red 2:1**

**Sauvignon Blanc +
Ruby Red 3:1**



**Sauvignon Blanc +
Bangalore Blue 2:1**

**Sauvignon Blanc +
Bangalore Blue 3:1**

Plate 6: Wine produced from blending of Sauvignon Blanc with Shiraz, Ruby Red, Bangalore Blue in two different ratio (2:1 and 3:1)



Italia + Shiraz 2:1



Italia + Shiraz 3:1



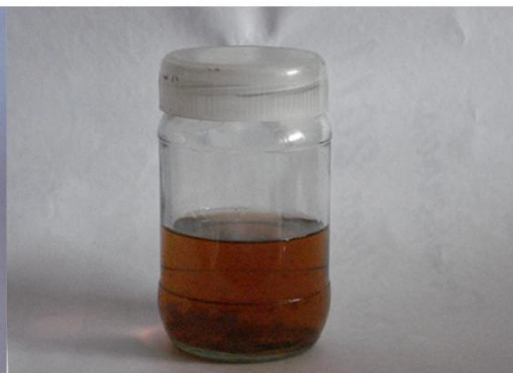
Italia + Ruby Red 2:1



Italia + Ruby Red 3:1



Italia + Bangalore Blue 2:1



Italia + Bangalore Blue 3:1

Plate9: Wine produced from blending of Italia with Shiraz, Ruby Red, Bangalore Blue in two different ratio (2:1 and 3:1)

Table 4.1. Pruning weight (kg/vine) of different varieties of Grape for both the seasons during 2006-07 and 2007-08 years

T.no	Variety	Summer pruning weight (kg/vine)			Winter pruning weight (kg/vine)		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	0.73	1.33	1.03	0.26	0.66	0.46
T ₂	Cabernet Sauvignon	1.33	2.23	1.78	0.63	1.13	0.88
T ₃	Gulabi	2.73	3.50	3.11	1.30	1.50	1.40
T ₄	Shiraz	4.56	5.33	4.94	2.13	3.40	2.76
T ₅	Bangalore Blue	2.36	4.46	3.41	1.53	1.76	1.64
T ₆	Pusa Navrang	2.16	3.10	2.63	0.56	1.26	0.91
T ₇	Athens	5.06	5.40	5.23	2.03	2.40	2.21
T ₈	Ruby Red	3.26	5.26	4.26	0.66	2.00	1.33
White							
T ₉	Thompson Seedless	1.56	2.33	1.94	0.73	1.60	1.16
T ₁₀	Chenin Blanc	1.73	2.33	2.03	0.73	0.83	0.78
T ₁₁	Sauvignon Blanc	1.56	2.90	2.23	0.23	1.06	0.64
T ₁₂	Italia	2.83	4.63	3.73	1.13	2.20	1.66
T ₁₃	Symphony	1.86	2.36	2.11	1.10	1.36	1.23
	Mean	2.43	3.47		1.00	1.62	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.18	0.53	*	0.12	0.34
Years	*	0.07	0.20	*	0.04	0.13
Varieties x Years	NS	0.26	NS	NS	0.17	NS

Table 4.2. Days taken for bud break in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Days taken for bud break		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	14.03	16.30	15.16
T ₂	Cabernet Sauvignon	14.43	17.30	15.86
T ₃	Gulabi	9.06	11.13	10.09
T ₄	Shiraz	13.00	15.00	14.00
T ₅	Bangalore Blue	8.06	8.93	8.49
T ₆	Pusa Navrang	7.20	9.10	8.15
T ₇	Athens	15.20	17.23	16.21
T ₈	Ruby Red	20.10	22.33	21.21
White				
T ₉	Thompson Seedless	17.03	18.86	17.94
T ₁₀	Chenin Blanc	9.10	10.60	9.85
T ₁₁	Sauvignon Blanc	10.60	12.53	11.56
T ₁₂	Italia	14.10	16.63	15.36
T ₁₃	Symphony	12.90	15.03	13.96
	Mean	12.67	14.69	

	F-test	SEM	CD at 5%
Varieties	*	0.68	1.94
Years	*	0.26	0.76
Varieties x Years	*	0.97	2.75

Table 4.3. Number of canes per vine in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Number of canes per vine		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	36.56	39.43	37.99
T ₂	Cabernet Sauvignon	40.83	55.06	47.94
T ₃	Gulabi	32.93	37.13	35.03
T ₄	Shiraz	50.50	59.36	54.93
T ₅	Bangalore Blue	32.56	36.66	34.61
T ₆	Pusa Navrang	41.46	47.06	44.26
T ₇	Athens	39.60	49.10	44.35
T ₈	Ruby Red	37.36	40.86	39.11
White				
T ₉	Thompson Seedless	30.76	35.06	32.91
T ₁₀	Chenin Blanc	52.56	55.23	53.89
T ₁₁	Sauvignon Blanc	38.50	45.56	42.03
T ₁₂	Italia	31.30	37.50	34.40
T ₁₃	Symphony	38.56	42.90	40.73
	Mean	38.72	44.68	

	F-test	SEM	CD at 5%
Varieties	*	1.01	2.87
Years	*	0.39	1.12
Varieties x Years	NS	1.43	NS

Table 4.4. Cane diameter (mm) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Cane diameter (mm)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	9.54	12.33	10.93
T ₂	Cabernet Sauvignon	11.76	13.56	12.66
T ₃	Gulabi	16.33	17.13	16.73
T ₄	Shiraz	14.93	16.00	15.46
T ₅	Bangalore Blue	15.30	18.46	16.88
T ₆	Pusa Navrang	16.20	16.50	16.35
T ₇	Athens	16.36	17.53	16.94
T ₈	Ruby Red	16.83	19.46	18.14
White				
T ₉	Thompson Seedless	15.17	16.16	15.66
T ₁₀	Chenin Blanc	13.46	14.20	13.83
T ₁₁	Sauvignon Blanc	14.16	14.86	14.51
T ₁₂	Italia	16.90	20.30	18.60
T ₁₃	Symphony	14.10	14.66	14.38
	Mean	14.69	16.24	

	F-test	SEM	CD at 5%
Varieties	*	0.65	1.85
Years	*	0.25	0.72
Varieties x Years	NS	0.92	NS

Table 4.5. Shoot length (cm) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Shoot length (cm)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	68.00	62.65	65.33
T ₂	Cabernet Sauvignon	69.66	75.66	72.66
T ₃	Gulabi	74.00	80.00	77.00
T ₄	Shiraz	64.66	66.33	65.50
T ₅	Bangalore Blue	49.00	57.65	53.33
T ₆	Pusa Navrang	59.34	64.60	62.00
T ₇	Athens	77.33	81.00	79.16
T ₈	Ruby Red	59.00	62.34	60.66
White				
T ₉	Thompson Seedless	74.66	75.60	75.16
T ₁₀	Chenin Blanc	68.67	70.00	69.33
T ₁₁	Sauvignon Blanc	64.65	66.00	65.32
T ₁₂	Italia	63.55	60.00	61.72
T ₁₃	Symphony	64.68	64.00	64.32
	Mean	65.94	68.15	

	F-test	SEM	CD at 5%
Varieties	*	1.74	4.95
Years	*	0.68	1.94
Varieties x Years	NS	2.47	NS

Table 4.6. Number of leaves in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Number of leaves		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	14.33	14.66	14.49
T ₂	Cabernet Sauvignon	13.66	14.33	13.99
T ₃	Gulabi	11.00	14.66	12.83
T ₄	Shiraz	21.66	21.33	21.49
T ₅	Bangalore Blue	9.00	10.66	9.83
T ₆	Pusa Navrang	13.66	15.33	14.49
T ₇	Athens	21.00	23.66	22.33
T ₈	Ruby Red	20.66	26.66	23.66
White				
T ₉	Thompson Seedless	15.33	20.66	17.99
T ₁₀	Chenin Blanc	15.00	22.00	18.50
T ₁₁	Sauvignon Blanc	15.00	22.33	18.66
T ₁₂	Italia	10.00	13.66	11.83
T ₁₃	Symphony	15.66	20.00	17.83
	Mean	15.07	18.45	

	F-test	SEM	CD at 5%
Varieties	*	0.55	1.58
Years	*	0.21	0.61
Varieties x Years	*	0.78	2.23

Table 4.7. Leaf area (cm²) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Leaf area (cm ²)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	48.66	43.93	46.29
T ₂	Cabernet Sauvignon	64.03	54.70	59.36
T ₃	Gulabi	68.30	64.70	66.50
T ₄	Shiraz	66.06	57.00	61.53
T ₅	Bangalore Blue	122.73	102.33	112.53
T ₆	Pusa Navrang	95.20	69.93	82.56
T ₇	Athens	76.16	68.10	72.13
T ₈	Ruby Red	99.26	84.63	91.94
White				
T ₉	Thompson Seedless	76.26	65.60	70.93
T ₁₀	Chenin Blanc	45.96	38.46	42.21
T ₁₁	Sauvignon Blanc	71.90	57.66	64.78
T ₁₂	Italia	56.53	46.40	51.46
T ₁₃	Symphony	76.26	65.60	70.93
	Mean	74.40	63.00	

	F-test	SEM	CD at 5%
Varieties	*	2.74	7.77
Years	*	1.07	3.05
Varieties x Years	NS	3.88	NS

Table 4.8. Days taken for 50% flowering in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Days taken for 50% flowering		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	34.70	37.96	36.33
T ₂	Cabernet Sauvignon	35.56	40.90	38.23
T ₃	Gulabi	34.12	37.73	35.92
T ₄	Shiraz	32.56	36.53	34.54
T ₅	Bangalore Blue	24.83	30.43	27.63
T ₆	Pusa Navrang	23.16	27.56	25.36
T ₇	Athens	34.30	41.66	37.98
T ₈	Ruby Red	41.26	45.53	43.39
White				
T ₉	Thompson Seedless	41.60	45.53	43.56
T ₁₀	Chenin Blanc	23.16	29.33	26.24
T ₁₁	Sauvignon Blanc	35.13	40.93	38.03
T ₁₂	Italia	42.00	46.74	44.37
T ₁₃	Symphony	23.90	33.20	28.55
	Mean	32.79	38.00	

	F-test	SEM	CD at 5%
Varieties	*	0.95	2.69
Years	*	0.37	1.05
Varieties x Years	NS	1.34	NS

Table 4.9. Number of bunches per vine in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Number of bunches per vine		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	64.30	76.63	70.46
T ₂	Cabernet Sauvignon	85.13	90.36	87.74
T ₃	Gulabi	43.90	47.50	45.70
T ₄	Shiraz	87.60	107.90	97.75
T ₅	Bangalore Blue	52.93	56.73	54.83
T ₆	Pusa Navrang	86.26	104.80	95.53
T ₇	Athens	61.06	59.90	60.48
T ₈	Ruby Red	45.20	47.33	46.26
White				
T ₉	Thompson Seedless	34.00	40.53	37.26
T ₁₀	Chenin Blanc	101.30	126.26	113.78
T ₁₁	Sauvignon Blanc	50.33	52.86	51.59
T ₁₂	Italia	35.73	41.76	38.74
T ₁₃	Symphony	66.73	78.70	72.71
	Mean	62.65	71.63	

	F-test	SEM	CD at 5%
Varieties	*	2.52	7.19
Years	*	0.99	2.82
Varieties x Years	NS	3.57	NS

Table 4.10. Mean bunch weight (g) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Mean bunch weight (g)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	152.33	146.26	149.29
T ₂	Cabernet Sauvignon	91.76	84.36	88.06
T ₃	Gulabi	92.46	86.73	89.59
T ₄	Shiraz	133.46	121.80	127.63
T ₅	Bangalore Blue	108.10	101.63	104.86
T ₆	Pusa Navrang	119.20	113.23	116.21
T ₇	Athens	155.56	154.23	154.89
T ₈	Ruby Red	140.96	132.26	136.61
White				
T ₉	Thompson Seedless	311.93	303.66	307.79
T ₁₀	Chenin Blanc	145.46	131.06	138.26
T ₁₁	Sauvignon Blanc	102.63	95.03	98.83
T ₁₂	Italia	335.56	327.66	331.61
T ₁₃	Symphony	99.53	97.23	98.38
	Mean	152.99	145.78	

	F-test	SEM	CD at 5%
Varieties	*	5.25	14.86
Years	NS	2.06	NS
Varieties x Years	NS	7.42	NS

Table 4.11. Mean bunch length (cm) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Mean bunch length (cm)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	10.83	10.70	10.76
T ₂	Cabernet Sauvignon	9.40	8.66	9.03
T ₃	Gulabi	7.36	7.76	7.56
T ₄	Shiraz	13.00	11.66	12.33
T ₅	Bangalore Blue	8.63	9.10	8.86
T ₆	Pusa Navrang	11.60	10.56	11.08
T ₇	Athens	9.70	9.30	9.50
T ₈	Ruby Red	9.20	9.03	9.11
White				
T ₉	Thompson Seedless	19.60	16.20	17.90
T ₁₀	Chenin Blanc	10.16	10.03	10.09
T ₁₁	Sauvignon Blanc	6.80	6.53	6.66
T ₁₂	Italia	18.80	15.20	17.00
T ₁₃	Symphony	7.36	6.73	7.04
	Mean	10.95	10.11	

