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PREPARATION AND EVALUATION OF MUSKMELON WINE: EFFECT OF DILUTION OF PULP, DAHP, PECTINESTERASE ENZYME AND CITRIC ACID ON PHYSICO-CHEMICAL AND SENSORY QUALITY CHARACTERISTICS

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ABSTRACT

An attempt has been made to study the effect of dilution, addition of diammonium hydrogen phosphate (DAHP), pectinesterase enzyme and citric acid on the fermentability, physico-chemical and sensory quality characteristics of muskmelon wine. Initial physico-chemical characteristics of the muskmelon pulp showed that it is an average source of sugars and a good source of phenols, which make it more suitable as fermentation media. Out of the two dilutions, fermentation of 1:1 dilution of muskmelon pulp gave good fermentability, physico-chemical and sensory characteristics except fermentation efficiency and amino acid content. Fermentability, physico-chemical and sensory characteristics of muskmelon wine was found to be affected significantly by the addition of DAHP in the must. The addition of pectinesterase enzyme significantly effected fermentability, physico-chemical and sensory characteristics of the muskmelon wine except pH, titratable acidity and amino acid content. Addition of citric acid in the must did not show any drastic impact on the quality of muskmelon wine. Clustering of the data showed that muskmelon wine prepared using 1:1 dilution of pulp with the addition of DAHP and pectinesterase enzyme fell in one cluster, whereas, the rest of the wines fell in the other cluster. Physico-chemical characteristics and variables of muskmelon wine were reduced to two principal components using Principal Component Analysis (PCA) that accounted for 89.02% and 98.03% variation respectively. It is concluded that 1:1 dilution of muskmelon pulp, with the addition of DAHP, pectinesterase enzyme and citric acid can be successfully used for the preparation of good quality muskmelon wine.

Key word: Muskmelon, dilution, DAHP, pectinesterase enzyme, citric acid, wine, cluster analysis, PCA.

INTRODUCTION

The Muskmelon (*Cucumis melo*), a member of *Cucurbitaceae* family (Bailey and Bailey, 1976) and consumed as fresh, is a cheaper and delicious fruit commercially grown throughout the world including India. A fruit of medium size with a thick peel and reticulate surface is relished as a dessert fruit. Besides, it has low calories and fat content and is an excellent source of vitamin A and C, minerals, especially potassium, phosphorus and iron (Parveen *et al.*, 2012; Priyanka *et al.*, 2015). The fruit possesses useful medicinal properties such as analgesic, anti-inflammatory, anti-oxidant, anti-ulcer, anti-cancer, anti-microbial, diuretic, anti-diabetic, and anti-fertility activity (Aranceta, 2004; Milind and Kulwant, 2011). It has a soft, sweet juicy flesh with musk like odor, but is highly perishable (Milind and Kulwant, 2011) and is sometimes dried, ground and used with cereals while making bread, biscuits etc. But to utilize large quantities of the muskmelon produced during the glut periods, it becomes necessary to explore alternate methods for its utilization. Preparation of alcoholic beverages is one such outlet for its economic utilization but there is only limited information available on this aspect (Teotia *et al.*, 1991).

Wine is an alcoholic beverage made by fermentation of fruit juice using *Saccharomyces cerevisiae* and grapes has been the principal fruit employed in the preparation of a variety of wines. Nevertheless, other fruits have also been made into wine such as apple, known as cider, pear for perry, plum for table and fortified wine (Schrödter, 1981; Joshi, 1997; Joshi and Kumar, 2011). Basically, wines can be made from any substrate having sufficient fermentable sugar, nitrogen source and other requirements for yeast growth (Joshi *et al.*, 1990; Joshi and Kumar, 2011; Joshi *et al.*, 2012). Dilution of pulp, initial sugar content, nitrogen sources and their concentration, addition of enzyme and maintenance of must pH are some of the important factors which affect the quality of any fruit wine as reported earlier (Kumar *et al.*, 2011; Joshi *et al.*, 2012; Singh and Puyo, 2014). However, there is no information on the dilution level of the pulp due to pulpy nature of the muskmelon, lowering of pH of the must, addition of enzyme for juice extraction and clarification wine, addition of appropriate nitrogen source for conducting the alcoholic fermentation etc. So, keeping this all in view, the current study was aimed to study the effect of different variables (different dilutions, citric acid, nitrogen source and enzyme) on fermentability, physico-chemical as well as sensory quality characteristics of muskmelon wine and the results so obtained are reported here.

