Fruit quality of Taif grape (*Vitis vinifera* L.) cultivars

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Abstract: In Saudi Arabia, grape is the second most important economical fruit where the total production of grapes is about 131000 tons. Taif region produces 3000 tons of grapes. Because of the health benefits of grape juice, the main aim of this research was to evaluate the fruit quality of Taif region grape cultivars. The specific objectives were as follows: 1) Determining physical characters of cultivars from Taif region and 2) Identifying chemical composition of these cultivars. For achieving these objectives, ten seeded samples were collected representing five cultivars namely; Italian, American, Lebanese, Syrian and Taify from different locations in Taif region namely; Abbasah, Bani Saad, A1-Qaim and A1-Hawiyyah. For fruit physical characteristics; cluster, berry and sensory characteristics were evaluated. The result of cluster characters indicated that Italian cultivar clusters were well filled and compacted. As for berry characters, American cultivar had the highest values. Finally, for sensory characters, the American cultivar had the best sensory quality. However, for chemical characters; total soluble solids (ºBrix), acidity, titratable acidity, ºBrix/ titratable acidity ratio and total anthocyanins content were measured. The obtained results indicated that, Taify clones had the highest records for these measurements. Also, many minor and macro elements were determined by ICP-OES for chemical characters evaluation. The result indicated that Taify clones had the highest value comparing with the rest studied cultivars. Finally, organic acid tartaric, malic, citric acids and succinic were determined by HPLC as main chemical characters of grapes. The highest contents were found in Taify clones. According to the measured parameters, Taify clones showed the best quality for chemical composition while American and Italian cultivars showed the best quality for physical parameters. Therefore, it was concluded that Taify clones are better candidate for industrial food processing than other cultivars. Also, it was recommended that the obtained physical and chemical characteristics can be used as potential bench marks for fruit quality of local grapes in Saudi Arabia and specifically in Taif region.
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1. Introduction

Vitis vinifera is a species native to the Mediterranean region, central Europe, and southwestern Asia, from Morocco and Spain north to southern Germany and east to northern Iran. The fruit is a berry, known as a grape **(Zohary and Hopf, 2000)** which are attached to the stem. Many berries make up the cluster or bunch of grapes. Economically, the physical and chemical compositions of grapes are good indicators of fruit quality. Therefore, extensive research has been done to identify the physical and chemical characteristics of grapes that serve as quality measures **(Gishen *et al.*, 2004; Tardaguila and Martinez de Toda, 2005)**. Physical maturity of grapes is defined as the stage when the fruit reaches its largest berry diameter, cluster weight and berry size. Also, color, sweetness and aroma of the berry are useful indicators of grape physical maturity. However, chemical maturity depends mainly on maximum sugar content and sugar/acid ratio **(Khan *et al.*, 2008)**.

Many volatile odorous compounds are found in juice. These aromatic substances are derived from three major sources: grapes (fruits), Aging and maturation. Grapes contain numerous flavor compounds. Some of these compounds have been reported to give a variety their distinct varietals character. The odorous compounds in grapes are largely present in the skin and the layers of cells immediately beneath it. Their concentration (flavor compounds) tends to increase during ripening. It is important that the grapes be harvested when the flavor is at its peak. Many factors affect the concentration of aroma compounds in grapes. Manipulation and control of these factors is necessary for attaining the desired flavor level at harvest. In addition to the four basic flavors (sweet, sour, salty, and bitter) that humans can recognize in fruits and vegetables, aroma has an important influence on the final consumer acceptance of the commodity **(Defilippi *et al.*, 2009)**. Among the flavor metabolites already mentioned, sugar and organic acid compositions, which are measured through total soluble solids (TSS) and titratable acidity (TA), are most commonly associated with the taste of fruits, including table grapes **(Ferguson and Boyd, 2002; Shiraishi *et al.*, 2010)**.

Despite the importance of TA to the overall flavor, growers mainly use TSS (sweetness) as an indicator of ripeness and most of the commercial varieties are considered mature when TSS ranges from 15 to 18%.

Chemical composition of grapes, similar to other species, is influenced by several factors such as maturity, genotype and growing conditions **(Liu *et al.*, 2006)**.

