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Physico-Chemical Properties of Juice in Different Wine Varieties of Grape (*Vitis vinifera* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Physico-Chemical properties of juice in thirteen wine grape varieties (eight coloured and five white) were evaluated to assess the feasibility of growing wine grape varieties under Southern Telangana conditions. Observations recorded on 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. Total Soluble Solids (TSS) of juice in different varieties ranged from 15.43^{o}B to 21.95^{o}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 were found to be within the standard range as reported by Karibasappa and Adsule, 2008 *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%). The results signifies the potential `for cultivation of wine grape varieties under Southern Zone of Telangana.

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1. INTRODUCTION

The genus *Vitis* comprises of three natural groups based on geographical locations *viz*., North American, Eurasian and Asiatic [1]. 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 (Patrice et al., 2013). The domesticated grape (*Vitis vinifera* [L] is one of the oldest cultivated plants reported to be originated in middle east [2]. Grape cultivation in India has been commercially taken up under a wide range of soil and climatic conditions. Major grape-growing states are Maharashtra, Karnataka, Telangana, Andhra Pradesh, Tamil Nadu, and the north-western region covering Punjab, Haryana, western Uttar Pradesh, Rajasthan and Madhya Pradesh.

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. The wine sector is currently demonstrating positive and dynamic growth mainly due to a change in lifestyle, health consciousness and awareness about wine as a healthy drink rather than an alcoholic beverage [3,4]. Although India is not traditionally a wine drinking country, but the Indian wine industry has been steadily growing over the last decade. Wine is gradually becoming a part of urban Indian life style. This shows the need for development of wine industry in Telangana, for domestic as well as for export market. As a preliminary step there is a need to find the suitability of growing grape wine varieties for wine making, Hence it is necessary to know the physico-chemical characters of the juice. Further, wine making is an age old practice that requires specific quality parameters to meet the wine standards. Different types of wines have different values of TSS, acidity and pH [4,5]. Hence it is a pre requisite to analyse the bio-chemical properties of juice. Keeping this in view, an experiment was proposed to evaluate physico-chemical properties of juice in wine varieties of grape with an objective to find the suitability of growing wine varieties under Southern Telangana Zone.

2. MATERIALS AND METHODS

An experiment was conducted to study the quality performance of wine varieties of grape at Grape Research Station, Rajendranagar, Hyderabad . 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. 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. Wine is prepared from grape juice. Observations on physico-chemical properties of juice *viz*., Juice recovery ,Total Soluble Solids , Titrable Acidity, pH of the juice and Sugars were recorded during the two cropping seasons, First Year (2006-07) and second year (2007-08) and data were analyzed statistically.

2.1 Sample Collection

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 analysis.

2.2 Physico-Chemical Analysis of Juice

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

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.

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

2. Total Soluble Solids (^{0}Brix)

The Total Soluble Solids of the pulp and wine was determined by using ERMA hand refractometer and expressed as ^{0}B.

3. Titrable Acidity (%)

Titrable 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.

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

4. pH of the juice

pH of juice was determined by digital pH meter. The pH was calibrated at 25^0C 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.

5. Sugars

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

2.3 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 dissappearance of pink colour.

2.4 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.

2.5 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 to250 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.

$$\text{Reducing sugar (\%)} = \frac{\text{Factor X Dilution X100}}{\text{Titre value X Volume of the sample}}$$

2.6 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. RESULTS AND DISCUSSION

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 1.

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 inturn was comparable with Sauvignon Blanc (72.49%) and Cabernet Sauvignon (72.36%). Minimum mean juice recovery was recorded in cultivar Gulabi (54.26%) preceeded 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 inturn depends on pulpiness [6] (Saranraj et al., 2017), size and seediness of berries [7].

Patil et al*.* [8] 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 [9]; 76.00% in Pusa Navrang and 62.67% in Ruby Red [10].

2. Total Soluble Solids (^{o}Brix)

The important constituent of wine is ethanol, 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 2.