MATERIALS AND METHODS

Materials: Muskmelon was procured from the local market of Solan (Himachal Pradesh, India) and converted into pulp and used as a substrate for the fermentation. Yeast strain *Saccharomyces cerevisiae* var. *ellipsoideus* (UCD 595) used was procured from Indian Institute of Horticulture Research, Bangalore (Karnataka, India). Sucrose, the common sugar used to ameliorate the must was procured from the local market. Citric acid, KMS, DAHP and chemicals used during the entire study were procured from M/S Loba Chemicals, Solan (HP). The pectinesterase used was procured from M/S Triton Chemical, Mysore (India).

Experimental: To study the effect of different dilutions, citric acid, nitrogen source and enzyme on the fermentation behavior, physico-chemical and sensory characteristics of muskmelon wine, different combinations of each other were tested (Table 1). The muskmelon must of various treatments was prepared by diluting the pulp in 1:0.5 and 1:1 ratio with water, TSS of the respective musts was raised to 24ºB with 70°B sugar syrup. After amelioration, DAHP @ 0.1% and citric acid @ 0.5% were added to these musts, respectively, along with the control (no addition of DAHP and citric acid, respectively). To all these musts, sulphur dioxide (100 ppm) was added to kill the wild microorganisms in the form of potassium meta bisulphite (KMS) and pectinesterase enzyme was added @ 0.5% along with the control (without pectinesterase enzyme). After 4 hours, the respective musts were inoculated with 5% of 24h old *Saccharomyces cerevisiae* var. *ellipsoideus* and kept for the fermentation at room temperature. When a stable TSS was reached the fermentation was considered as complete. Airlocks were fitted in the mouth of glass bottles near the end of fermentation (Joshi, 1997). After the completion of fermentation, the wines were siphoned, filtered and filled in 200 ml bottles, keeping 2.5 cm head-space, followed by crown corking and mild pasteurization and used for analyzing physico-chemical and sensory properties. In order to study the effect of multiple replicate fermentations on the quality characteristics of muskmelon wine, each combination as prepared earlier was, fermented three times at the same conditions. A complete flowchart for preparation of muskmelon wine is given in Figure 1.

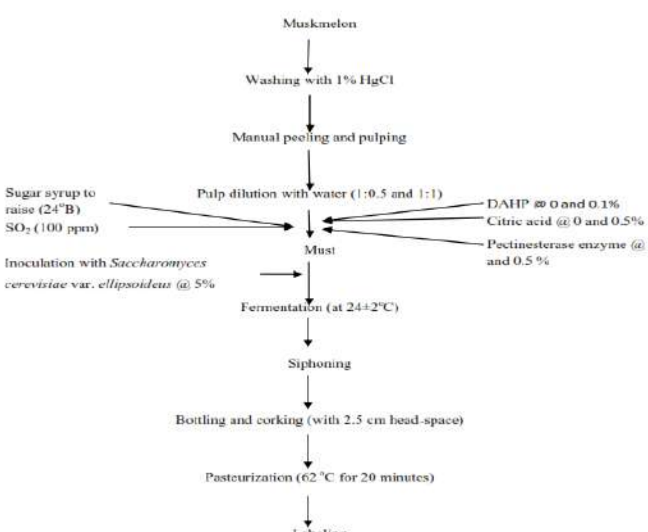


Figure 1. Flowchart for preparation of muskmelon wine.

Analysis: During fermentation, fall in TSS (ºB) was monitored at appropriate intervals of time. The wines were analyzed for different physico-chemical characteristics, viz. total soluble solids, titratable acidity (as citric acid), pH, sugars as per the standard methods (Chemists and Horwitz, 1980), ethanol was measured colorimetrically by potassium dichromate method. The total phenol content in muskmelon wines was determined by Folin Ciocalteu procedure given by (Singleton and Esau, 1969). Total amino acids and proteins were estimated by the standard procedure as described by (Sadasivam, 1996). Rate of fermentation (ºB/24 hours) and fermentation efficiency (%) was estimated with following formulas:

$$\text{Rate of fermentation} = \frac{\text{Initial TSS - Final TSS}}{\text{Time}}$$

$$\text{Fermentation efficiency} = \frac{\text{Actual alcohol produced}}{\text{Theoretical alcohol Produced}} \times 100$$

(Theoretical alcohol = Sugar used x 0.64, Sugar used= Initial TSS – Final TSS)

Sensory analysis: For sensory evaluation, chilled and coded samples of muskmelon wines were served to the semi-trained panel of judges to evaluate sensory characteristics on a prescribed performed as described by Schrödter (1981) and Joshi (2006). Each sample was evaluated for various quality attributes, viz. color and appearance, taste and aroma, bitterness and overall acceptability.