Grape fruit consists of 70 to 80% water and many dissolved solids. These soluble solids include numerous organic and inorganic compounds. The important groups of compounds include; sugars, organic acids, phenolic compounds, nitrogenous compounds, aroma compounds, minerals and pectic substances.

Large portion of the soluble solid in grapes is sugars. The sugar content of the juice is often expressed in terms of °Brix. The unit °Brix represents grams of sugar per 100 grams of juice. Commonly, it is interpreted as grams of sugar per 100 ml of juice. The sugar content of the juice in terms of °Brix can be measured by a refractometer or a °Brix hydrometer.

Organic acids are the most abundant solids present in grape. They are a very important component of juice. They are responsible for the tart taste and have a marked influence on juice stability, color, and pH. The principal organic acids found in grapes are tartaric, malic, and to a small extent, citric **(Mato *et al.*, 2007).** Many other organic acids, including amino acids, are also found in juice, but tartaric and malic acid account for over 90% of the total acids present. The evolution of tartaric and malic acids in grapes is useful for checking their processes of maturation **(LamiKanra *et al.*, 1995)**. During the early period of berry growth, concentration of both acids increases in the fruit. With the onset of ripening, the sugar accumulates in the fruit and the acid concentration decreases. Generally the reduction in malic acid is greater, and consequently, at maturity, the fruit contains more tartaric acid than malic. Grapes are one of the rare fruits that contain tartaric acid. It is present as free acid and a salt, such as potassium bitartrate. The acid composition of grapes is influenced by many factors such as variety, climatic region, and cultural practices. Generally in ripe grapes, the acid levels are lower in a warmer climatic region than in a cooler region.

Grape juice consists largely of water (81–86%), with a high concentration of the sugars glucose and fructose. It presents an elevated acidity due to the presence of tartaric, malic and citric acids. These acids ensure a low pH value, guaranteeing equilibrium between acidic and sweet tastes **(Gurak *et al.*, 2010).**

The acidity is expressed as titratable acidity (TA). It is an important parameter used in quality evaluation of juice. Acid content of the juice has an important bearing on juice pH. Acids upon dissociation liberate H^+ ions, which are measured and expressed in terms of pH. Thus acidity and pH are related. Differences in the acidity of the table grape at harvest can be due to differences between varieties, environmental conditions, storage time, and other factors **(Diakou *et al.*, 1997; Navarro *et al.*, 2001; Liu *et al.*, 2006)**.

At the same time, coloration is a relevant factor in the quality of fruits and fruit derivative, however, the coloration is affected by the total content of anthocyanins and its distribution is affected by other factors such as the amount of chloroplasts, the formation of anthocyanin metal complexes and also by pH **(Chitarra and Chitarra, 2005)**. Color is an important attribute related to the visual appeal and the quality of grape food products **(Bridle and Timberlake, 1997)**. The most abundant anthocyanins in grapes are the glucoside forms of cyanidin, malvidin, delphinidin, peonidin, petunidin and pelargonidin **(Liang *et al.*, 2008).** Grape juice color is often dependent upon the skin color which varies mainly due to the composition and the content of anthocyanins **(Carreňo and Martĭnez, 1995, Corrales *et al.*, 2009)**. The anthocyanin content of fruits is greatly influenced by various genetic (cultivar), environmental and agronomic factors. Anthocyanins are highly unstable and very susceptible to degradation.

Minerals usually make up approximately 0.2 to 0.6% of the fresh weight of the fruit. The important mineral compounds include; potassium, sodium, iron, phosphates, sulfate, and chloride. Of the mineral compounds mentioned above, potassium is the most important mineral. It accounts for 50 to 70% of the cations in the juice. During ripening, the potassium content of the grape increases. Its movement into fruit leads to the formation of potassium bitartrate, which reduces the acidity and increases the juice pH. They can be divided into macro-minerals such as sodium, potassium, magnesium calcium and phosphorus; and micro-minerals such as iron, copper, zinc and manganese. They play an important role in human nutrition because they are not synthesized in the body. Therefore, there has been increasing interest in evaluating the macro- and micro-elements in fruits **(DiSilvestro, 2005; Belitz *et al.,* 2009)**.