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

With regard to the years, the mean TSS content was significantly less in 2007-08 (17.05 ^{o}B) than that in 2006-07 (17.97^{o}B). In 2006-07, Cv.Shiraz showed highest TSS content (22.30 ^{o}B) and was superior over others. This was followed by Chenin Blanc (19.50 ^{o}B), Cabernet Sauvignon (19.06 ^{o}B) and Zinfandel (18.70 ^{o}B) which were at par with each other. Minimum TSS content was recorded by Italia (15.66 ^{o}B) preceeded by Gulabi (16.06 ^{o}B) and Symphony (16.46 ^{o}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 ^{o}B) and was superior over others. This was followed by Cabernet Sauvignon (18.76 ^{o}B), Chenin Blanc (18.16^{o}B) which were superior over the rest of the cultivars. Whereas, Italia showed minimum TSS of 15.20 ^{o}B, closely preceeded by Gulabi (15.20^{o}B) and Symphony (15.66^{o}B) and were at par. The rest of the cultivars showed intermediate TSS values ranging from 16.20 (Athens) to 17.63^{o}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 ^{o}B and 21.60 ^{o}B) while Italia (15.66 ^{o}B) in 2006-07 and Gulabi (15.20 ^{o}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 Kocher et al*.,* 2009, TSS range of 19.5 -23.0 ^{0}B and 20.5-23.5 ^{0}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 ^{0}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 [11]. On the contrary, hot conditions during ripening period increases the sugar levels in grape.

Variation in TSS among the varieties was reported earlier (Saranraj et al., 2017), Gaurav et al*.,* [6]; Patil et al*.,* [8]; Ghosh et al*.,* [12]; Havinal et al*.,* [13]; Karibasappa and Adsule, [14]. In the present study Shiraz has recorded highest TSS (21.95^{o}B) among the coloured varieties and Chenin Blanc in white varieties (18.81^{o}B). Karibasappa and Adsule (2008) reported 18.5^{o}B TSS in Chenin Blanc from Pune, which supports the results of present study. TSS recorded in case of Cabernet Sauvignon (18.91^{o}B) which was less than that (22.6^{o}B) reported by Havinal et al*.* [13] 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 [15,12].

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 ^{o}B) whereas the same variety grown in Haryana, Punjab and Tamil Nadu have less brix (12.15^{o}B). Grapes with low TSS are not preffered for wine making.

3. Titrable Acidity (%)

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 3 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 preceeded 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 preceeded 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 [15]. Further, requirement of acidity in juice varies for different types of wines. Javier et al., 2022 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 [12]. 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*.* [16] 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 [11]. 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. pH

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. 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 preceeded 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-tartarate and calcium tartarate and colour stability in (red) wine (Javier et al., 2022). 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 (Saranraj et al., 2017). A pH greater than 3.6 makes wine unstable. Wines made from low pH grapes will be inferior in quality (flabby) and those from high pH will be tart and metallic [15].

Gaurav et al., [6] reported range of pH from 3.2 to 3.5 respectively in various grape varieties under sub tropical conditions of North India. Saranraj et al., 2017 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 [15]. 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. [17], almost all the varieties screened are suitable for making wines except Italia.

5. Total Sugar Content (%)

The data recorded on total sugar content of juice as furnished in Table 5 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 preceeded 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%) preceeded 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 Cv. 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.

6. Reducing Sugar Content (%)

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 6).

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%) preceeded 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 significanty 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 preceeded 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% [6], 15.80% to 24.15% and 14.15% to 23.80% [8].

Table 1. Percent juice recovery in different wine varieties of grape during two cropping seasons

Treatments	Varieties	Juice recovery (%)		
		2006-07	2007-08	Mean
		Coloured		
T_1	Zinfandel	65.66	68.60	67.13
T_2	Cabernet Sauvignon	71.63	73.10	72.36
T_3	Gulabi	53.00	55.53	54.26
T_4	Shiraz	74.86	74.73	74.80
T_5	Bangalore Blue	58.33	59.80	59.06
T_6	Pusa Navrang	75.60	79.90	77.75
T_7	Athens	65.60	65.56	65.58
T_8	Ruby Red	60.56	61.36	60.96
		White		
T_9	Thompson Seedless	69.80	70.10	69.95
T_{10}	Chenin Blanc	80.43	76.33	78.38
T_{11}	Sauvignon Blanc	67.40	67.80	67.60
T_{12}	Italia	57.10	55.56	56.33
T_{13}	Symphony	72.53	72.46	72.50
	Mean	**67.11**	**67.75**	
		F-test	SEM	CD at 5%
Varieties		*	1.16	3.30
Years		NS	0.45	NS
Varieties x Years		NS	1.65	NS