Statistical analysis: Data were analyzed by using GraphPad Prism (La Jolla, CA, USA) (version 5.01) software. To get the effect of different variables on muskmelon wine independently, the results were expressed as means ± standard deviation of the respective measure, irrespective of the others. Differences between the means were tested for statistical significance using a one-way analysis of variance (ANOVA) followed by Bonferroni post hoc test and the significance level was set at 5% ($P<0.05$) for all parameters. Cluster analysis of data was performed to get a comparative comprehensive overview of physico-chemical properties of the muskmelon wine by using SPSS 16.0 software. The output obtained was plotted as a dendrogram and the interpretation of data was made, accordingly. The statistical analysis of the data obtained from sensory evaluation of the muskmelon wine was done by Randomized Block Design (RBD) as given by Cockrane and Cox (1963).

RESULTS AND DISCUSSION

Physico-chemical characteristics of muskmelon pulp: TSS, reducing, non-reducing and total sugars, titratable acidity of musk melon pulp were 10.80°B, 3.44%, 4.02%, 7.46% and 0.12% as citric acid, respectively. These results indicated that the fruits were harvested at full maturity and having good eating quality because about 8-10ºB TSS is crucial to good eating quality of muskmelon (Artes *et al.*, 1993). Similar results have been also recorded by Beaulieu and Lea (2007); Menon and Ramana Rao (2012); Parveen *et al.* (2012). It is apparent from these results that the pulp/juice of muskmelon has sugar content which in itself cannot produce enough ethanol to be classified as table wine. So amelioration of the pulp with sugar needs to be done so as to make ethanol in the range of 10-12% (v/v). The pH value of the juice was recorded to be 5.43 which was in line with the findings of the earlier studies (Augustin *et al.*, 1988; Beaulieu and Lea, 2007; Parveen *et al.*, 2012). Polyphenolics are the most important constituents of any food from health point of view, i.e. acting as antioxidant known to play a very significant role in human health. Total phenols and protein content were recorded to be 623 mg/l and 751 mg/l, respectively (Table 1).

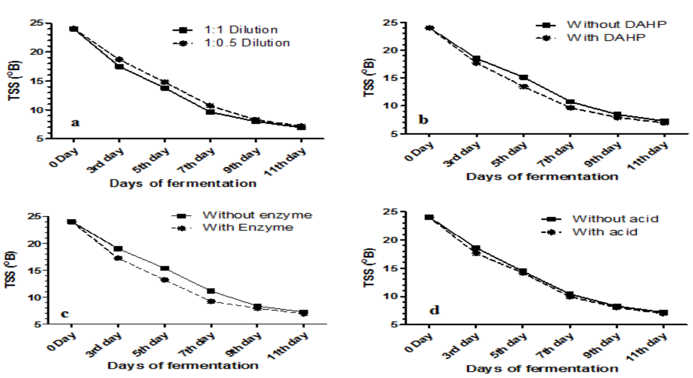
Physico-chemical characteristics	Mean* ± SD
TSS (°B)	10.80±0.06
pH	5.43±0.01
Titratable acidity (% citric acid)	0.12±0.01
Reducing sugars (%)	3.44±0.14
Non-reducing sugars (%)	4.02±0.19
Total sugars (%)	7.46±0.16
Total phenols (mg/l)	623±12.04
Total proteins (mg/l)	751±11.04

* Each value is an average of 3 replicates

Table 1: Physico-chemical characteristics of muskmelon pulp.

Similar results have been also reported by Menon and Ramana Rao (2012) for total phenols. On the basis of these characteristics, it can conclude muskmelon pulp/juice could be a good fermentation medium. But due to the thickness of the pulp, it needs to be diluted with water in suitable proportion prior to must fermentation. With respect to the acidity it can be said that is a low acid fruit, so addition of acid is needed to have normal alcoholic fermentation (Schrödter, 1981).

Effect of different variables on the fermentability of the muskmelon pulp: In general, TSS declined with the increase in fermentation time (Figure 2).