In Saudi Arabia, grape is the second most important economical fruit after dates. The total cultivated area of grape is about 10000 ha which produced 131000 tons of grapes every year. Taif produced 3000 tons of grapes every year (www.menareport.com. 2001). Many grape varieties have been cultivated in Taif region. These varieties have been screened and evaluated by **Abd-El-Kawi and El-Yami (1992a)**. They found only four varieties differed in their bud behavior **(Abd-El-Kawi and El-Yami, 1992b)** and in their vegetation characters **(Abd-El-Kawi and El-Yami, 1992c)**. Recently, **Al-Yami (2008)** surveyed, evaluated and described grape varieties in Taif region. Their results could be summarized as: Al-Bayadi variety is considered the main white variety and makes up 90% of the total area of grapes in Taif. It shows best fruit characteristics. A1-Razqui and A1-Nakhee1i grapes are considered secondary varieties. A1-Sawadi grape is a black seeded variety. It had good physical and chemical characteristics after A1-Bayadi variety.

In conclusion, cultivar quality can be characterized by physical measurements and by analysis of chemical compounds. These examinations of grape parameters remain the most important and easiest means for the identification of grape quality **(Schneider, 1996)**.Therefore; the main aim of this research was to evaluate the fruit quality of Taif region grape cultivars collected from different locations. The specific objectives were as follows: 1) Determining physical and sensory characters of grape cultivars from Taif region. 2) Identifying of chemical composition of these grape cultivars.

2. Materials and Methods

Italian, American, Syrian, Lebanese table grape cultivars and six clones of Taify table grape cultivar were selected from different locations in Taif governorate namely; Abbasah, Bani Saad, A1-Qaim and Al Halaka, for this study that was carried out in 2010-2011. The chosen vines were eight years old, grown in a sandy loam soil, spaced at 2 x 3 meters apart, and irrigated by the drip system. Three replicates for each cultivar were taken. Three clusters from each cultivar were harvested and immediately transported to the laboratory and kept in – 20 °C until analysis. For studying the fruit physical and chemical characteristics, date of fruit harvesting takes place when the berries attain full color stage and the TSS reach 16-17% according to **Tourky *et al*. (1995)**.

Fruit Physical characteristics:

Cluster characteristics:

Clusters were collected from upper, middle and lower position of the grape vine to obtain cluster length (cm), cluster weight (g), number of berries /cluster and cluster compactness. Cluster compactness was measured on score range from 1 to 3 where 1 is very compact and 3 is less compact (table 2) **(Christodulou *et al.*, 1968)**.

Berry characteristics:

From the harvested grapes two kg berries were chosen randomly for analyzing berry weight, flesh weight of five berries, seeds weight of five berries, berry size, berry diameter and berry flesh thickness. Berry diameter and flesh thickness measured using Vernier caliper whereas berry weight and seed weight were measured using a digital top-load balance with an accuracy of two decimal units.

Sensory evaluation:

Grape berries were evaluated for, aroma and sweetness using a 5-point scale with six trained panelists. Also, skin color was measured according to **Hunter (1979)** where, L: lightness, R: redness, Y: yellowness and B: black.

The testing was done in a clean, quiet, air conditioned and odor free room where each panelist used separate tables during judgments. The attributes and product acceptability were expressed as follows:

Aroma: 5 natural; 4: loss of aroma; 3: no aroma; 2: light strange aroma; 1: strong strange aroma.

Sweetness: 5 very sweet; 4: sweet; 3: acceptable sweetness; 2: low in sweetness; 1: no sweetness at all.

Berry skin color: L: lightness, R, redness, Y, yellowness and B, black.

Fruit Chemical characteristics:

Preparation of grape juice

About fifty of frozen grapes berries per each cultivar were thawed overnight (12 h) at 4 °C, crushed using a blender and allowed to settle to obtain a clear juice. Juice was filtered on a double layer cheese cloth to remove skin and pulp from the juice. The obtained juice was immediately frozen at -20 °C. Frozen juice samples were analyzed within one month of juice preparation.

Representative samples were taken for the determination of °Brix and titratable acidity before sensory evaluation.

Total soluble solids

Total Soluble solids (T.S.S.) (%) in berry juice were measured using a table refractometer (Model N-50E; Atago, Tokyo, Japan). Refractive index was recorded and converted to °Brix. Measurements were performed at 25 ± 0.5 °C.