*Note: *- Significant, NS- Non significant*

Table 2. Total soluble solids of juice in different wine varieties of grape during two cropping seasons

Treatments	Varieties	Total soluble solids (°Brix)		
		2006-07	2007-08	Mean
		Coloured		
T_1	Zinfandel	17.63	18.70	18.16
T_2	Cabernet Sauvignon	18.76	19.06	18.91
T_3	Gulabi	15.20	16.06	15.63
T_4	Shiraz	21.60	22.30	21.95
T_5	Bangalore Blue	16.63	17.40	17.01
T_6	Pusa Navrang	17.00	17.33	17.16
T_7	Athens	16.20	18.23	17.21
T_8	Ruby Red	16.66	17.16	16.91
		White		
T_9	Thompson Seedless	16.73	17.17	16.95
T_{10}	Chenin Blanc	18.13	19.50	18.81
T_{11}	Sauvignon Blanc	16.30	18.70	17.50
T_{12}	Italia	15.20	15.66	15.43
T_{13}	Symphony	15.66	16.46	16.06
	Mean	**17.05**	**17.98**	
		F-test	SEM	CD at 5%
Varieties		*	0.24	0.70
Years		*	0.09	0.27
Varieties x Years		*	0.34	0.99

*Note: *- Significant, NS- Non significant*

Table 3. Titrable acidity of juice in different wine varieties of grape during two cropping seasons

Treatments	Varieties	Titrable acidity (%)		
		2006-07	2007-08	Mean
		Coloured		
T_1	Zinfandel	0.54	0.50	0.52
T_2	Cabernet Sauvignon	0.51	0.41	0.45
T_3	Gulabi	0.61	0.59	0.60
T_4	Shiraz	0.65	0.66	0.65
T_5	Bangalore Blue	0.79	0.78	0.78
T_6	Pusa Navrang	0.69	0.72	0.70
T_7	Athens	0.65	0.61	0.63
T_8	Ruby Red	0.46	0.30	0.38
		White		
T_9	Thompson Seedless	0.54	0.48	0.49
T_{10}	Chenin Blanc	0.90	0.81	0.85
T_{11}	Sauvignon Blanc	0.50	0.48	0.49
T_{12}	Italia	0.71	0.67	0.69
T_{13}	Symphony	0.51	0.50	0.51
	Mean	**0.62**	**0.58**	
		F-test	SEM	CD at 5%
Varieties		*	0.02	0.07
Years		*	0.01	0.03
Varieties x Years		NS	0.03	NS

*Note: *- Significant, NS- Non significant*

Table 4. pH of Juice in different wine varieties of grape during two cropping seasons

Treatments	Varieties	pH		
		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	3.10	2.96	3.03
T_6	Pusa Navrang	3.20	3.40	3.31
T_7	Athens	3.60	3.46	3.53
T_8	Ruby Red	2.96	3.10	3.03
		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		*	0.05	0.14
Years		NS	0.02	NS
Varieties x Years		NS	0.07	NS

*Note: *- Significant, NS- Non significant*

Table 5. Total sugar content of juice (%) in different wine varieties of grape during two cropping years

Treatments	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

*Note: *- Significant, NS- Non significant*

Table 6. Reducing sugar content of juice (%) in different wine varieties of grape during two cropping years

Treatments	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

*Note: *- Significant, NS- Non significant*

4. CONCLUSION

There were significant differences in wine varieties with respect to physic- chemical properties of juice, juice recovery was maximum in Chenin Blanc among the white varieties and in Pusa Navrang from the coloured ones. However, the results clearly indicates the possibility of growing these varieties in Southern Telangana Zone diversifying the grape uses from table grapes to wine grapes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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