	F-test	SEM	CD at 5%
Varieties	*	0.29	0.84
Years	*	0.11	0.33
Varieties x Years	NS	0.42	NS

Table 4.12. Number of berries per bunch in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Number of berries/bunch		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	69.30	66.36	67.83
T ₂	Cabernet Sauvignon	66.23	64.43	65.33
T ₃	Gulabi	30.66	32.80	31.73
T ₄	Shiraz	65.50	62.03	63.76
T ₅	Bangalore Blue	37.70	42.20	39.95
T ₆	Pusa Navrang	86.93	87.40	87.16
T ₇	Athens	58.90	55.96	57.43
T ₈	Ruby Red	55.46	70.96	63.21
White				
T ₉	Thompson Seedless	84.27	81.23	82.75
T ₁₀	Chenin Blanc	65.43	73.26	69.34
T ₁₁	Sauvignon Blanc	42.66	46.16	44.41
T ₁₂	Italia	78.10	79.60	78.85
T ₁₃	Symphony	46.60	55.46	51.03
	Mean	60.59	62.91	

	F-test	SEM	CD at 5%
Varieties	*	1.88	5.31
Years	*	0.73	2.08
Varieties x Years	NS	2.65	NS

Table 4.13. Hundred berry weight (g) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Hundred berry weight (g)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	222.66	213.50	218.08
T ₂	Cabernet Sauvignon	144.83	125.60	135.21
T ₃	Gulabi	282.33	280.10	281.21
T ₄	Shiraz	182.93	192.40	187.66
T ₅	Bangalore Blue	283.60	267.53	275.56
T ₆	Pusa Navrang	126.33	120.06	123.19
T ₇	Athens	258.73	244.03	251.38
T ₈	Ruby Red	230.30	191.20	210.75
White				
T ₉	Thompson Seedless	336.16	310.10	323.13
T ₁₀	Chenin Blanc	205.06	191.96	198.51
T ₁₁	Sauvignon Blanc	240.76	225.76	233.26
T ₁₂	Italia	424.70	403.73	414.21
T ₁₃	Symphony	250.30	233.03	241.66
	Mean	245.28	230.69	

	F-test	SEM	CD at 5%
Varieties	*	5.29	15.04
Years	*	2.07	5.90
Varieties x Years	NS	7.48	NS

Table 4.14. Berry diameter (mm) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Berry diameter (mm)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	16.26	14.30	15.28
T ₂	Cabernet Sauvignon	14.96	13.10	14.03
T ₃	Gulabi	17.16	15.86	16.51
T ₄	Shiraz	11.53	11.73	11.63
T ₅	Bangalore Blue	14.66	12.63	13.64
T ₆	Pusa Navrang	11.40	10.10	10.75
T ₇	Athens	14.26	15.00	14.63
T ₈	Ruby Red	15.63	14.80	15.21
White				
T ₉	Thompson Seedless	13.46	13.03	13.24
T ₁₀	Chenin Blanc	12.70	11.60	12.15
T ₁₁	Sauvignon Blanc	13.33	11.13	12.23
T ₁₂	Italia	18.40	17.47	17.93
T ₁₃	Symphony	14.23	12.53	13.38
	Mean	14.46	13.32	

	F-test	SEM	CD at 5%
Varieties	*	0.61	1.74
Years	*	0.24	0.68
Varieties x Years	*	0.87	2.47

Table 4.15. Fruit yield (kg /vine) of different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Fruit yield (kg/vine)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	9.46	10.36	9.91
T ₂	Cabernet Sauvignon	7.00	8.44	7.72
T ₃	Gulabi	4.53	5.36	4.94
T ₄	Shiraz	12.80	14.16	13.48
T ₅	Bangalore Blue	5.44	6.62	6.03
T ₆	Pusa Navrang	9.13	12.43	10.78
T ₇	Athens	8.44	8.78	8.61
T ₈	Ruby Red	6.66	6.83	6.74
White				
T ₉	Thompson Seedless	10.50	12.56	11.53
T ₁₀	Chenin Blanc	15.23	18.40	16.81
T ₁₁	Sauvignon Blanc	4.38	4.64	4.51
T ₁₂	Italia	12.50	14.56	13.53
T ₁₃	Symphony	6.83	7.80	7.31
	Mean	8.68	10.07	

	F-test	SEM	CD at 5%
Varieties	*	0.43	1.24
Years	*	0.17	0.48
Varieties x Years	NS	0.62	NS

Table 4.16. Heat unit requirement (Degree days) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Heat Units (Degree days)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	1878.54	1936.20	1907.37
T ₂	Cabernet Sauvignon	1932.02	2131.26	2031.64
T ₃	Gulabi	1834.00	1929.36	1881.68
T ₄	Shiraz	1825.20	1894.20	1859.70
T ₅	Bangalore Blue	1771.32	1860.26	1815.79
T ₆	Pusa Navrang	1720.36	1732.13	1726.24
T ₇	Athens	1914.82	2064.63	1989.72
T ₈	Ruby Red	1984.23	2255.70	2119.96
White				
T ₉	Thompson Seedless	1924.80	2155.53	2040.16
T ₁₀	Chenin Blanc	1747.80	1780.43	1764.11
T ₁₁	Sauvignon Blanc	1872.73	1980.30	1926.51
T ₁₂	Italia	1969.73	2445.20	2207.46
T ₁₃	Symphony	1784.26	1848.34	1816.30
	Mean	1858.44	2001.04	

	F-test	SEM	CD at 5%
Varieties	*	33.33	94.80
Years	*	13.70	37.18
Varieties x Years	*	47.14	134.06

Table 4.17. Juice recovery (%) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Juice recovery (%)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	68.60	65.66	67.13
T ₂	Cabernet Sauvignon	73.10	71.63	72.36
T ₃	Gulabi	55.53	53.00	54.26
T ₄	Shiraz	74.86	74.73	74.79
T ₅	Bangalore Blue	61.36	60.56	60.96
T ₆	Pusa Navrang	79.90	75.60	77.75
T ₇	Athens	65.60	65.56	65.58
T ₈	Ruby Red	59.80	58.33	59.06
White				
T ₉	Thompson Seedless	70.10	69.80	69.95
T ₁₀	Chenin Blanc	80.43	76.33	78.38
T ₁₁	Sauvignon Blanc	72.53	72.46	72.49
T ₁₂	Italia	57.10	55.56	56.33
T ₁₃	Symphony	67.80	67.40	67.60
	Mean	68.20	66.66	

	F-test	SEM	CD at 5%
Varieties	*	1.16	3.30
Years	NS	0.45	NS
Varieties x Years	NS	1.65	NS

Table 4.18. Total soluble solids (°B) of juice in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Total soluble solids (°B)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	18.70	17.63	18.16
T ₂	Cabernet Sauvignon	19.06	18.76	18.91
T ₃	Gulabi	16.06	15.20	15.63
T ₄	Shiraz	22.30	21.60	21.95
T ₅	Bangalore Blue	17.40	16.63	17.01
T ₆	Pusa Navrang	17.33	17.00	17.16
T ₇	Athens	18.23	16.20	17.21
T ₈	Ruby Red	17.16	16.66	16.91
White				
T ₉	Thompson Seedless	17.17	16.73	16.95
T ₁₀	Chenin Blanc	19.50	18.13	18.81
T ₁₁	Sauvignon Blanc	18.70	16.30	17.50
T ₁₂	Italia	15.66	15.20	15.43
T ₁₃	Symphony	16.46	15.66	16.06
	Mean	17.97	17.05	

	F-test	SEM	CD at 5%
Varieties	*	0.24	0.70
Years	*	0.09	0.27
Varieties x Years	*	0.34	0.99

Table 4.19. Titrable acidity of juice (%) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Titrable acidity (%)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	0.62	0.73	0.67
T ₂	Cabernet Sauvignon	0.58	0.62	0.60
T ₃	Gulabi	0.63	0.70	0.66
T ₄	Shiraz	0.74	0.78	0.76
T ₅	Bangalore Blue	0.82	0.86	0.84
T ₆	Pusa Navrang	0.68	0.72	0.70
T ₇	Athens	0.71	0.74	0.72
T ₈	Ruby Red	0.48	0.54	0.51
White				
T ₉	Thompson Seedless	0.55	0.64	0.59
T ₁₀	Chenin Blanc	0.91	0.93	0.92
T ₁₁	Sauvignon Blanc	0.72	0.74	0.73
T ₁₂	Italia	0.80	0.81	0.80
T ₁₃	Symphony	0.60	0.65	0.62
	Mean	0.68	0.72	

	F-test	SEM	CD at 5%
Varieties	*	0.02	0.07
Years	*	0.01	0.03
Varieties x Years	NS	0.03	NS

Table 4.20. pH of juice in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	pH of juice		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	3.43	3.50	3.46
T ₂	Cabernet Sauvignon	3.56	3.36	3.46
T ₃	Gulabi	3.50	3.40	3.45
T ₄	Shiraz	3.56	3.30	3.43
T ₅	Bangalore Blue	2.96	3.10	3.03
T ₆	Pusa Navrang	3.10	2.96	3.03
T ₇	Athens	3.60	3.46	3.53
T ₈	Ruby Red	3.20	3.40	3.30
White				
T ₉	Thompson Seedless	3.50	3.53	3.51
T ₁₀	Chenin Blanc	3.26	3.56	3.41
T ₁₁	Sauvignon Blanc	3.56	3.40	3.48
T ₁₂	Italia	3.00	2.93	2.96
T ₁₃	Symphony	3.56	3.40	3.48
	Mean	3.37	3.36	

	F-test	SEM	CD at 5%
Varieties	*	0.03	0.09
Years	NS	0.02	NS
Varieties x Years	NS	0.07	NS

Table 4.21. Total sugar content of juice (%) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Total sugar content of juice (%)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	17.50	17.09	17.29
T ₂	Cabernet Sauvignon	18.36	17.43	17.89
T ₃	Gulabi	15.57	15.18	15.37
T ₄	Shiraz	19.79	18.78	19.28
T ₅	Bangalore Blue	15.52	15.39	15.45
T ₆	Pusa Navrang	19.21	17.22	18.21
T ₇	Athens	16.37	15.96	16.16
T ₈	Ruby Red	16.21	15.50	15.85
White				
T ₉	Thompson Seedless	17.21	16.47	16.84
T ₁₀	Chenin Blanc	19.49	18.66	19.07
T ₁₁	Sauvignon Blanc	16.87	16.25	16.56
T ₁₂	Italia	13.72	12.57	13.14
T ₁₃	Symphony	16.27	15.66	15.91
	Mean	17.08	16.31	

	F-test	SEM	CD at 5%
Varieties	*	0.30	0.85
Years	*	0.12	0.37
Varieties x Years	*	0.34	0.99

Table 4.22. Reducing sugar content of juice (%) in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Variety	Reducing sugar content of juice (%)		
		2006-07	2007-08	Mean
Coloured				
T ₁	Zinfandel	13.96	13.63	13.79
T ₂	Cabernet Sauvignon	14.64	13.90	14.27
T ₃	Gulabi	12.42	12.11	12.26
T ₄	Shiraz	15.78	14.98	15.38
T ₅	Bangalore Blue	13.11	13.00	13.05
T ₆	Pusa Navrang	8.27	7.41	7.84
T ₇	Athens	13.06	12.73	12.89
T ₈	Ruby Red	12.93	12.36	12.64
White				
T ₉	Thompson Seedless	13.73	13.14	13.43
T ₁₀	Chenin Blanc	15.54	14.88	15.21
T ₁₁	Sauvignon Blanc	13.45	12.96	13.20
T ₁₂	Italia	10.94	10.02	10.48
T ₁₃	Symphony	12.96	12.41	12.69
	Mean	13.14	12.58	

	F-test	SEM	CD at 5%
Varieties	*	0.20	0.61
Years	*	0.12	0.35
Varieties x Years	*	0.24	0.71

Table 4.23. Total soluble solids of wine (°B) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Total soluble solids of wine (°B)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	8.86	9.13	8.99	7.80	8.06	7.93
T ₂	Cabernet Sauvignon	8.20	8.93	8.56	7.10	7.80	7.45
T ₃	Gulabi	10.20	10.46	10.33	9.06	8.93	8.99
T ₄	Shiraz	7.80	8.06	7.93	6.83	6.93	6.88
T ₅	Bangalore Blue	9.96	10.13	10.04	9.00	9.03	9.01
T ₆	Pusa Navrang	8.40	9.28	8.84	7.80	8.26	8.03
T ₇	Athens	9.73	9.80	9.76	8.73	8.93	8.83
T ₈	Ruby Red	10.26	10.40	10.33	9.13	9.53	9.33
White							
T ₉	Thompson Seedless	8.86	9.06	8.96	7.06	8.13	7.59
T ₁₀	Chenin Blanc	8.06	8.33	8.19	7.00	7.20	7.10
T ₁₁	Sauvignon Blanc	9.93	10.06	9.99	9.13	9.33	9.23
T ₁₂	Italia	10.80	11.06	10.93	9.93	10.10	10.01
T ₁₃	Symphony	9.46	9.73	9.59	8.20	8.26	8.23
	Mean	9.27	9.57		8.20	8.50	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.07	0.21	*	0.06	0.19
Years	*	0.02	0.08	*	0.02	0.05
Varieties x Years	*	0.10	0.30	*	0.09	0.27