Acidity

Acidity was measured by two methods; the first method included using of pH meter at room temperature. Grape juice pH was measured using a digital pH meter (Model: pH 211, HANNA instruments). The meter was calibrated with commercial buffer solutions at pH 7.0 and 4.0. Ten milliliter samples were placed in a beaker with a magnetic stirrer and measured at 20 ± 0.5 °C. For total titratable acidity, samples of 20 ml were placed into a 250 ml beaker and 80 mL of distilled water was added. This solution was then titrated against standardized 0.1 N NaOH (Sigma-aldrich) to the phenolphthalein end point (pH= 8.2 ± 0.1). The volume of NaOH was converted to gm citric acid per 100 mL of berry juice. The titrated volume of 0.1 N NaOH was recorded and citric acid (gm tartaric acid per 100 ml juice) was calculated using the following formulas:

a. Normality of citric acid = N x V (NaOH) = N' x V' (citric acid).

b. Citric acid (gm/100ml juice) = M.W. of citric acid x normality of citric acid x volume of grape juice /100.

Finally, the °Brix to acid ratio for each sample was calculated by dividing the °Brix value by % titratable acidity.

Total anthocyanins

Total anthocyanins was measured based on the methods described by **Iland *et al.* (1996, 2000)**. 200 ul of juice was added to 3.8 ml 1 M HCl and incubate for three hours at room temperature. Absorbance of the solution was measured using spectrophotometer at 520 nm using 1 M HCl a blank. The total anthocyanins was calculated from the following equation:

Anthocyanins (mg/ml) = A_{520} X DF X 1000^a / 500^b X 100^c

A_{520} = Absorbance at 520 nm

DF = dilution factor of juice in 1 M HCl

a = 1000 for mg

b = absorbance of 1% malvidin

c = df of malvidin

Elements determination

Elemental analysis was carried out on an Inductively Coupled Plasma, Optical- Emission Spectroscopy (ICP-OES) Model: Optima 2100 DV, connected with Perkin Elmer auto sampler Model: AS-93 plus (Dual view, Perkin Elmer life and Analytical Sciences, USA). Standard solutions were prepared by dilution each pure element standards obtained from Merck (Darmstadt, Germany). Analytical grade nitric acid (65% Merck) was used for the mineralization of the samples. All aqueous solutions and dilutions were prepared with ultra pure water (Milli-Q, Millipore, Bedford, USA).

HPLC analysis of organic acids

For quantitative analysis of organic acid, HPLC standards (tartaric acid, malic acid, citric acid and succinic acid) were dissolved in ethanol at a final concentration of 1 mg/ml. The HPLC instrument model: Agilent 1100 was used with the following conditions:

The column type used for separation was Hypersil Gold 4.6 x 150 mm with 5 µM diameter. The buffer used as an eluent was 50 mM Phosphate buffer adjusted to pH 2.8 by sulfuric acid. The flow rate used for separation was 0.7 ml/min. The injection volume used for the standards and samples was 10 µl. The temperature used during separation process was 30°C. The wavelength used was 214 nm.

Statistical analysis

Analysis of variance (ANOVA) by using SPSS 16.0 was used to compare the treatments. Means were compared using Duncan test at the 5% level.

3. Results and Discussion

Grape cultivars were collected from different locations in Taif region namely; Al roddaf, Bani Saad, A1-Qaim and A1-Hawiyyah. A vineyard was chosen from each location to represent the cultivar. Grape cultivars were collected at maturity stage. Maturity stage attained when the fruits have attained acceptable eating quality which is dependent upon juice content of the fruit, total sugars and the sugar-acid ratio. These characteristics vary with the area of cultivation, season, cultivar, etc. Therefore, ten seeded samples were chosen representing five cultivars namely; Italian, American, Lebanese, Syrian and Taify. Six different clone samples of the Taify cultivar were collected from different regions (Table 1).

Table (1): Grape (*Vitis vinifera* L.) cultivars understudy and their locations in Taif regions, Saudi Arabia.