Figur:e 2. Fermentation behavior of musts having different variables, dilution (a), DAHP (b), enzyme (c) and citric acid (d)

The higher decrease in TSS during initial fermentation of all treatments is attributed to enhanced fermentability of musts followed by a slight decrease in the TSS on the subsequent days of the fermentation (Figure 2), which might be due to the availability of more sugar and presence of less ethyl alcohol in the medium in the initial stages. However, with the increase in time, the ethanol content increased thus, exerting inhibitory effect on the fermentability (Mota *et al.*, 1984; Nishino *et al.*, 1985; Sharma and Joshi, 1996). Among the different dilutions of pulp, the higher reduction in the TSS was observed in 1:1 dilution and lower was in 1:0.5 dilution which might be due to the lesser dilution of the pulp resulting in the must of higher consistency/thickness than the other dilution, may have an effect on the alcoholic fermentation (Joshi *et al.*, 2012). A Similar trend was also reported earlier by Joshi *et al.* (2012); Norraset and Tiwawan (2014) in jamun wine and *Melodorum fruticosum* wine, respectively. Regarding the effect of DAHP, the higher reduction in TSS was observed in the musts having DAHP as compared to the must without DAHP (Figure 2) .It might be due to the presence of DAHP which acts as a source of nitrogenous food and is necessary for the rapid and complete fermentation of must (Schrödter, 1981; Joshi *et al.*, 1990; Sapna *et al.*, 2015). Pectinolytic enzyme significantly affected the fermentability of the musts (Figure 2) than the control which could be due to the release of fermentable sugar from the pulpy material because of the action of enzymes (Joshi *et al.*, 2013). Similar results have been reported by (Joshi and Bhutani, 1991). The must with addition of citric acid was almost comparable to that without citric acid with respect to the fermentability (Figure 2).

Effect of different dilution of muskmelon pulp: Dilution of the thick pulp before fermentation plays an important role in better fermentability of the must and various studies on dilution of pulp have been conducted by various researchers for the production of wine Joshi *et al.* (1990), Shukla *et al.* (1991), Joshi and Kumar (2011), Kumar *et al.* (2011), Joshi *et al.* (2012). The data pertaining to the effect of dilution on various physico-chemical characteristics of muskmelon wine are presented in Table 2, which revealed a significant effect of dilution on the majority of the physico-chemical characteristics except fermentation efficiency and amino acid content. In absolute values, however, the differences were too marginal to have any drastic impact on the quality of wine. Higher rate of fermentation, titratable acidity, ethanol content and lower TSS, pH, reducing and total sugars were observed in muskmelon wine prepared from 1:1 dilution of the pulp as compared to the muskmelon wine prepared from 1:0.5 dilution of the pulp. It is in accordance to the findings of Joshi *et al.* (1990) can be correlated with high fermentability of the must discussed earlier (Figure 2) because as the dilution level increased, the thickness of the pulp decreased, which helped in the better fermentation (Joshi *et al.*, 2012). Results further revealed that the alcohol content ranged between 9.33 to 9.50 % (v/v) in wine prepared from varied dilutions, which shows that the fermentation was completed to almost dryness. Since table wine contains alcohol content from 7 to 14 % (Schrödter, 1981) hence, both the wines prepared in the present study fall in this category.

Physico-chemical characteristics	Dilution of pulp		Addition of DAHP	
	1:0.5 (pulp:water)	1:1 (pulp:water)	With DAHP	Without DAHP
TSS (°B)	**7.21±0.05 ^{a*}	6.98±0.07^{b}	6.94±0.06 ^{a}	7.25±0.07 ^{b}
Rate of Fermentation (°B) 24 hrs	1.52±0.02 ^{a}	1.55±0.02 ^{b}	1.55±0.02 ^{a}	1.52±0.02 ^{b}
Fermentation efficiency (%)	86.83±2.53 ^{a}	87.21±2.26 ^{a}	88.57±2.29 ^{a}	85.63±2.15 ^{b}
pH	3.99±0.12 ^{a}	3.72±0.07 ^{b}	3.80±0.09 ^{a}	3.91±0.10 ^{b}
Titratable acidity (% citric acid)	0.59±0.03 ^{a}	0.66±0.02 ^{b}	0.68±0.02 ^{a}	0.57±0.02 ^{b}
Reducing sugars (mg/100 ml)	550.25±35.31 ^{a}	391.38±33.04 ^{b}	279.50±25.72 ^{a}	662.13±43.36 ^{b}
Total sugars (%)	1.39±0.06 ^{a}	1.09±0.08 ^{b}	0.76±0.03 ^{a}	1.81±0.08 ^{b}
Ethanol (% v/v)	9.33±0.14 ^{a}	9.50±0.15 ^{b}	9.67±0.12 ^{a}	9.16±0.18 ^{b}
Total phenols (mg/l)	210.13±11.76 ^{a}	191.00±10.27 ^{b}	193.50±18.83^{a}	207.63±19.17 ^{b}
Amino acids (mg/100 ml)	51.54±4.11 ^{a}	47.18±3.56 ^{a}	33.75±5.50 ^{a}	64.97±7.35 ^{b}
Protein content (mg/100 ml)	306.25±26.64 ^{a}	269.38±24.07 ^{b}	280.13±10.50 ^{a}	295.50±13.01^{b}

** Mean ± SD (n=3) and *different lower case superscripts in the same row indicate the significant difference (p<0.05).

Table 2. Effect of different variables (dilution of pulp and DAHP) on the physico-chemical characteristics of muskmelon wine.