Table 4.24. Titrable acidity of wine (%) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Titrable acidity of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	0.50	0.54	0.52	0.45	0.51	0.48
T ₂	Cabernet Sauvignon	0.41	0.51	0.46	0.38	0.42	0.40
T ₃	Gulabi	0.59	0.61	0.60	0.52	0.59	0.55
T ₄	Shiraz	0.65	0.66	0.65	0.52	0.55	0.53
T ₅	Bangalore Blue	0.78	0.79	0.78	0.67	0.71	0.69
T ₆	Pusa Navrang	0.59	0.62	0.60	0.53	0.58	0.55
T ₇	Athens	0.61	0.65	0.63	0.54	0.61	0.57
T ₈	Ruby Red	0.30	0.46	0.38	0.31	0.38	0.34
White							
T ₉	Thompson Seedless	0.48	0.54	0.51	0.42	0.45	0.43
T ₁₀	Chenin Blanc	0.81	0.90	0.85	0.76	0.82	0.79
T ₁₁	Sauvignon Blanc	0.48	0.50	0.49	0.42	0.43	0.42
T ₁₂	Italia	0.67	0.71	0.69	0.59	0.65	0.62
T ₁₃	Symphony	0.50	0.51	0.50	0.39	0.48	0.43
	Mean	0.56	0.61		0.50	0.55	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.01	0.05	*	0.03	0.09
Years	*	0.01	0.03	*	0.01	0.03
Varieties x Years	NS	0.02	NS	NS	0.04	NS

Table 4.25. Volatile acidity of wine (%) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Volatile acidity (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	0.044	0.045	0.044	0.038	0.041	0.039
T ₂	Cabernet Sauvignon	0.042	0.045	0.043	0.040	0.041	0.040
T ₃	Gulabi	0.062	0.064	0.063	0.052	0.059	0.055
T ₄	Shiraz	0.031	0.033	0.032	0.026	0.029	0.027
T ₅	Bangalore Blue	0.060	0.062	0.061	0.051	0.055	0.053
T ₆	Pusa Navrang	0.047	0.049	0.048	0.042	0.045	0.043
T ₇	Athens	0.051	0.055	0.053	0.049	0.052	0.050
T ₈	Ruby Red	0.071	0.076	0.073	0.063	0.068	0.065
White							
T ₉	Thompson Seedless	0.026	0.032	0.029	0.021	0.026	0.023
T ₁₀	Chenin Blanc	0.014	0.016	0.015	0.011	0.012	0.011
T ₁₁	Sauvignon Blanc	0.017	0.024	0.020	0.013	0.017	0.015
T ₁₂	Italia	0.033	0.037	0.035	0.028	0.031	0.029
T ₁₃	Symphony	0.013	0.016	0.014	0.010	0.011	0.010
	Mean	0.039	0.042		0.034	0.037	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.003	0.012	*	0.004	0.013
Years	NS	0.001	NS	NS	0.001	NS
Varieties x Years	NS	0.002	NS	NS	0.003	NS

Table 4.26. Total sugars content of wine (%) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Total Sugar content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	4.80	5.10	4.95	3.13	4.06	3.59
T ₂	Cabernet Sauvignon	4.70	4.87	4.78	3.06	3.13	3.09
T ₃	Gulabi	5.46	5.65	5.55	4.83	4.96	4.89
T ₄	Shiraz	4.33	4.42	4.37	3.10	3.26	3.18
T ₅	Bangalore Blue	5.23	5.57	5.40	3.60	3.73	3.66
T ₆	Pusa Navrang	5.32	5.60	5.46	4.83	4.90	4.86
T ₇	Athens	5.36	5.42	5.39	4.03	4.13	4.08
T ₈	Ruby Red	6.33	6.56	6.44	5.16	5.23	5.19
White							
T ₉	Thompson Seedless	5.33	5.57	5.45	4.20	4.33	4.26
T ₁₀	Chenin Blanc	4.33	4.46	4.39	3.16	3.20	3.18
T ₁₁	Sauvignon Blanc	5.13	5.53	5.33	4.43	4.64	4.53
T ₁₂	Italia	6.26	6.40	6.33	5.03	5.43	5.23
T ₁₃	Symphony	5.10	5.30	5.20	3.50	3.67	3.58
	Mean	5.20	5.41		4.00	4.20	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.05	0.16	*	0.04	0.14
Years	*	0.02	0.08	*	0.02	0.05
Varieties x Years	NS	0.10	NS	NS	0.07	NS

Table 4.27. Reducing sugar content of wine (%) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Reducing Sugar content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	3.20	3.29	3.24	2.06	2.23	2.14
T ₂	Cabernet Sauvignon	2.40	3.10	2.75	1.36	1.70	1.53
T ₃	Gulabi	4.03	4.20	4.11	2.53	2.68	2.60
T ₄	Shiraz	2.10	2.80	2.45	1.46	2.06	1.76
T ₅	Bangalore Blue	3.33	3.53	3.43	2.16	2.33	2.24
T ₆	Pusa Navrang	3.50	3.83	3.66	2.23	2.46	2.34
T ₇	Athens	4.00	4.23	4.11	2.96	3.10	3.03
T ₈	Ruby Red	4.10	4.30	4.20	3.03	3.23	3.13
White							
T ₉	Thompson Seedless	4.13	4.30	4.21	2.63	2.73	2.68
T ₁₀	Chenin Blanc	3.10	3.16	3.13	1.46	1.63	1.54
T ₁₁	Sauvignon Blanc	4.13	4.16	4.14	3.10	3.50	3.30
T ₁₂	Italia	4.46	5.33	4.89	3.26	3.40	3.33
T ₁₃	Symphony	4.10	4.13	4.11	3.23	3.46	3.34
	Mean	3.58	3.87		2.42	2.65	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.04	0.13	*	0.04	0.12
Years	*	0.02	0.05	*	0.01	0.04
Varieties x Years	NS	0.06	NS	NS	0.05	NS

Table 4.29. Tannin content of wine (%) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Tannin content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	0.039	0.045	0.042	0.032	0.039	0.035
T ₂	Cabernet Sauvignon	0.050	0.060	0.055	0.040	0.046	0.043
T ₃	Gulabi	0.055	0.062	0.058	0.053	0.054	0.053
T ₄	Shiraz	0.037	0.045	0.041	0.031	0.039	0.035
T ₅	Bangalore Blue	0.030	0.035	0.032	0.025	0.031	0.028
T ₆	Pusa Navrang	0.058	0.068	0.063	0.052	0.058	0.055
T ₇	Athens	0.051	0.053	0.052	0.045	0.046	0.045
T ₈	Ruby Red	0.064	0.071	0.067	0.058	0.063	0.060
White							
T ₉	Thompson Seedless	0.014	0.016	0.015	0.009	0.012	0.010
T ₁₀	Chenin Blanc	0.006	0.009	0.007	0.003	0.005	0.004
T ₁₁	Sauvignon Blanc	0.014	0.016	0.015	0.007	0.010	0.008
T ₁₂	Italia	0.019	0.022	0.020	0.014	0.018	0.016
T ₁₃	Symphony	0.015	0.016	0.015	0.008	0.011	0.009
	Mean	0.034	0.039		0.029	0.033	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.003	0.009	*	0.002	0.007
Years	*	0.001	0.003	NS	0.001	NS
Varieties x Years	NS	0.003	NS	NS	0.003	NS

Table 4.30. Total phenol content of wine (mg/l) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Total Phenol content of wine (mg/l)					
		Before			After		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	1334.66	1444.33	1389.49	1300.33	1404.66	1352.49
T ₂	Cabernet Sauvignon	1057.00	1111.33	1084.16	961.00	1054.66	1007.83
T ₃	Gulabi	1543.66	1574.66	1559.16	1529.00	1541.33	1535.16
T ₄	Shiraz	1181.33	1265.33	1223.33	1143.00	1216.66	1179.83
T ₅	Bangalore blue	1366.00	1426.00	1396.00	1319.33	1382.33	1350.83
T ₆	Pusa Navrang	1651.66	1741.33	1696.49	1607.33	1698.33	1652.83
T ₇	Athens	1534.00	1581.00	1557.50	1495.33	1526.33	1510.83
T ₈	Ruby Red	1635.00	1698.00	1666.50	1598.00	1641.00	1619.50
White							
T ₉	Thompson Seedless	440.33	462.00	451.16	414.00	430.33	422.16
T ₁₀	Chenin Blanc	229.00	244.00	236.50	207.33	219.34	213.33
T ₁₁	Sauvignon Blanc	234.00	260.66	247.33	210.00	225.00	217.50
T ₁₂	Italia	513.00	541.66	527.33	494.33	508.65	511.49
T ₁₃	Symphony	292.66	321.00	306.83	269.66	291.22	280.44
	Mean	1000.94	1051.63		965.28	1010.75	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	8.46	24.08	*	7.05	20.05
Years	*	3.32	10.01	*	4.76	14.64
Varieties x Years	NS	11.97	NS	NS	9.97	NS

Table 4.28. Alcohol content of wine (%) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Alcohol content of wine (%)					
		Before aging			After aging		
		C 2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	10.63	10.13	10.38	11.20	10.52	10.86
T ₂	Cabernet Sauvignon	11.43	10.33	10.88	12.13	10.83	11.48
T ₃	Gulabi	9.23	9.00	9.11	9.80	9.60	9.70
T ₄	Shiraz	11.73	11.13	11.43	13.00	11.50	12.25
T ₅	Bangalore Blue	9.20	9.12	9.16	9.80	9.56	9.68
T ₆	Pusa Navrang	8.56	8.43	8.49	9.46	9.26	9.36
T ₇	Athens	9.70	9.46	9.58	10.60	10.26	10.43
T ₈	Ruby Red	8.10	8.00	8.05	9.33	9.10	9.21
White							
T ₉	Thompson Seedless	10.20	9.76	9.98	10.60	10.26	10.43
T ₁₀	Chenin Blanc	11.55	11.06	11.30	12.93	11.23	12.08
T ₁₁	Sauvignon Blanc	10.00	9.63	9.81	10.46	10.13	10.29
T ₁₂	Italia	8.13	7.45	7.79	9.06	8.50	8.78
T ₁₃	Symphony	9.64	9.22	9.43	10.26	9.80	10.03
	Mean	9.85	9.44		10.66	10.04	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	0.04	0.12	*	0.05	0.15
Years	*	0.01	0.05	*	0.02	0.06
Varieties x Years	NS	0.07	NS	NS	0.06	NS

Table 4.31. Flavonoid content of wine (mg/l) before and after aging in different varieties of Grape during 2006-07 and 2007-08 years

T.no	Varieties	Flavonoid content of wine (mg/l)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
Coloured							
T ₁	Zinfandel	562.00	572.70	567.35	519.00	531.60	525.30
T ₂	Cabernet Sauvignon	823.65	819.00	821.32	773.00	794.00	783.50
T ₃	Gulabi	741.00	784.32	762.66	710.66	731.00	720.83
T ₄	Shiraz	610.33	654.23	632.28	581.00	601.32	591.16
T ₅	Bangalore Blue	729.00	761.60	745.30	694.32	711.24	702.78
T ₆	Pusa Navrang	944.62	983.66	964.14	900.65	944.20	922.42
T ₇	Athens	545.34	562.65	553.99	526.44	532.66	529.55
T ₈	Ruby Red	830.66	872.33	851.49	812.00	834.66	823.33
White							
T ₉	Thompson Seedless	162.00	154.62	158.31	141.32	129.00	135.16
T ₁₀	Chenin Blanc	143.60	148.00	145.80	118.66	126.00	122.33
T ₁₁	Sauvignon Blanc	154.55	161.23	157.89	125.55	136.33	130.94
T ₁₂	Italia	277.70	286.00	281.85	247.23	268.66	257.94
T ₁₃	Symphony	151.65	144.33	147.99	124.68	118.00	121.34
	Mean	513.54	531.12		482.65	496.82	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Varieties	*	12.54	37.25	*	10.86	32.45
Years	NS	11.00	NS	NS	10.33	NS
Varieties x Years	NS	13.60	NS	NS	11.22	NS