Results further revealed that the alcohol content ranged between 9.33 to 9.50 % (v/v) in wine prepared from varied dilutions, which shows that the fermentation was completed to almost dryness. Since table wine contains alcohol content from 7 to 14 % (Schrödter, 1981) hence, both the wines prepared in the present study fall in this category. The variation in the total phenols and total protein content was also related with the fermentability of the respective musts (Table 2). The highest value of total phenols and proteins was observed in muskmelon wine prepared from 1:0.5 dilution of pulp, which might be due to the low fermentability of the respective must, thus resulting in low reaction and precipitation of the phenolics and protein complex during fermentation (Kumar *et al*., 2015). In earlier reports, less precipitation of some of the tannins or protein and absorption by the yeast cells has been also reported (Schrödter, 1981).

Effect of addition of DAHP: The intrinsic importance of assimilable nitrogen to yeast growth and metabolism is a well known recognized fact in wine making (Singh and Puyo, 2014) and supplementation of must with nitrogen source has also been found essential in wine making. Because in the absence of nitrogen sources, the yeast i.e. reported to use the amino acids present in must resulting in the formation of higher alcohols (Schrödter, 1981) besides affecting some of the byproducts such as aromatic compounds, ethanol and glycerol (Albers *et al*., 1996; Nicolini *et al*., 2015). All the physico-chemical characteristics of muskmelon wine were found to be affected by the addition of DAHP in the pulp (Table 2). The results of the current study are in line with the findings of Kumar *et al.* (2011), Joshi *et al.* (1990) and Joshi and Bhutani (1991). However, higher rate of fermentation, fermentation efficiency, titratable acidity, ethanol content and lower TSS, pH, reducing and total sugars was observed in muskmelon wine prepared from the pulp having DAHP as compared to the muskmelon wine prepared from the pulp without DAHP, which might be due to the presence of DAHP which to acts as a source of nitrogen and phosphorus as food for the yeast, and is necessary to enhance the fermentation of must (Schrödter, 1981; Joshi *et al*., 1990; Sapna *et al*., 2015) As discussed earlier also and this enhanced fermentation is also responsible for the higher precipitation of total phenols and protein during fermentation; hence have low phenolics and protein content (Table 2). It is known that phenols/tannins react with proteins and precipitates, resulting in a decrease in concentrations of both protein and phenols during fermentation (Schrödter, 1981). Higher amino acids were recorded in muskmelon wine prepared from pulp having DAHP as compared to wine prepared without DAHP, which might be correlated with the fermentability and was confirmed with the correlation analysis of the data.

Effect of addition of enzyme: Addition of pectinesterase enzyme significantly affected all parameters examined except for pH, titratable acidity and amino acid content (Table 3). The results of the present study were in line with the findings of Joshi and Bhutani (1991) and Joshi *et al.* (2013) who reported that the addition of pectinesterase enzyme leads to a considerable improvement in the quality of apple wine. Further, a number of enzyme have been proposed for applications in juices and wines which are important hydrolyzing enzymes such as the pectic enzymes, proteases, glucanases, cellulose glucosidases and among them all, use of pectic enzyme helps to prevent the development of pectin hazes in wines and to hasten the process of clarification (Joshi *et al*., 2011)

Among the different wines, higher rate of fermentation, fermentation efficiency, pH, ethanol and lower TSS, titratable acidity, reducing and total sugars, total phenols and protein was recorded in muskmelon wine prepared from the must having pectinesterase enzyme (Table 3),. This might be due to the better fermentability of the must having enzyme which probably helps in releasing of fermentable sugar from the pulpy material as a result of enzyme action (Joshi *et al*., 2013). Addition of the enzyme is also known to reduce the quantity of phenolics/tannins owing to the precipitation, hydrolysis Addition of the enzyme is also known to reduce the quantity of phenolics/tannins owing to the precipitation, hydrolysis and degradation of phenolic compounds by the enzymatic reactions (Singleton and Esau, 1969; Joshi *et al*., 2013) and degradation of phenolic compounds by the enzymatic reactions (Singleton and Esau, 1969; Joshi *et al*., 2013).