**Table 4.32. Organoleptic evaluation of wine after aging in different varieties of Grape
(Mean of two years data)**

T.no	Varieties	Organoleptic evaluation						Overall acceptability	Mean
		Appearance	Aroma	Flavour	Taste	Colour			
Max. Score		20	20	20	20	20	20	20	
Coloured									
T ₁	Zinfandel	15.23	15.23	14.78	15.71	13.78	13.36	14.68	
T ₂	Cabernet Sauvignon	16.35	16.35	14.93	16.55	16.08	12.18	15.40	
T ₃	Gulabi	11.85	11.18	11.91	11.45	12.83	11.00	11.70	
T ₄	Shiraz	17.73	15.75	15.41	17.30	16.55	14.18	16.15	
T ₅	Bangalore Blue	13.71	13.81	13.61	14.50	13.66	13.55	13.80	
T ₆	Pusa Navrang	14.81	11.90	12.36	14.20	12.23	11.83	12.88	
T ₇	Athens	15.16	14.56	13.71	14.60	14.60	12.23	14.14	
T ₈	Ruby Red	12.70	11.91	10.43	11.61	10.23	10.66	11.25	
White									
T ₉	Thompson Seedless	14.30	13.21	14.66	14.05	12.76	10.95	13.32	
T ₁₀	Chenin Blanc	16.66	14.98	16.46	16.53	14.63	13.21	15.41	
T ₁₁	Sauvignon Blanc	12.75	14.88	15.23	13.61	15.73	12.30	14.08	
T ₁₂	Italia	10.66	10.96	11.26	10.11	10.55	10.50	10.67	
T ₁₃	Symphony	14.38	13.81	14.88	14.50	14.50	11.23	13.88	
	Mean	14.33	13.73	13.81	14.20	13.70	12.09		
	SEm	0.06	0.08	0.10	0.07	0.08	0.05		
	CD	0.19	0.25	0.28	0.22	0.24	0.14		
	F-test	*	*	*	*	*	*		
<p>* : Significant NS: Non significant Hedonic scale: 18-20 excellent, 15-17 good, 12-14 fair, 9-11 ordinary, 6-8 poor, 3-5 bad, 1-2 very bad</p>									

Table 4.38. Total soluble solids of wine (°B) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	Total Soluble Solids of wine (°B)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	7.33	8.13	7.73	7.00	7.53	7.26
T ₂	Thompson Seedless+Shiraz 3:1	7.46	8.53	7.99	7.13	7.86	7.49
T ₃	Thompson Seedless +Ruby Red 2:1	10.00	10.26	10.13	9.33	9.06	9.19
T ₄	Thompson Seedless+Ruby Red 3:1	8.10	10.00	9.05	7.66	8.06	7.86
T ₅	Thompson Seedless+B.Blue 2:1	9.06	9.60	9.33	8.86	9.20	9.03
T ₆	Thompson Seedless+B.Blue 3:1	8.20	9.33	8.76	7.20	8.33	7.76
T ₇	Chenin blanc+Shiraz 2:1	6.60	7.93	7.26	6.20	7.00	6.60
T ₈	Chenin blanc+Shiraz 3:1	6.63	8.33	7.48	6.13	7.53	6.83
T ₉	Chenin blanc+Ruby Red 2:1	9.40	9.73	9.56	8.80	8.93	8.86
T ₁₀	Chenin blanc+Ruby Red 3:1	9.06	9.40	9.23	8.00	8.40	8.20
T ₁₁	Chenin blanc+B.Blue 2:1	8.83	8.93	8.88	8.40	8.46	8.43
T ₁₂	Chenin blanc+B.Blue 3:1	8.53	8.66	8.59	8.13	8.20	8.16
T ₁₃	Sauvignon Blanc+Shiraz 2:1	9.03	9.26	9.14	9.00	9.13	9.06
T ₁₄	Sauvignon Blanc+Shiraz 3:1	9.10	9.23	9.16	8.86	9.06	8.96
T ₁₅	Sauvignon Blanc+Ruby Red2:1	10.46	10.86	10.66	10.03	10.40	10.21
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	10.30	10.66	10.48	9.96	10.26	10.11
T ₁₇	Sauvignon Blanc+B.Blue 2:1	10.16	10.33	10.24	9.83	10.06	9.94
T ₁₈	Sauvignon Blanc+B.Blue 3:1	9.80	9.93	9.86	9.13	9.33	9.23
T ₁₉	Italia +Shiraz 2:1	9.80	10.46	10.13	9.20	10.00	9.60
T ₂₀	Italia +Shiraz 3:1	10.13	10.26	10.19	9.26	10.13	9.69
T ₂₁	Italia +Ruby Red 2:1	10.46	10.86	10.66	10.13	10.46	10.29
T ₂₂	Italia +Ruby Red 3:1	10.40	10.53	10.46	10.00	10.26	10.13
T ₂₃	Italia +B.Blue 2:1	9.66	10.33	9.99	9.40	10.00	9.70
T ₂₄	Italia +B.Blue 3:1	9.80	10.00	9.90	9.03	9.73	9.38
	Mean	9.09	9.64		8.61	9.05	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.06	0.19	*	0.06	0.18
Years	*	0.02	0.05	*	0.01	0.05
Treatments x Years	*	0.09	0.27	NS	0.08	NS

Table 4.39. Titrable acidity of wine (%) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	Titrable acidity of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	0.62	0.67	0.64	0.55	0.62	0.58
T ₂	Thompson Seedless+Shiraz 3:1	0.71	0.77	0.74	0.61	0.72	0.66
T ₃	Thompson Seedless +Ruby Red 2:1	0.51	0.51	0.51	0.42	0.43	0.42
T ₄	Thompson Seedless+Ruby Red 3:1	0.53	0.54	0.53	0.46	0.49	0.47
T ₅	Thompson Seedless+B.Blue 2:1	0.71	0.77	0.74	0.66	0.68	0.67
T ₆	Thompson Seedless+B.Blue 3:1	0.84	0.96	0.90	0.75	0.88	0.81
T ₇	Chenin blanc+Shiraz 2:1	1.01	1.12	1.06	0.92	1.01	0.96
T ₈	Chenin blanc+Shiraz 3:1	1.14	1.20	1.17	1.00	1.12	1.06
T ₉	Chenin blanc+Ruby Red 2:1	0.50	0.58	0.54	0.41	0.50	0.45
T ₁₀	Chenin blanc+Ruby Red 3:1	0.61	0.67	0.64	0.44	0.50	0.47
T ₁₁	Chenin blanc+B.Blue 2:1	1.26	1.31	1.28	1.13	1.22	1.17
T ₁₂	Chenin blanc+B.Blue 3:1	1.33	1.43	1.38	1.21	1.26	1.23
T ₁₃	Sauvignon Blanc+Shiraz 2:1	0.91	1.10	1.00	0.86	1.00	0.93
T ₁₄	Sauvignon Blanc+Shiraz 3:1	1.01	1.22	1.11	0.90	1.12	1.01
T ₁₅	Sauvignon Blanc+Ruby Red2:1	0.93	0.96	0.94	0.79	0.82	0.80
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	1.00	1.07	1.03	0.88	0.96	0.92
T ₁₇	Sauvignon Blanc+B.Blue 2:1	1.19	1.28	1.23	1.04	1.19	1.11
T ₁₈	Sauvignon Blanc+B.Blue 3:1	1.25	1.31	1.28	1.06	1.20	1.13
T ₁₉	Italia +Shiraz 2:1	1.11	1.20	1.15	1.00	1.11	1.05
T ₂₀	Italia +Shiraz 3:1	1.20	1.22	1.21	1.05	1.09	1.07
T ₂₁	Italia +Ruby Red 2:1	0.79	0.80	0.79	0.61	0.75	0.68
T ₂₂	Italia +Ruby Red 3:1	0.77	0.81	0.79	0.71	0.75	0.73
T ₂₃	Italia +B.Blue 2:1	1.21	1.30	1.25	1.17	1.22	1.19
T ₂₄	Italia +B.Blue 3:1	1.33	1.53	1.43	1.07	1.32	1.19
	Mean	0.93	1.01		0.82	0.91	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.04	0.12	*	0.07	0.20
Years	NS	0.03	NS	*	0.02	0.06
Treatments x Years	NS	0.01	NS	NS	0.03	NS

Table 4.40. Volatile acidity of wine (%) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Volatile acidity of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	0.028	0.030	0.029	0.021	0.025	0.023
T ₂	Thompson Seedless+Shiraz 3:1	0.031	0.032	0.031	0.022	0.028	0.025
T ₃	Thompson Seedless +Ruby Red 2:1	0.035	0.036	0.035	0.028	0.034	0.031
T ₄	Thompson Seedless+Ruby Red 3:1	0.038	0.037	0.037	0.030	0.034	0.032
T ₅	Thompson Seedless+B.Blue 2:1	0.029	0.032	0.030	0.025	0.027	0.026
T ₆	Thompson Seedless+B.Blue 3:1	0.029	0.033	0.031	0.027	0.029	0.028
T ₇	Chenin blanc+Shiraz 2:1	0.019	0.017	0.018	0.011	0.013	0.012
T ₈	Chenin blanc+Shiraz 3:1	0.021	0.021	0.021	0.014	0.018	0.016
T ₉	Chenin blanc+Ruby Red 2:1	0.025	0.028	0.026	0.018	0.024	0.021
T ₁₀	Chenin blanc+Ruby Red 3:1	0.026	0.029	0.027	0.021	0.025	0.023
T ₁₁	Chenin blanc+B.Blue 2:1	0.021	0.022	0.021	0.015	0.019	0.017
T ₁₂	Chenin blanc+B.Blue 3:1	0.024	0.024	0.024	0.018	0.020	0.019
T ₁₃	Sauvignon Blanc+Shiraz 2:1	0.016	0.018	0.017	0.010	0.014	0.012
T ₁₄	Sauvignon Blanc+Shiraz 3:1	0.018	0.020	0.019	0.013	0.015	0.014
T ₁₅	Sauvignon Blanc+Ruby Red2:1	0.021	0.025	0.023	0.019	0.021	0.020
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	0.023	0.027	0.025	0.018	0.024	0.021
T ₁₇	Sauvignon Blanc+B.Blue 2:1	0.020	0.022	0.021	0.016	0.020	0.018
T ₁₈	Sauvignon Blanc+B.Blue 3:1	0.020	0.026	0.023	0.017	0.021	0.019
T ₁₉	Italia +Shiraz 2:1	0.038	0.040	0.039	0.032	0.036	0.034
T ₂₀	Italia +Shiraz 3:1	0.040	0.042	0.041	0.034	0.038	0.036
T ₂₁	Italia +Ruby Red 2:1	0.042	0.047	0.044	0.036	0.042	0.039
T ₂₂	Italia +Ruby Red 3:1	0.045	0.048	0.046	0.039	0.044	0.041
T ₂₃	Italia +B.Blue 2:1	0.038	0.040	0.039	0.036	0.038	0.037
T ₂₄	Italia +B.Blue 3:1	0.041	0.043	0.042	0.036	0.040	0.038
	Mean	0.028	0.030		0.023	0.027	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.002	0.005	*	0.001	0.003
Years	*	0.005	0.015	NS	0.002	NS
Treatments x Years	NS	0.003	NS	NS	0.003	NS

Table 4.41. Total sugar content of wine (%) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Total sugars content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	4.20	4.55	4.37	3.08	3.28	3.18
T ₂	Thompson Seedless+Shiraz 3:1	4.47	4.73	4.60	3.31	3.68	3.49
T ₃	Thompson Seedless +Ruby Red 2:1	5.78	5.97	5.87	4.78	5.09	4.93
T ₄	Thompson Seedless+Ruby Red 3:1	5.40	5.61	5.50	4.13	4.87	4.50
T ₅	Thompson Seedless+B.Blue 2:1	4.29	4.39	4.34	3.36	3.72	3.54
T ₆	Thompson Seedless+B.Blue 3:1	4.14	4.21	4.17	3.15	3.18	3.16
T ₇	Chenin blanc+Shiraz 2:1	3.22	3.54	3.38	2.16	2.34	2.25
T ₈	Chenin blanc+Shiraz 3:1	3.60	3.80	3.70	2.14	2.48	2.31
T ₉	Chenin blanc+Ruby Red 2:1	4.57	4.60	4.59	4.14	4.24	4.19
T ₁₀	Chenin blanc+Ruby Red 3:1	4.13	4.41	4.27	4.01	4.13	4.07
T ₁₁	Chenin blanc+B.Blue 2:1	4.34	4.36	4.35	3.26	3.64	3.45
T ₁₂	Chenin blanc+B.Blue 3:1	4.04	4.34	4.19	3.01	3.09	3.05
T ₁₃	Sauvignon Blanc+Shiraz 2:1	3.54	3.87	3.70	2.59	2.67	2.63
T ₁₄	Sauvignon Blanc+Shiraz 3:1	3.61	4.02	3.81	2.87	2.88	2.87
T ₁₅	Sauvignon Blanc+Ruby Red2:1	5.29	5.72	5.50	4.55	4.70	4.62
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	5.16	5.39	5.27	4.16	4.34	4.25
T ₁₇	Sauvignon Blanc+B.Blue 2:1	4.49	4.61	4.55	3.81	4.11	3.96
T ₁₈	Sauvignon Blanc+B.Blue 3:1	4.13	4.19	4.16	3.74	3.80	3.77
T ₁₉	Italia +Shiraz 2:1	5.10	5.22	5.16	4.35	4.48	4.41
T ₂₀	Italia +Shiraz 3:1	5.34	5.54	5.44	4.44	4.65	4.54
T ₂₁	Italia +Ruby Red 2:1	6.02	6.19	6.10	5.42	5.64	5.53
T ₂₂	Italia +Ruby Red 3:1	5.70	5.96	5.83	5.27	5.39	5.33
T ₂₃	Italia +B.Blue 2:1	5.53	5.83	5.68	5.07	5.42	5.24
T ₂₄	Italia +B.Blue 3:1	5.14	5.55	5.34	4.87	5.10	4.98
	Mean	4.63	4.85		3.81	4.03	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.04	0.13	*	0.03	0.09
Years	*	0.01	0.03	*	0.02	0.06
Treatments x Years	NS	0.06	NS	NS	0.04	NS

Table 4.42. Reducing sugar content of wine (%) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Reducing sugar content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	3.14	3.19	3.16	2.91	2.95	2.93
T ₂	Thompson Seedless+Shiraz 3:1	3.15	3.60	3.37	2.92	3.09	3.00
T ₃	Thompson Seedless +Ruby Red 2:1	4.55	4.82	4.68	4.09	4.46	4.27
T ₄	Thompson Seedless+Ruby Red 3:1	4.15	4.44	4.29	3.90	4.16	4.03
T ₅	Thompson Seedless+B.Blue 2:1	3.42	3.72	3.57	3.06	3.27	3.16
T ₆	Thompson Seedless+B.Blue 3:1	3.36	3.42	3.39	3.09	3.30	3.19
T ₇	Chenin blanc+Shiraz 2:1	2.02	2.06	2.04	1.80	1.89	1.84
T ₈	Chenin blanc+Shiraz 3:1	2.17	2.24	2.20	1.88	1.95	1.91
T ₉	Chenin blanc+Ruby Red 2:1	3.86	4.13	3.99	3.57	3.88	3.72
T ₁₀	Chenin blanc+Ruby Red 3:1	3.44	3.86	3.65	3.23	3.42	3.32
T ₁₁	Chenin blanc+B.Blue 2:1	3.29	3.70	3.49	3.03	3.26	3.14
T ₁₂	Chenin blanc+B.Blue 3:1	2.98	3.18	3.08	2.51	2.87	2.69
T ₁₃	Sauvignon Blanc+Shiraz 2:1	2.35	2.69	2.52	2.06	2.42	2.24
T ₁₄	Sauvignon Blanc+Shiraz 3:1	2.79	2.96	2.87	2.25	2.45	2.35
T ₁₅	Sauvignon Blanc+Ruby Red2:1	4.15	4.37	4.26	3.90	4.14	4.02
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	4.10	4.08	4.09	3.80	3.93	3.86
T ₁₇	Sauvignon Blanc+B.Blue 2:1	3.66	3.79	3.72	3.25	3.42	3.33
T ₁₈	Sauvignon Blanc+B.Blue 3:1	3.31	3.43	3.37	2.95	3.07	3.01
T ₁₉	Italia +Shiraz 2:1	3.93	4.36	4.14	3.45	3.91	3.68
T ₂₀	Italia +Shiraz 3:1	4.34	4.85	4.59	3.88	4.23	4.05
T ₂₁	Italia +Ruby Red 2:1	5.33	5.54	5.43	4.79	4.81	4.80
T ₂₂	Italia +Ruby Red 3:1	5.01	5.14	5.07	4.17	4.34	4.25
T ₂₃	Italia +B.Blue 2:1	4.79	5.06	4.92	4.28	4.63	4.45
T ₂₄	Italia +B.Blue 3:1	4.21	4.87	4.54	3.80	4.21	4.00
	Mean	3.64	3.89		3.27	3.50	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.04	0.11	*	0.02	0.06
Years	*	0.01	0.03	NS	0.07	NS
Treatments x Years	NS	0.06	NS	NS	0.03	NS

Table 4.44. Tannin content of wine (%) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Tannin content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	0.017	0.021	0.019	0.012	0.017	0.014
T ₂	Thompson Seedless+Shiraz 3:1	0.015	0.019	0.017	0.011	0.015	0.013
T ₃	Thompson Seedless +Ruby Red 2:1	0.022	0.027	0.024	0.018	0.023	0.020
T ₄	Thompson Seedless+Ruby Red 3:1	0.019	0.024	0.021	0.016	0.019	0.017
T ₅	Thompson Seedless+B.Blue 2:1	0.018	0.026	0.022	0.015	0.018	0.016
T ₆	Thompson Seedless+B.Blue 3:1	0.018	0.024	0.021	0.014	0.016	0.015
T ₇	Chenin blanc+Shiraz 2:1	0.011	0.013	0.012	0.008	0.012	0.010
T ₈	Chenin blanc+Shiraz 3:1	0.010	0.013	0.011	0.006	0.008	0.007
T ₉	Chenin blanc+Ruby Red 2:1	0.033	0.035	0.034	0.028	0.029	0.028
T ₁₀	Chenin blanc+Ruby Red 3:1	0.025	0.027	0.026	0.022	0.024	0.023
T ₁₁	Chenin blanc+B.Blue 2:1	0.018	0.023	0.020	0.015	0.018	0.016
T ₁₂	Chenin blanc+B.Blue 3:1	0.013	0.018	0.015	0.010	0.013	0.011
T ₁₃	Sauvignon Blanc+Shiraz 2:1	0.020	0.025	0.022	0.017	0.021	0.019
T ₁₄	Sauvignon Blanc+Shiraz 3:1	0.018	0.021	0.019	0.015	0.018	0.016
T ₁₅	Sauvignon Blanc+Ruby Red2:1	0.030	0.032	0.031	0.026	0.030	0.028
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	0.026	0.029	0.027	0.022	0.025	0.023
T ₁₇	Sauvignon Blanc+B.Blue 2:1	0.024	0.027	0.025	0.020	0.022	0.021
T ₁₈	Sauvignon Blanc+B.Blue 3:1	0.022	0.024	0.023	0.019	0.020	0.019
T ₁₉	Italia +Shiraz 2:1	0.028	0.032	0.030	0.023	0.025	0.024
T ₂₀	Italia +Shiraz 3:1	0.022	0.030	0.026	0.016	0.021	0.018
T ₂₁	Italia +Ruby Red 2:1	0.049	0.051	0.050	0.043	0.045	0.044
T ₂₂	Italia +Ruby Red 3:1	0.036	0.038	0.037	0.029	0.032	0.030
T ₂₃	Italia +B.Blue 2:1	0.029	0.031	0.030	0.026	0.029	0.027
T ₂₄	Italia +B.Blue 3:1	0.022	0.027	0.024	0.018	0.021	0.019
	Mean	0.022	0.026		0.018	0.021	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.002	0.007	*	0.003	0.010
Years	NS	0.004	NS	NS	0.005	NS
Treatments x Years	NS	0.003	NS	NS	0.002	NS

Table 4.45. Total phenol content of wine (mg/l) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Total Phenol content of wine (mg/l)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	507.03	509.0	508.01	486.66	492.63	489.64
T ₂	Thompson Seedless+Shiraz 3:1	494.66	497.66	496.16	473.55	481.32	477.43
T ₃	Thompson Seedless +Ruby Red 2:1	540.03	545.33	542.68	516.23	525.00	520.61
T ₄	Thompson Seedless+Ruby Red 3:1	521.11	527.65	524.38	501.00	513.12	507.06
T ₅	Thompson Seedless+B.Blue 2:1	505.13	511.0	508.06	495.04	509.00	502.02
T ₆	Thompson Seedless+B.Blue 3:1	492.66	499.65	496.15	474.00	479.30	476.65
T ₇	Chenin blanc+Shiraz 2:1	286.33	292.00	289.16	251.24	267.67	259.45
T ₈	Chenin blanc+Shiraz 3:1	258.66	266.0	262.33	221.65	235.00	228.32
T ₉	Chenin blanc+Ruby Red 2:1	332.00	344.66	338.33	319.32	329.57	324.44
T ₁₀	Chenin blanc+Ruby Red 3:1	322.33	331.67	327.00	300.05	305.35	302.70
T ₁₁	Chenin blanc+B.Blue 2:1	315.65	329.00	322.32	301.10	310.12	305.61
T ₁₂	Chenin blanc+B.Blue 3:1	295.00	303.32	299.16	274.31	284.63	279.47
T ₁₃	Sauvignon Blanc+Shiraz 2:1	258.0	260.33	259.16	240.33	247.65	243.99
T ₁₄	Sauvignon Blanc+Shiraz 3:1	240.66	249.66	245.16	222.33	243.00	232.66
T ₁₅	Sauvignon Blanc+Ruby Red2:1	302.0	313.33	307.66	270.10	275.66	272.88
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	284.34	291.32	287.83	258.67	264.02	261.34
T ₁₇	Sauvignon Blanc+B.Blue 2:1	286.20	298.66	292.43	254.10	272.00	263.05
T ₁₈	Sauvignon Blanc+B.Blue 3:1	274.01	286.66	280.33	237.64	241.35	239.49
T ₁₉	Italia +Shiraz 2:1	508.00	514.34	511.17	480.54	485.24	482.89
T ₂₀	Italia +Shiraz 3:1	491.00	503.00	497.00	453.12	472.60	462.86
T ₂₁	Italia +Ruby Red 2:1	592.33	607.00	599.66	553.78	588.00	570.89
T ₂₂	Italia +Ruby Red 3:1	577.66	591.25	584.45	535.11	553.00	544.05
T ₂₃	Italia +B.Blue 2:1	538.31	565.64	551.97	513.25	531.66	522.45
T ₂₄	Italia +B.Blue 3:1	516.00	536.33	526.16	487.62	509.37	498.49
	Mean	405.96	415.43		380.03	392.34	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	7.70	24.2	*	6.47	19.75
Years	NS	3.50	NS	NS	3.82	NS
Treatments x Years	NS	3.25	NS	NS	5.48	NS

Table 4.43. Alcohol content of wine (%) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Alcohol content of wine (%)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	11.48	11.28	11.38	11.59	11.44	11.51
T ₂	Thompson Seedless+Shiraz 3:1	10.51	10.27	10.39	10.72	10.38	10.55
T ₃	Thompson Seedless +Ruby Red 2:1	8.20	8.13	8.16	8.40	8.28	8.34
T ₄	Thompson Seedless+Ruby Red 3:1	8.63	8.32	8.47	8.83	8.54	8.68
T ₅	Thompson Seedless+B.Blue 2:1	9.15	9.05	9.10	9.24	9.15	9.19
T ₆	Thompson Seedless+B.Blue 3:1	9.71	9.54	9.62	9.83	9.73	9.78
T ₇	Chenin blanc+Shiraz 2:1	11.97	11.77	11.87	12.11	11.97	12.04
T ₈	Chenin blanc+Shiraz 3:1	10.52	10.31	10.41	10.72	10.67	10.69
T ₉	Chenin blanc+Ruby Red 2:1	8.33	8.08	8.20	8.54	8.21	8.37
T ₁₀	Chenin blanc+Ruby Red 3:1	9.27	9.20	9.23	9.39	9.27	9.33
T ₁₁	Chenin blanc+B.Blue 2:1	10.18	10.10	10.14	10.30	10.17	10.23
T ₁₂	Chenin blanc+B.Blue 3:1	10.63	10.54	10.58	10.82	10.67	10.74
T ₁₃	Sauvignon Blanc+Shiraz 2:1	10.26	10.16	10.21	10.40	10.29	10.34
T ₁₄	Sauvignon Blanc+Shiraz 3:1	10.11	9.85	9.98	10.22	10.07	10.14
T ₁₅	Sauvignon Blanc+Ruby Red2:1	8.91	8.87	8.89	9.20	9.02	9.11
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	9.33	9.12	9.22	9.43	9.25	9.34
T ₁₇	Sauvignon Blanc+B.Blue 2:1	9.26	9.13	9.19	9.42	9.39	9.40
T ₁₈	Sauvignon Blanc+B.Blue 3:1	9.61	9.26	9.43	9.71	9.62	9.66
T ₁₉	Italia +Shiraz 2:1	8.42	8.35	8.38	8.69	8.52	8.60
T ₂₀	Italia +Shiraz 3:1	8.28	8.11	8.19	8.41	8.27	8.34
T ₂₁	Italia +Ruby Red 2:1	8.03	7.95	7.99	8.20	8.02	8.11
T ₂₂	Italia +Ruby Red 3:1	8.24	8.00	8.12	8.33	8.11	8.22
T ₂₃	Italia +B.Blue 2:1	8.32	8.27	8.29	8.54	8.38	8.46
T ₂₄	Italia +B.Blue 3:1	8.42	8.31	8.36	8.49	8.41	8.45
	Mean	9.40	9.24		9.56	9.40	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	0.03	0.10	*	0.04	0.12
Years	*	0.01	0.03	*	0.01	0.04
Treatments x Years	NS	0.05	NS	NS	0.06	NS