	Addition of pectinesterase enzyme		Addition of citric acid	
Physico-chemical characteristics	**With enzyme**	**Without enzyme**	**With citric acid**	**Without citric acid**
TSS (°B)	6.94±0.07^{a}	7.25±0.09^{b}	6.99±0.06^{a}	7.20±0.05^{a}
Rate of Fermentation (°B) 24 hrs	1.55±0.02^{a}	1.52±0.02^{b}	1.55±0.03^{a}	1.53±0.02^{a}
Fermentation efficiency (%)	89.57±2.74^{a}	84.42±2.65^{b}	86.44±2.93^{a}	84.73±2.83^{a}
pH	3.81±0.17^{a}	3.90±0.15^{a}	3.59±0.15^{a}	4.12±0.18^{b}
Titratable acidity (% citric acid)	0.65±0.05^{a}	0.60±0.05^{a}	0.71±0.08^{a}	0.54±0.08^{b}
Reducing sugars (mg/100 ml)	330.13±32.37^{a}	611.50±39.36^{b}	458.88±29.52^{a}	482.75±35.82^{a}
Total sugars (%)	0.90±0.09^{a}	1.67±0.13^{b}	1.21±0.12^{a}	1.30±0.11^{a}
Ethanol (% v/v)	9.78±0.21^{a}	9.05±0.15^{b}	9.41±0.17^{a}	9.11±0.19^{a}
Total phenols (mg/l)	199.63±16.97^{a}	221.50±15.88^{b}	198.38±14.55^{a}	214.75±15.02^{b}
Amino acids (mg/100 ml)	49.19±3.23^{a}	49.53±3.31^{a}	45.16±4.61^{a}	53.56±7.21^{b}
Protein content (mg/100 ml)	263.00±15.88^{a}	312.63±16.97^{b}	263.25±11.14^{a}	312.38±14.70^{b}

Table 3. Effect of different variables (enzyme and citric acid) on the physico-chemical characteristics of muskmelon wine.

Effect of addition of citric acid: It is evident from the data (Table 3) that addition of citric acid content in the must have a significant effect on a fewer physico-chemical characteristics (pH, titratable acidity, ethanol content, phenolics, amino acids and protein content) as compared to other variables under study but again in the absolute values the differences were too marginal to have any drastic impact on the quality of muskmelon wine. The pH of juice/must is an important parameter for the successful progress of fermentation because of two possible reasons that is retarding the growth of harmful bacteria by acidic solution and promoting the growth of yeast which grows well in acidic conditions (Mathewson, 1980). Higher titratable acidity and lower pH were observed in muskmelon wine prepared from the must with citric acid (Table 3) which is apparently due to the contribution of the citric acid for the acidity and is responsible for the better fermentation of the must. Besides, carbon dioxide formed during fermentation might have resulted in the formation of carbonate ions and that might have ultimately increased the acidity (Zoecklein *et al.*, 1955). The finding showed that the muskmelon wine prepared by with/without addition of citric acid had alcohol content ranged between 9.11 to 9.41per cent (v/v) (Table 3) which shows that the fermentation was completed to almost dryness. Table wine contains alcohol from 7 to 14% (Schrödter, 1981) and from this point of view both the wines fell within the category of table wines. Phenolics and protein contents of the muskmelon wine prepared from the must with citric acid content were low as compared to the wine prepared from the must without citric acid content (Table 3) which might be due to the precipitation of these compounds during fermentation as discussed earlier. Higher amino acids were recorded in muskmelon wine prepared from the pulp without citric acid as compared to the wine prepared with citric acid, which might be correlated with the fermentability.

Effect of different variables on the sensory quality characteristics: It is clearly visible from the figure 3, that all the wines prepared under study by considering different variables fell in 'like moderately' category. By separating the effect of every variable, the similar trend was observed as it was seen in the physico-chemical analysis of these wines. Among the different dilutions, muskmelon wine prepared from 1:1 dilution of pulp had significantly higher scores for all the sensory characteristics as compared to 1:0.5 dilution of pulp. The results of the present study are in line with the findings of Joshi *et al.* (2012) who reported that *jamun* wine prepared from 1:1 dilution of pulp had the best scores for all the sensory attributes as compared to the wine prepared from other dilutions. Wine prepared by ameliorating the must with DAHP had the best scores for all the sensory characteristics as compared to without amelioration of pulp (Figure 3).