Table: 4.46. Flavonoid content of wine (mg/l) before and after aging in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	Flavonoid content of wine (mg/l)					
		Before aging			After aging		
		2006-07	2007-08	Mean	2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	139.39	150.29	144.84	132.60	142.03	137.31
T ₂	Thompson Seedless+Shiraz 3:1	136.14	146.71	141.42	125.09	138.89	131.99
T ₃	Thompson Seedless +Ruby Red 2:1	149.18	156.18	152.68	138.25	140.43	139.34
T ₄	Thompson Seedless+Ruby Red 3:1	138.29	146.36	142.32	128.09	135.89	131.99
T ₅	Thompson Seedless+B.Blue 2:1	147.18	160.18	153.68	137.26	140.89	139.07
T ₆	Thompson Seedless+B.Blue 3:1	139.29	145.35	142.32	130.99	135.15	133.07
T ₇	Chenin blanc+Shiraz 2:1	106.90	118.17	112.53	100.81	110.44	105.62
T ₈	Chenin blanc+Shiraz 3:1	104.07	112.34	108.20	95.34	102.77	99.05
T ₉	Chenin blanc+Ruby Red 2:1	160.06	181.03	170.54	155.54	170.52	163.03
T ₁₀	Chenin blanc+Ruby Red 3:1	118.63	130.87	124.75	110.04	122.98	116.51
T ₁₁	Chenin blanc+B.Blue 2:1	115.05	132.25	123.65	103.78	128.56	116.17
T ₁₂	Chenin blanc+B.Blue 3:1	105.25	120.36	112.80	94.81	114.65	104.73
T ₁₃	Sauvignon Blanc+Shiraz 2:1	150.23	167.55	158.89	148.00	157.01	152.50
T ₁₄	Sauvignon Blanc+Shiraz 3:1	145.97	158.65	152.31	132.26	145.89	139.07
T ₁₅	Sauvignon Blanc+Ruby Red2:1	158.62	178.90	168.76	148.55	160.90	154.72
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	147.63	164.48	156.05	147.25	151.31	149.28
T ₁₇	Sauvignon Blanc+B.Blue 2:1	154.95	170.06	162.50	143.55	165.90	154.72
T ₁₈	Sauvignon Blanc+B.Blue 3:1	148.97	155.65	152.31	134.94	146.34	140.64
T ₁₉	Italia +Shiraz 2:1	227.60	247.44	237.52	222.84	229.10	225.97
T ₂₀	Italia +Shiraz 3:1	186.89	212.28	199.58	172.62	188.26	180.44
T ₂₁	Italia +Ruby Red 2:1	265.54	280.08	272.81	261.22	268.29	264.75
T ₂₂	Italia +Ruby Red 3:1	244.92	256.07	250.49	227.21	238.43	232.82
T ₂₃	Italia +B.Blue 2:1	251.93	270.03	260.98	234.98	260.75	247.86
T ₂₄	Italia +B.Blue 3:1	232.30	244.74	238.52	218.10	230.69	224.39
		161.45	175.25		151.83	163.58	

	F-test	SEM	CD at 5%	F-test	SEM	CD at 5%
Treatments	*	5.40	16.32	*	4.30	13.01
Years	NS	4.12	NS	NS	3.62	NS
Treatments x Years	NS	3.86	NS	NS	5.02	NS

Table:4.47. Organoleptic evaluation of wine after aging in different cultivars of Grape (Mean of two years data)

T.no.	Treatments	Organoleptic evaluation						Overall acceptability	Mean
		Appearance	Aroma	Flavour	Taste	Colour			
Max. Score		20	20	20	20	20	20	20	
T ₁	Thompson Seedless+Shiraz 2:1	16.53	15.41	15.73	16.53	16.31	17.41	16.32	
T ₂	Thompson Seedless+Shiraz 3:1	14.75	13.21	12.63	13.11	14.41	14.46	13.76	
T ₃	Thompson Seedless +Ruby Red 2:1	13.46	10.96	13.66	13.45	15.01	15.56	13.68	
T ₄	Thompson Seedless+Ruby Red 3:1	13.40	14.51	14.56	14.50	16.95	16.40	15.05	
T ₅	Thompson Seedless+B.Blue 2:1	14.30	12.16	12.86	14.50	14.11	13.20	13.52	
T ₆	Thompson Seedless+B.Blue 3:1	14.10	14.26	14.63	15.05	14.78	13.91	14.45	
T ₇	Chenin blanc+Shiraz 2:1	17.18	16.25	16.55	17.30	17.83	18.31	17.23	
T ₈	Chenin blanc+Shiraz 3:1	15.16	13.20	14.51	15.71	15.56	15.40	14.92	
T ₉	Chenin blanc+Ruby Red 2:1	13.51	10.63	13.15	13.41	13.91	14.35	13.16	
T ₁₀	Chenin blanc+Ruby Red 3:1	13.95	12.63	14.55	15.69	14.55	14.66	14.33	
T ₁₁	Chenin blanc+B.Blue 2:1	14.38	11.25	13.73	13.90	14.33	14.30	13.64	
T ₁₂	Chenin blanc+B.Blue 3:1	15.36	14.40	16.08	16.25	15.53	15.41	15.50	
T ₁₃	Sauvignon Blanc+Shiraz 2:1	15.30	14.53	14.50	14.60	15.36	15.90	15.03	
T ₁₄	Sauvignon Blanc+Shiraz 3:1	14.38	12.18	14.60	13.65	15.10	15.56	14.24	
T ₁₅	Sauvignon Blanc+Ruby Red2:1	14.58	11.31	11.55	14.20	14.51	12.91	13.17	
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	14.16	13.70	12.23	14.31	14.71	13.58	13.78	
T ₁₇	Sauvignon Blanc+B.Blue 2:1	14.50	12.86	13.78	12.20	14.90	14.10	13.72	
T ₁₈	Sauvignon Blanc+B.Blue 3:1	14.70	14.25	14.83	13.98	15.16	14.51	14.57	
T ₁₉	Italia +Shiraz 2:1	15.06	14.51	14.66	13.33	13.65	15.85	14.51	
T ₂₀	Italia +Shiraz 3:1	13.18	11.15	13.86	12.90	13.23	14.83	13.19	
T ₂₁	Italia +Ruby Red 2:1	11.66	12.75	12.26	12.01	12.63	11.55	12.14	
T ₂₂	Italia +Ruby Red 3:1	13.10	14.98	13.66	14.30	13.10	12.23	13.56	
T ₂₃	Italia +B.Blue 2:1	12.35	10.26	11.63	12.13	13.16	12.26	11.96	
T ₂₄	Italia +B.Blue 3:1	13.28	12.93	12.26	13.51	13.41	12.43	12.97	
	Mean	14.26	13.09	13.85	14.18	14.67	14.54		
	F- test	*	*	*	*	*	*		
	Sem	0.06	0.07	0.08	0.08	0.07	0.12		
	CD	0.17	0.21	0.22	0.28	0.19	0.34		
* : Significant NS: Non significant									
Hedonic scale: 18-20 excellent, 15-17 good, 12-14 fair, 9-11 ordinary, 6-8 poor, 3-5 bad, 1-2 very bad									

Table 4.34. Titrable acidity of juice (%) in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no.	Treatments	Titrable acidity of juice (%)		
		2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	0.78	0.81	0.80
T ₂	Thompson Seedless+Shiraz 3:1	0.87	0.90	0.88
T ₃	Thompson Seedless +Ruby Red 2:1	0.64	0.65	0.64
T ₄	Thompson Seedless+Ruby Red 3:1	0.67	0.71	0.69
T ₅	Thompson Seedless+B.Blue 2:1	0.91	0.96	0.94
T ₆	Thompson Seedless+B.Blue 3:1	0.97	1.02	0.99
T ₇	Chenin blanc+Shiraz 2:1	1.06	1.22	1.14
T ₈	Chenin blanc+Shiraz 3:1	1.26	1.40	1.33
T ₉	Chenin blanc+Ruby Red 2:1	1.30	1.33	1.31
T ₁₀	Chenin blanc+Ruby Red 3:1	1.41	1.37	1.39
T ₁₁	Chenin blanc+B.Blue 2:1	1.51	1.55	1.53
T ₁₂	Chenin blanc+B.Blue 3:1	1.73	1.60	1.66
T ₁₃	Sauvignon Blanc+Shiraz 2:1	1.03	1.03	1.03
T ₁₄	Sauvignon Blanc+Shiraz 3:1	1.16	1.37	1.27
T ₁₅	Sauvignon Blanc+Ruby Red2:1	0.63	0.69	0.66
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	0.72	0.72	0.72
T ₁₇	Sauvignon Blanc+B.Blue 2:1	1.39	1.51	1.45
T ₁₈	Sauvignon Blanc+B.Blue 3:1	1.51	1.31	1.41
T ₁₉	Italia +Shiraz 2:1	1.20	1.13	1.16
T ₂₀	Italia +Shiraz 3:1	1.31	1.25	1.28
T ₂₁	Italia +Ruby Red 2:1	0.86	0.92	0.89
T ₂₂	Italia +Ruby Red 3:1	0.98	0.96	0.97
T ₂₃	Italia +B.Blue 2:1	1.42	1.37	1.40
T ₂₄	Italia +B.Blue 3:1	1.60	1.51	1.55
	Mean	1.12	1.14	

	F-test	SEM	CD at 5%
Treatments	*	0.02	0.06
Years	NS	0.06	NS
Treatments x Years	*	0.03	0.08

Table 4.33. Total soluble solid content of juice (°B) in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	TSS of juice (°B)		
		2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	21.26	21.33	21.29
T ₂	Thompson Seedless+Shiraz 3:1	20.20	20.20	20.20
T ₃	Thompson Seedless +Ruby Red 2:1	20.40	21.00	20.70
T ₄	Thompson Seedless+Ruby Red 3:1	20.13	20.00	20.06
T ₅	Thompson Seedless+B.Blue 2:1	19.36	19.93	19.65
T ₆	Thompson Seedless+B.Blue 3:1	19.06	19.40	19.23
T ₇	Chenin blanc+Shiraz 2:1	21.26	21.66	21.46
T ₈	Chenin blanc+Shiraz 3:1	20.33	20.86	20.60
T ₉	Chenin blanc+Ruby Red 2:1	21.13	20.06	20.59
T ₁₀	Chenin blanc+Ruby Red 3:1	19.73	19.60	19.66
T ₁₁	Chenin blanc+B.Blue 2:1	19.80	20.73	20.26
T ₁₂	Chenin blanc+B.Blue 3:1	18.93	20.40	19.66
T ₁₃	Sauvignon Blanc+Shiraz 2:1	20.60	20.53	20.56
T ₁₄	Sauvignon Blanc+Shiraz 3:1	19.80	19.73	19.76
T ₁₅	Sauvignon Blanc+Ruby Red2:1	18.80	19.46	19.13
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	18.13	18.53	18.33
T ₁₇	Sauvignon Blanc+B.Blue 2:1	17.13	17.53	17.33
T ₁₈	Sauvignon Blanc+B.Blue 3:1	18.20	17.66	17.93
T ₁₉	Italia +Shiraz 2:1	19.73	18.86	19.30
T ₂₀	Italia +Shiraz 3:1	18.53	18.53	18.53
T ₂₁	Italia +Ruby Red 2:1	18.00	18.60	18.30
T ₂₂	Italia +Ruby Red 3:1	17.53	17.86	17.70
T ₂₃	Italia +B.Blue 2:1	16.53	17.86	17.20
T ₂₄	Italia +B.Blue 3:1	15.93	17.00	16.46
	Mean	19.19	18.47	

	F-test	SEM	CD at 5%
Treatments	*	0.22	0.64
Years	*	0.06	0.18
Treatments x Years	*	0.32	0.91

Table 4.35. pH of juice in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	pH of juice		
		2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	4.00	3.60	3.80
T ₂	Thompson Seedless+Shiraz 3:1	3.80	3.50	3.65
T ₃	Thompson Seedless +Ruby Red 2:1	3.90	3.93	3.91
T ₄	Thompson Seedless+Ruby Red 3:1	3.83	3.70	3.76
T ₅	Thompson Seedless+B.Blue 2:1	3.70	3.93	3.81
T ₆	Thompson Seedless+B.Blue 3:1	3.53	3.70	3.61
T ₇	Chenin blanc+Shiraz 2:1	3.70	4.06	3.88
T ₈	Chenin blanc+Shiraz 3:1	3.50	3.93	3.71
T ₉	Chenin blanc+Ruby Red 2:1	4.06	4.13	4.10
T ₁₀	Chenin blanc+Ruby Red 3:1	3.90	3.90	3.90
T ₁₁	Chenin blanc+B.Blue 2:1	3.63	3.46	3.55
T ₁₂	Chenin blanc+B.Blue 3:1	3.56	3.40	3.48
T ₁₃	Sauvignon Blanc+Shiraz 2:1	4.23	3.90	4.06
T ₁₄	Sauvignon Blanc+Shiraz 3:1	4.10	3.80	3.95
T ₁₅	Sauvignon Blanc+Ruby Red2:1	4.13	4.13	4.13
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	4.06	4.10	4.08
T ₁₇	Sauvignon Blanc+B.Blue 2:1	4.13	3.56	3.85
T ₁₈	Sauvignon Blanc+B.Blue 3:1	3.93	3.50	3.71
T ₁₉	Italia +Shiraz 2:1	4.10	3.90	4.00
T ₂₀	Italia +Shiraz 3:1	4.06	3.83	3.95
T ₂₁	Italia +Ruby Red 2:1	4.03	4.16	4.10
T ₂₂	Italia +Ruby Red 3:1	3.96	4.06	4.01
T ₂₃	Italia +B.Blue 2:1	3.80	3.73	3.76
T ₂₄	Italia +B.Blue 3:1	3.73	3.56	3.65
	Mean	3.89	3.81	

	F-test	SEM	CD at 5%
Treatments	*	0.04	0.12
Years	*	0.01	0.03
Treatments x Years	NS	0.06	NS

Table 4.36. Total sugar content of juice (%) in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	Total sugar content of juice (%)		
		2006-07	2007-08	Mean
T ₁ .	Thompson Seedless+Shiraz 2:1	19.37	19.03	19.20
T ₂ .	Thompson Seedless+Shiraz 3:1	17.94	17.78	17.86
T ₃ .	Thompson Seedless +Ruby Red 2:1	15.74	15.39	15.56
T ₄ .	Thompson Seedless+Ruby Red 3:1	15.03	14.90	14.96
T ₅ .	Thompson Seedless+B.Blue 2:1	16.21	15.62	15.91
T ₆ .	Thompson Seedless+B.Blue 3:1	15.62	15.40	15.51
T ₇ .	Chenin blanc+Shiraz 2:1	20.20	19.86	20.03
T ₈ .	Chenin blanc+Shiraz 3:1	17.73	17.33	17.53
T ₉ .	Chenin blanc+Ruby Red 2:1	16.38	16.10	16.24
T ₁₀ .	Chenin blanc+Ruby Red 3:1	15.37	15.34	15.35
T ₁₁ .	Chenin blanc+B.Blue 2:1	17.35	17.14	17.24
T ₁₂ .	Chenin blanc+B.Blue 3:1	17.31	17.04	17.17
T ₁₃ .	Sauvignon Blanc+Shiraz 2:1	17.06	16.62	16.84
T ₁₄ .	Sauvignon Blanc+Shiraz 3:1	15.64	15.52	15.58
T ₁₅ .	Sauvignon Blanc+Ruby Red2:1	14.05	14.04	14.04
T ₁₆ .	Sauvignon Blanc+Ruby Red 3:1	13.94	13.63	13.78
T ₁₇ .	Sauvignon Blanc+B.Blue 2:1	14.56	14.09	14.32
T ₁₈ .	Sauvignon Blanc+B.Blue 3:1	14.21	13.78	13.99
T ₁₉ .	Italia +Shiraz 2:1	14.05	13.78	13.91
T ₂₀ .	Italia +Shiraz 3:1	13.94	13.63	13.78
T ₂₁ .	Italia +Ruby Red 2:1	13.97	13.68	13.82
T ₂₂ .	Italia +Ruby Red 3:1	13.90	13.41	13.65
T ₂₃ .	Italia +B.Blue 2:1	14.21	14.12	14.16
T ₂₄ .	Italia +B.Blue 3:1	14.04	13.95	13.99
	Mean	15.74	15.46	

	F-test	SEM	CD at 5%
Treatments	*	0.07	0.21
Years	*	0.02	0.06
Treatments x Years	NS	0.06	NS

Table 4.37. Reducing sugar content of juice (%) in different blended varieties of Grape during 2006-07 and 2007-08 years

T.no	Treatments	Reducing sugar content of juice (%)		
		2006-07	2007-08	Mean
T ₁	Thompson Seedless+Shiraz 2:1	14.14	13.81	13.97
T ₂	Thompson Seedless+Shiraz 3:1	13.79	13.67	13.73
T ₃	Thompson Seedless +Ruby Red 2:1	11.93	11.51	11.72
T ₄	Thompson Seedless+Ruby Red 3:1	11.87	11.20	11.53
T ₅	Thompson Seedless+B.Blue 2:1	13.84	12.98	13.41
T ₆	Thompson Seedless+B.Blue 3:1	13.60	12.96	13.28
T ₇	Chenin blanc+Shiraz 2:1	17.07	16.78	16.92
T ₈	Chenin blanc+Shiraz 3:1	15.18	14.18	14.68
T ₉	Chenin blanc+Ruby Red 2:1	12.47	11.90	12.18
T ₁₀	Chenin blanc+Ruby Red 3:1	12.27	11.70	11.98
T ₁₁	Chenin blanc+B.Blue 2:1	14.31	13.84	14.07
T ₁₂	Chenin blanc+B.Blue 3:1	14.16	13.59	13.87
T ₁₃	Sauvignon Blanc+Shiraz 2:1	15.45	13.61	14.53
T ₁₄	Sauvignon Blanc+Shiraz 3:1	14.70	13.26	13.98
T ₁₅	Sauvignon Blanc+Ruby Red2:1	12.00	11.61	11.80
T ₁₆	Sauvignon Blanc+Ruby Red 3:1	11.88	11.30	11.59
T ₁₇	Sauvignon Blanc+B.Blue 2:1	12.55	11.99	12.27
T ₁₈	Sauvignon Blanc+B.Blue 3:1	12.28	11.71	11.99
T ₁₉	Italia +Shiraz 2:1	12.38	11.80	12.09
T ₂₀	Italia +Shiraz 3:1	12.00	11.33	11.66
T ₂₁	Italia +Ruby Red 2:1	11.78	10.99	11.38
T ₂₂	Italia +Ruby Red 3:1	11.09	10.69	10.89
T ₂₃	Italia +B.Blue 2:1	12.00	11.84	11.92
T ₂₄	Italia +B.Blue 3:1	11.86	11.56	11.71
	Mean	13.10	12.49	

	F-test	SEM	CD at 5%
Treatments	*	0.04	0.12
Years	*	0.01	0.03
Treatments x Years	NS	0.06	NS

CHAPTER V

SUMMARY AND CONCLUSIONS

An experiment entitled on “Studies on growth, yield and wine production from different varieties of grape” was carried out at the Department of Horticulture, College of Agriculture, ANGRAU, Rajendranagar in collaboration with Grape Research Station, Rajendranagar, Hyderabad. Thirteen grape varieties (8 coloured and 5 white) grown at Grape Research Station were selected to study the growth, yield performance and their suitability for wine production. Among the varieties selected for the study, ten were wine grape varieties introduced from traditional grape growing countries and the remaining three varieties, *viz.*, Bangalore Blue, Pusa Navrang and Thompson Seedless were the native grape varieties which were found suitable for wine making.

The investigation consists of three experiments first being studying the growth and yield performance of thirteen varieties, second experiment consists of evaluation of these varieties for their suitability to wine making and third comprising of blending white varieties with coloured varieties to evaluate the effect of blending on quality of wine. The study was carried out for two cropping seasons and the wine prepared was analysed for biochemical parameters twice (before aging and after aging). The sensory evaluation of wine was done to assess the overall acceptability of wine after aging (90 days of storage).

Observations on growth (pruning weight, days taken for bud break, number of canes, cane diameter, shoot length, no. of leaves, leaf area, days taken for 50% flowering) and yield characters (no. of bunches, bunch weight, length, no of berries per bunch, hundred berry weight, berry diameter and fruit yield per vine) showed significant variations among the varieties studied. In the present investigation, summer pruning weight of different varieties of grape ranged from 1.03 to 5.23 kg/vine while

winter pruning weight ranged from 0.46 to 2.76 kg/vine with highest being recorded by the variety Shiraz and lowest by Zinfandel in both the seasons. Based on the pruning weight, varieties were classified as vigorous weighing 4.26 kg/vine to 5.23 kg/vine (Athens, Shiraz, Ruby Red); moderately vigorous weighing 2.03 kg/vine to 3.73 kg/vine (Italia, Bangalore Blue, Gulabi, Pusa Navrang, Sauvignon Blanc, Symphony and Chenin Blanc); less vigorous weighing 1.03 kg/vine to 1.94 kg/vine (Zinfandel, Cabernet Sauvignon and Thompson Seedless).

Days required for bud break varied from 8.15 d with Cv. Pusa Navrang to 21.21 d by Cv. Ruby Red. On this basis, varieties were grouped as Early varieties (Pusa Navrang, Bangalore Blue, Chenin Blanc and Gulabi), Mid season varieties (Sauvignon Blanc, Symphony, Shiraz, Zinfandel, Italia and Cabernet Sauvignon) and Late season varieties (Ruby Red, Thompson Seedless and Athens).

In the present investigation, the number of canes per vine varied from 32.91 to 54.93 while diameter of cane ranged from 10.93 to 18.60 mm. Maximum number of canes was produced by Cv. Shiraz while minimum by Thompson Seedless followed by Italia. This difference in number of canes may be due to difference in vigour of the variety. In contrast, maximum diameter of cane was recorded by Italia and minimum in Cv. Zinfandel. Shoot length was significantly maximum in Athens (79.16 cm) closely followed by Gulabi and minimum was recorded in case of Bangalore Blue (53.33 cm).

With respect to the number of leaves and area, significant difference among the varieties studied was noticed. Leaf number varied from minimum of 9.83 to a maximum of 23.66 and the leaf area ranged from a minimum of 42.21 cm² in Chenin Blanc to a maximum of 112.53 cm² in cultivar Bangalore Blue. Days taken for 50% flowering varied significantly from minimum of 25.36 days in the variety Pusa Navrang to maximum of 44.37 days in Thompson Seedless.

Yield parameters were influenced significantly by the varieties. With respect to number of bunches, the variety Chenin Blanc recorded highest number of bunches

per vine (113.78) followed by Shiraz (97.75) and least in the variety Thompson Seedless (37.26) where as maximum bunch weight was noticed in the variety Italia (331.61 g) followed by Thompson Seedless and minimum in Cabernet Sauvignon (88.06 g). The variety Italia besides having higher bunch weight showed maximum diameter of berry (17.9 mm) and higher berry weight (414.21 g per 100 berries). Yield ranged from 4.51 to 16.81 kg/vine with maximum recorded by the variety Chenin Blanc (16.81 kg/vine) while it was minimum with Sauvignon Blanc (4.51 kg/vine). Heat unit requirement in different cultivars of grape varied from 1726.25 degree days to 2207.46 degree days being recorded maximum by the variety Italia and minimum by Pusa Navrang.

The physico-chemical properties of juice revealed that juice recovery was maximum in Chenin Blanc (78.38%) among the white varieties and in Pusa Navrang (77.75%) from the coloured ones. TSS of juice in different varieties ranged from 15.43 °B to 21.95 °B .Maximum TSS was recorded in Cv. Shiraz followed by Cabernet Sauvignon while minimum content of was observed in Italia. The titrable acidity of juice ranged from minimum of 0.51% in Ruby Red to maximum of 0.92% in Chenin Blanc and all the varieties are found to be within the standard range *i.e.* (dry table wines require high acidity of 0.6 to 0.9%, while sweet dessert wines require 0.5 to 0.6% acidity). pH of the juice ranged from 2.96 (Italia) to 3.53 (Athens) which indicated that as per the pH norms, all the varieties screened are suitable for making wines except Italia. Highest total and reducing sugar content of juice was observed in Shiraz (19.28 % and 15.38 %) followed by Chenin Blanc (19.07% and 15.21%) and on the other hand, minimum total sugar content (13.14%) was recorded by Cv. Italia and reducing sugar content in Pusa Navrang (7.84 %).

Bio-chemical properties of wine (TSS, titrable acidity, volatile acidity, sugars, alcohol, total phenols, tannins and flavonoids) were analysed twice *i.e.* before and after aging showed significant variation among the varieties evaluated. A decrease in the above mentioned parameters was observed in wine samples after aging, except

with the content of alcohol. Minimum TSS in wine after aging was recorded by Cv. Shiraz (7.93 °B) preceded by Chenin Blanc (8.20 °B) and highest TSS content was noticed in Italia (10.93 °B). Chenin Blanc recorded highest titrable acidity (0.79%) followed by the Bangalore Blue (0.62 %) and minimum content was found in the wine of Ruby Red (0.34%). Volatile acid content of wines after aging in different varieties varied from 0.011 to 0.063% and were within the standard limits. Among the varieties, Ruby Red recorded maximum volatile acidity followed by Gulabi while all the white varieties showed minimum volatile acidity content in wine except Italia.

In the present investigation, Italia recorded maximum total and reducing sugar content followed by Symphony while Cabernet Sauvignon and Chenin Blanc found to have minimum content of reducing sugar in the wine after aging. The alcohol content of wine in different varieties after aging ranged from 7.79% (Italia) to 11.43% (Shiraz). Tannin content of wines from coloured varieties were higher than those of white varieties, due to extraction of more tannins from skin and seeds of coloured varieties, while the juice of white varieties were fermented without skin and seeds. In the present investigation, wide range of tannin content was noticed in wine after aging from 0.004 to 0.060%. Maximum tannin content was observed in the variety Ruby Red while minimum in the variety Chenin Blanc. Total Phenol content in wine after aging varied from a minimum of 213.30 mg/l in Cv. Chenin Blanc to a maximum of 1652.83 mg/l in Cv. Pusa Navrang. It was evident from the results that coloured varieties have recorded higher total phenol and flavonoid content than white ones. Among the varieties evaluated, higher content of flavonoid was found in the variety Pusa Navrang (922.42 mg/l) followed by Ruby Red (823.33 mg/l) and least content was observed in Chenin Blanc (122.33 mg/l).

After the aging, organoleptic evaluation of different wine samples was done according to the hedonic scale. The highest score 16.15 (good) for average quality was obtained by Shiraz followed by Chenin Blanc(15.41) which was comparable with the variety Cabernet Sauvignon (15.40) and the lowest score 10.67 (ordinary)

was obtained by Italia. The score of the remaining varieties was in the range from 11.25 in Ruby Red to 14.68 in Zinfandel.