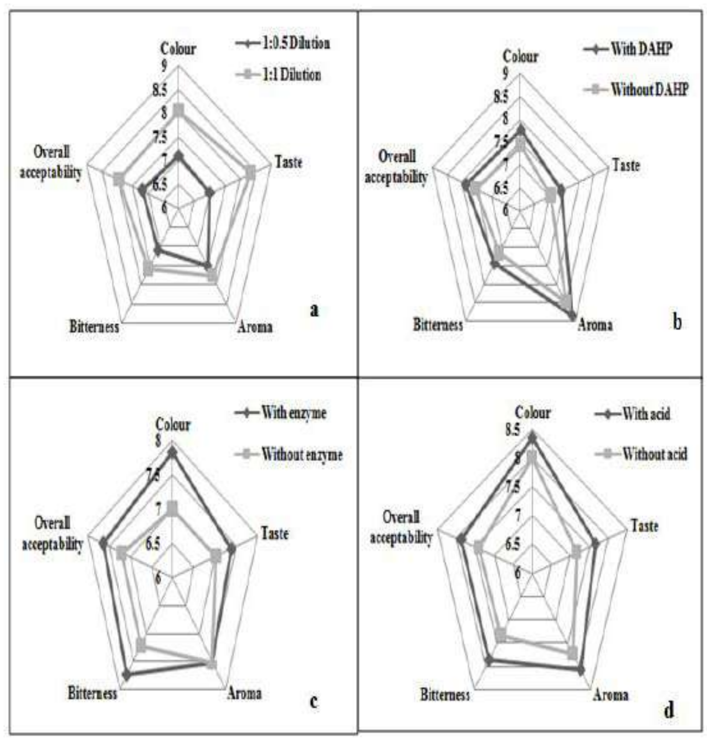


Figure 3: Effect of different variables {dilution (a), DAHP (b), enzyme (c) and citric acid (d) on the sensory quality characteristics

The results of the current study are in line with the finding of Kocher (2011) who reported that di-ammonium hydrogen orthophosphate (DAHP) supplementation improves the wine color, total acids, bouquet, taste, aroma and overall sensory quality of guava wine.

It is also evident from the figure 3, that the addition of the pectinesterase enzyme in the must increased the scores for all the sensory attributes increased as compared to the wine without enzyme. The results of the present study are in line with the findings of Espejo and Armada (2010) who reported that the wines made with enzymes were the highest rated on aroma intensity, partly because the typical aromas that predominated were more intense. Neubeck (1975) reported that the use of commercial pectic enzymes in wine preparations produced wines with a fruitier flavor and bouquet. Acids are not only responsible for the sour taste, but also modify the perception of other taste and mouth feel sensations at the same time and the same has been observed during the sensory analysis of muskmelon wine (Figure 3). A high juice pH is undesirable for the production of quality wines as it results in wines of low quality for example, reduced color stability and poor taste (Kodur, 2015). Singleton (1987) reported that wines of high pH (≥3.9) are very susceptible to oxidation and loss of their fresh aroma and young color. Acids are also involved in the precipitation of pectins and proteins which improve the color and appearance of wine that otherwise could cloud a finished wine (Jackson, 2000).

Cluster analysis of the different variables used for preparation of muskmelon wine: The data obtained from physico-chemical analysis of muskmelon wine was analyzed using cluster analysis with rescaled distance cluster analysis and shown in figure 4.

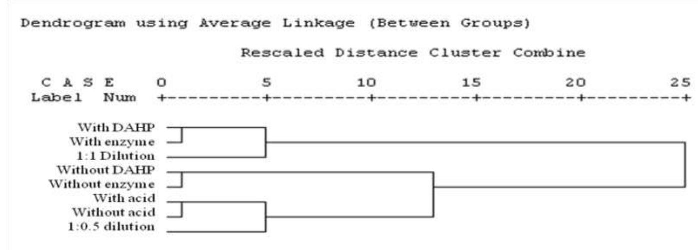


Figure 4. Cluster analysis of the different variables used for preparation of muskmelon wine.

It is evident from the figure that there was a formation of two major clusters. First cluster comprises of the muskmelon wine prepared with 1:1 dilution of pulp, with DAHP, with enzyme, which indicated that these variants have the significant effect on the physico-chemical characteristics of muskmelon wine as compared to the addition of citric acid, who failed to fall in this cluster. A second cluster comprises of the muskmelon wine prepared with 1:0.5 dilution of pulp, without DAHP, without enzymes, with or without citric acid, which indicated that these variable are different from the 1st cluster in term of quality or having the significant inferior quality characteristics as compared to the variables fall in 1st clusters.

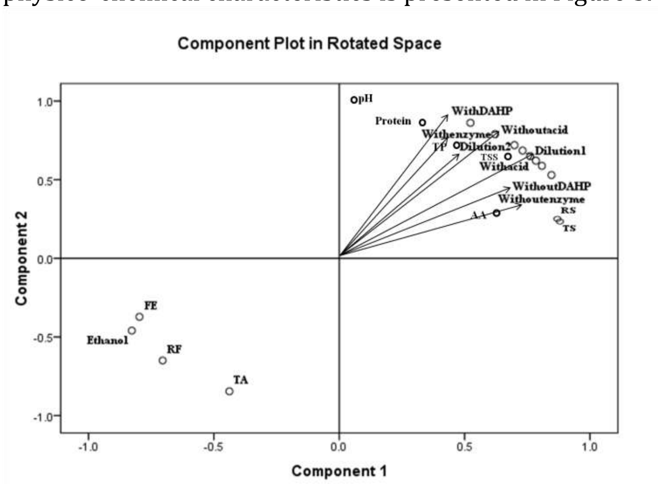
Principal components analysis Eleven physico-chemical characteristics and eight variables of muskmelon wine were reduced to two principal components (PC1 and PC2) using PCA respectively, which had Eigenvalues greater than one and retained for rotation (Hair *et al.*, 1998; Panda *et al.*, 2014). It is further evident from the PCA analysis of physico-chemical characteristics that PC1 and PC2 accounted for 77.96% and 11.06% of variance and the total variations were 89.02%, whereas, PCA analysis of variables accounted 98.03% for PC1 and 1.93% for PC2 of variance and the total variance was 99.96% (Table 4).

Physic-chemical characteristics	Principal Components of physico-chemical characteristics		Variables	Principal Components of variables	
	PC1	PC2		PC1	PC2
TSS	0.766	0.633	1:0.5 Dilution	0.789	0.614
RF	-0.705	-0.650	1:1 Dilution	0.704	0.710
FE	-0.797	-0.372	With DAHP	0.529	0.848
pH	0.135	0.976	Without DAHP	0.851	0.525
TA	-0.438	-0.846	With enzyme	0.627	0.778
RS	0.948	0.280	Without enzyme	0.813	0.582
TS	0.958	0.257	With citric acid	0.766	0.642
Ethanol	-0.827	-0.460	Without citric acid	0.736	0.677
Total phenols	0.591	0.693	Total variance explained (%)	98.03	1.93
Amino acids	0.739	0.265			
Protein	0.453	0.853			
Total variance explained (%)	77.96	11.06			

RF: Rate of Fermentation, FE: Fermentation efficiency, TA: Titratable acidity, RS: Reducing sugars, TS: Total sugars, Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization (Eigen value >1).

Table 4. Physico-chemical characteristics and variables loadings scores and percentage variance for two analytical principal components of muskmelon wine (PC1 and PC2) using varimax rotation.

To assist interpretation of dimensions, the factor pattern was rotated using the varimax method (Panda *et al.*, 2014). An attribute correlated to load heavily on a given component if the factor loading is greater than 0.72 (Stevens, 1992). Out of the eleven physico-chemical characteristics, four physico-chemical characteristics (TSS, reducing and total sugars and amino acids) loaded heavily on PC1 in positive terms, whereas, fermentation efficiency and ethanol in negative terms indicating a strong correlation among them, respectively. On PC2, pH and protein were loaded heavily in positive terms, whereas, titratable acidity in negative terms. Out of the eight variables, five variables (1:0.5 dilution, without DAHP, without enzymes, with and without citric acid) loaded heavily on PC1 in positive terms indicating a strong correlation among them. On PC2, with DAHP and with enzyme were loaded heavily in positive terms. Graphical representation of principal components (PC 1 vs. PC 2) of physico-chemical characteristics is presented in Figure 5.



RF: Rate of Fermentation, FE: Fermentation efficiency, TA: Titratable acidity, RS: Reducing sugars, TS: Total sugars, TP: Total phenols, AA: Amino acids, Dilution1: 1:0.5 Dilution, Dilution1: 1:1 Dilution

Figure 5. Graphical representation of principal components (PC 1 vs. PC 2) of physico-chemical characteristics

CONCLUSIONS

Initial physico-chemical characteristics of pulp/juice and initial variables (dilution of pulp, sugar sources and their concentration, nitrogenous sources and their concentration, enzyme concentration, pH of must, microorganisms used for inoculation, temperature etc.) plays an important role in the quality characteristics of wine. Physico-chemical properties of the muskmelon pulp showed that it is a good fermentation media beside its other uses. Must prepared with 1:1 dilution of pulp, DAHP and pectinesterase enzyme resulted in good fermentability, physico-chemical and sensory quality characteristics. Application of cluster analysis to the data also showed similar results. It is concluded that the muskmelon wine of good quality can be prepared from 1:1 dilution of pulp, with DAHP, pectinesterase enzyme and citric acid.

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