Blending is an useful technique to overcome defects in the varieties. It improves the quality of wine of the varieties which were deficient in colour or chemical composition. With respect to the physico chemical parameters of juice in different blended treatments, TSS of the juice varied from 16.46 °B to 21.46 °B. T₇ has recorded maximum TSS while minimum content was observed with T₂₄. Blending with the cultivar Shiraz has showed maximum TSS of juice when compared to that of Ruby Red and Bangalore Blue. Maximum titrable acidity was recorded with T₁₂ (1.66 %) followed by T₂₄ (1.53%) and minimum was observed with T₃ (0.64%). Varieties blended with Bangalore Blue recorded higher content of acidity while those blended with Ruby Red showed minimum content. pH ranged from a minimum of 3.48 to 4.13. White varieties which were blended with Ruby Red recorded highest pH value while those blended with Bangalore Blue showed lowest value.

With respect to the bio chemical properties of wine, reduction in the TSS and titrable acidity, sugars of wine was observed after fermentation in all the treatments and among them, T₇ closely preceded by T₈ showed minimum content of TSS, total and reducing sugars whereas highest was recorded with T₂₁. The volatile acid content of wine after aging in the treatments varied from 0.017 to 0.046% with minimum in the treatment T₁₃ and maximum in T₂₂ and all the treatments were within the range of International standard. Wine produced from the blends of Italia with Ruby Red showed higher content of volatile acidity. Further, among the coloured varieties blended, Ruby Red recorded maximum volatile acidity content over Bangalore Blue and Shiraz. With respect to the different ratios, wines blended with 3:1 ratio recorded maximum content of acidity than 2:1 ratio.

Alcohol content of blended wine after aging varied from 7.99 to 11.87% with highest content being recorded with T₇ followed by T₁ while least content was found with T₂₁. Tannin content of wine showed a wide variation in which maximum

content was recorded with T₂₁ (0.044%) and minimum content in T₈ (0.007%). White varieties blended with Shiraz showed lesser content while those blended with Ruby red recorded higher values. The ratio 3:1 showed minimum content of tannin in all the treatments as compared to 2:1.

Total phenol content of wine after aging varied significantly among the different treatments. Significantly maximum content of total phenols was recorded with T₂₁ (570.89 mg/l) followed by T₂₂ (544.05 mg/l). Whereas minimum content was observed in T₈ (228.32 mg/l). The white varieties blended with Shiraz registered minimum content of total phenols in wine while those blended with Ruby Red showed maximum content in their corresponding wine. Among the two ratios tried, 3:1 showed minimum content of total phenol in all the treatments when compared to 2:1. Similarly, significantly higher content of flavonoids was recorded with T₂₁ (264.75mg/l) and minimum content was observed in T₈ (99.05mg/l).

Organoleptic evaluation of wine samples showed significant variations among the treatments. Average score of wine samples of different blended cultivars ranged from a minimum of 11.96 in T₂₃ to 17.23 in T₇. Based on the average score, wine made from blended varieties can be graded as good (T₇, T₁, T₁₂, T₄ and T₁₃), while rest of the treatments produced fair quality wine except T₂₃ which was graded as ordinary.

Conclusions

Based on the pruning weight, varieties were classified as vigorous (Athens, Shiraz, Ruby Red); moderately vigorous (Italia, Bangalore Blue, Gulabi, Pusa Navrang, Sauvignon Blanc, Symphony and Chenin Blanc); less vigorous (Zinfandel, Cabernet Sauvignon and Thompson Seedless).

On the basis of bud break requirement, varieties were grouped as early (Pusa Navrang, Bangalore Blue, Chenin Blanc and Gulabi), mid season (Sauvignon Blanc, Symphony, Shiraz, Zinfandel, Italia and Cabernet Sauvignon) and late season varieties (Ruby Red, Thompson Seedless and Athens).

The variety Chenin Blanc recorded highest number of bunches per vine and least in Thompson Seedless whereas maximum bunch weight was noticed in the variety Italia followed by Thompson Seedless and minimum in Cabernet Sauvignon. Yield ranged from 4.51 kg/vine to 16.81 kg/vine with maximum recorded by the variety Chenin Blanc and minimum in Sauvignon Blanc.

The physico-chemical properties of juice revealed that juice recovery was maximum in Chenin Blanc (78.38%) among the white varieties and in Pusa Navrang from the coloured ones. TSS of juice in different varieties ranged from 15.43 to 21.95°B. Maximum TSS was recorded in Cv. Shiraz and minimum in Italia.

With respect to the bio-chemical properties of wine, Chenin Blanc recorded maximum titrable acidity (0.79%) and minimum content was found in the wine of Ruby Red (0.34%). Volatile acid content of wine after aging in different varieties varied from 0.011 to 0.063% and were within the standard limits.

The alcohol content of wine in different varieties after aging ranged from 7.79% (Italia) to 11.43% (Shiraz). Coloured varieties have recorded higher total phenol content, tannins and flavonoids than the white ones. The highest score of 16.15 for average quality was obtained by Shiraz followed by Chenin Blanc (15.41) and the lowest score 10.67 was obtained by Italia.

Blending improves the quality of wine of the varieties which were deficient in colour or chemical composition. Wine prepared from the blends of Chenin Blanc with Shiraz 2:1(T₇) are good over the others followed by Thompson Seedless with Shiraz 2:1(T₁) and Chenin Blanc with Bangalore Blue 2:1(T₁₁). Hence, it can be concluded that wine blends prepared from Chenin Blanc with Shiraz 2:1 ranked good followed by Thompson Seedless with Shiraz 2:1 while Chenin Blanc with Bangalore blue 2:1 were graded as satisfactory.

Table 5.1. Quality parameters of wine from grapes

S.no	Bio-Chemical Properties of wine	Standard International Wine composition (A)	Wine quality in different varieties studied (B)
1.	pH	3.4-4.2	2.96-3.53
2.	Titration acidity	0.40- 1.5%	0.40- 0.79%
3.	Volatile acidity	Should not be more than 0.1%	0.01- 0.065%
4.	Total Sugars	3.0- 6.0%	3.09- 5.23%
5.	Reducing Sugars	0.1-2.0%	1.53- 3.34%
6.	Alcohol	7.9-14.6%	8.78- 12.25%
7.	Tannins	0.002-1.40% (White wine) 0.04-3.26% (Red wine)	0.004-0.01% (White wine) 0.028 – 0.060% (Red wine)
8.	Total Phenols	246-426 mg/l (White wine) 910- 2160 mg/l (Red wine)	213-511 mg/l (White wine) 1007-1652 mg/l (Red wine)
9.	Flavonoids	10- 50 mg/l (White wine) Up to 800 mg/l (Red wine)	121-257 mg/l (White wine) 525-922 mg/l (Red wine)

A - (Adil *et al.*,1980; Karibasappa and Adsule, 2008 & Bhalerao, 2000)

B - (Results of the present study)

FUTURE LINE OF WORK

1. There is need to develop a separate production technology for wine grape varieties and also area expansion.
2. Maturity standards for harvesting grape berries for wine making need to be determined for different varieties at different places and also for different types of wine.
3. Wine grape growers must be encouraged by providing financial assistance from Government. The basic hinderance in the production of wine on large scale in the country is its marketing, as wine has less consumer performance than other liquours. However, wine production and marketing has tremendous potential in the country.
4. Wine industry in India is changing rapidly. This change has been reflected in the domestic market, which is reported growing at a rate of 30% per annum. This should further be raised by encouraging wine grape production and establishment of new wineries.
5. The prospects and possibilities of wine production in India are required to be viewed from many aspects *viz.*, maturity standards for wine grape cultivars, possibilities of wine sale within the country, export potential, availability of raw material, machinery and technical know- how.

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APPENDIX - A

**Weekly meteorological data recorded at Rajendranagar, Hyderabad
during the period from 15th October, 2006 to 08th April, 2007**

Week No.	Period	Temperature (°C)		RH (%)		Rain fall (mm)	Rainy days	Sunshine (hrs.)	Wind Speed (kmph)	Evaporation (mm)
		Maximum	Minimum	I	II					
42	15-21	32.0	20.2	93	45	0.0	0	7.9	2.9	4.8
43	22-28	30.8	19.4	89	51	0.8	0	7.9	3.7	4.8
44	29-04 NOV	26.1	21.5	95	77	39.1	3	1.8	4.8	2.6
45	05-11	28.2	19.7	96	64	0.4	0	4.7	2.6	3.8
46	12-18	28.8	16.7	90	51	0.0	0	9.0	3.3	4.8
47	19-25	29.0	17.9	87	47	0.0	0	6.3	2.9	4.0
48	26-02 DEC	30.7	17.5	88	41	0.0	0	8.7	3.6	5.2
49	03-09	29.5	14.7	92	39	0.0	0	8.9	3.4	4.1
50	10-16	28.8	13.5	89	37	0.0	0	8.4	3.0	4.4
51	17-23	27.7	11.4	87	36	0.0	0	8.2	3.3	4.5
52	24-31	28.3	13.3	87	38	0.0	0	8.7	3.1	4.4
1	01-07 JAN	28.4	12.0	86	33	0.0	0	8.7	2.5	4.2
2	08-14	27.6	12.9	88	37	0.0	0	9.3	3.8	3.8
3	15-21	30.2	13.7	86	33	0.0	0	9.2	2.7	4.0
4	22-28	30.7	15.5	85	34	0.0	0	9.0	3.3	4.7
5	29-04 FEB	31.4	15.5	84	26	0.0	0	8.9	4.9	5.3
6	05-11	31.9	16.5	83	31	0.0	0	9.2	4.3	4.7
7	12-18	30.6	16.1	82	34	0.0	0	8.4	4.0	4.2
8	19-25	30.5	14.3	82	26	0.0	0	9.9	5.7	5.1
9	26-04 MAR	33.9	16.6	67	22	0.0	0	10.1	4.6	6.2
10	05-11	34.6	21.4	80	29	0.0	0	8.4	6.0	6.2
11	12-18	34.4	19.3	70	25	0.0	0	8.7	5.4	6.7
12	19-25	37.6	22.4	61	19	0.0	0	7.0	3.8	6.8
13	26-01 APR	37.4	20.6	70	19	0.0	0	8.4	4.5	7.1
14	02-08	38.8	22.0	75	20	0.0	0	8.8	4.8	7.4
TOTAL		777.7	424.5	2094	912	40.3	3	204.3	96.9	123.8
AVERAGE		31.1	17.0	84	36	1.6	0	8.2	3.9	5.0

APPENDIX - B
Weekly meteorological data recorded at Rajendranagar, Hyderabad
during the period from 15th October, 2007 to 08th April, 2008

Week No.	Period	Temperature (°C)		RH (%)		Rain fall (mm)	Rainy days	Sunshine (hrs.)	Wind Speed (kmph)	Evaporation (mm)
		Maximum	Minimum	I	II					
42	15-21	30.8	18.8	89	54	2.8	1	7.6	2.5	5.6
43	22-28	29.9	18.9	89	53	0.0	0	6.8	3.7	5.6
44	29-04 NOV	29.1	20.1	92	61	21.8	2	4.4	3.3	4.8
45	05-11	31.2	16.2	92	40	0.0	0	9.3	2.6	5.9
46	12-18	29.4	11.7	86	26	0.0	0	8.6	3.4	5.1
47	19-25	28.5	10.7	84	30	0.0	0	9.3	2.9	4.4
48	26-02 DEC	29.2	12.8	84	42	0.0	0	8.8	2.7	4.4
49	03-09	27.9	13.6	85	39	0.0	0	7.1	3.1	4.1
50	10-16	28.6	14.8	89	37	0.0	0	7.9	3.2	4.5
51	17-23	29.7	15.4	79	38	0.0	0	7.6	4.4	4.9
52	24-31	32.0	13.4	80	30	0.0	0	9.3	2.2	5.1
1	01-07 JAN	29.1	12.7	81	29	0.0	0	8.9	3.8	4.6
2	08-14	29.9	12.1	81	29	0.0	0	9.2	2.9	4.5
3	15-21	31.1	12.0	78	24	0.0	0	9.9	3.0	5.0
4	22-28	30.8	14.9	78	32	0.0	0	8.6	4.4	4.9
5	29-04 FEB	30.6	14.8	73	34	0.0	0	9.3	3.6	5.0
6	05-11	28.7	19.7	81	48	1.2	0	4.3	4.6	3.4
7	12-18	29.2	18.7	89	43	73.2	3	6.8	4.6	4.3
8	19-25	32.6	18.6	86	38	0.0	0	9.3	3.4	5.5
9	26-04 MAR	32.9	15.3	76	26	0.0	0	9.7	3.0	5.6
10	05-11	35.1	15.7	67	19	0.0	0	8.9	3.7	6.1
11	12-18	34.1	20.5	74	30	0.0	0	7.4	4.4	6.2
12	19-25	31.3	21.5	81	69	91.6	3	5.0	5.4	5.4
13	26-01 APR	32.7	22.3	85	51	6.4	1	6.2	3.4	5.4
14	02-08	33.6	21.5	77	39	36.4	1	8.5	4.7	5.7
TOTAL		768.0	406.9	2056	960	233.4	11	198.6	89.0	126.0