No.	Cultivar	Location
1	Italian	Prince Bandar Farm, Al roddaf region, Taif.
2	American	Prince Bandar Farm, Al roddaf region, Taif.
3	Taify ($clone_a$)	Mehanna Farm, Al Halaka region, near from Al Hawaiya.
4	Lebanese	Prince Bandar Farm, Al roddaf region, Taif.
5	Syrian	M. El-Abasy farm, Al-Qaim region
6	Taify ($clone_b$) (Al-Bayadi)	Mastour Farm, Al Raha village, Al wadi region.
7	Taify ($clone_c$)	Al Raha village, Al-Talha Al Olaia region.
8	Taify ($clone_d$) (Al-Bayadi)	Al Raha village, south Bani Saad region.
9	Taify ($clone_e$) (Al-Bayadi)	Al Raha village, Al Khowkaa region.
10	Taify ($clone_f$) (Al-Bayadi)	Al Galla Farm, Wadi Al Shorot village, Bani Saad region.

Fruit Physical characteristics:

Cluster characteristics:

Data concerning cluster characteristics are presented in Table 2. Cluster length, cluster weight, cluster compactness and number of berries/cluster were recorded as quantitative traits. With regard to cluster length, the results in table (2) found that the differences among the grape cultivars were significant. American and Taify ($clone_b$) had the highest recorded values for cluster length (21 cm). Also, data illustrated in table (2) showed that highly significant differences among sampled grape cultivars for cluster weight and number of berries/cluster. Italian cultivar had the highest cluster weight (604 cm), while Taify ($clone_f$) had the lowest one (187 cm). As for number of berries/cluster values, it was noticed that Taify ($clone_a$) had the highest record (97), while Syrian cultivar had the lowest one (37).

Concerning cluster compactness there were significant differences among sampled local grape cultivars for cluster compactness, Italian, Taify ($clone_a$), Taify ($clone_c$) and Taify ($clone_f$) had the highest values (3) as compared to Lebanese, Syrian and Taify ($clone_d$) which had the lowest records (1). It is clear that in Italian cultivar, Taify ($clone_a$), Taify ($clone_c$) and Taify ($clone_f$) the cluster was well filled and compacted. The result in this respect is agreed with many investigators worked on different cultivars **(Aisha *et al*., 1998; Marwad 2002 a&b)**.

Table (2): Average cluster length, cluster weight, cluster compactness and number of berries /cluster of studied grape (*Vitis vinifera* L.) cultivars.

No.	Cultivar	Average cluster length (cm)	Average cluster weight (g)	Average cluster compactness	Average number of berries /cluster
1	Italian	19.5^{b}	604^{a}	3	75^{c}
2	American	21^{a}	388^{c}	2	50^{h}
3	Taify (clone$_a$)	18.5^{c}	482^{b}	3	97^{a}
4	Lebanese	18.5^{c}	362^{e}	1	59^{e}
5	Syrian	19.5^{b}	219^{i}	1	37^{i}
6	Taify (clone$_b$)	21^{a}	369^{d}	2	65^{d}
7	Taify (clone$_c$)	18.5^{c}	290^{g}	3	84^{b}
8	Taify (clone$_d$)	15.5^{d}	253^{h}	1	52^{g}
9	Taify (clone$_e$)	19^{bc}	328^{f}	2	75^{c}
10	Taify (clone$_f$)	14^{e}	187^{j}	3	57^{f}

Means having the same alphabetical letters within each column are not significantly different at $P \leq 0.0$
5 according to Duncan's multiple range test.

Berry characteristics

Data concerning berry physical characteristics are presented in Tables 3 and 4. Data in table (3) show a highly significant variation among sampled local grape cultivars for physical parameters records, except for berry flesh thickness which had a non-significant differences among grape cultivars. Italian cultivar had the highest values for weight of five berries, flesh weight of five berries, seeds weight of five berries, Berry diameter and berry flesh thickness (54g, 50.80g, 1.067g, 1.467cm and 0.80cm) respectively. American cultivar had the highest berry size (9.00 cm^3), while Taify (clone$_d$) had the lowest value (2.67 cm^3). In the mean time, Taify (clone$_d$) had the lowest values for weight of five berries, flesh weight of five berries, berry size, berry diameter and berry flesh thickness (12g, 9.00g, 2.67cm^3 , 0.467cm and 0.46cm) respectively.

The result is in harmony with many investigators worked on different cultivars **(Sabry *et al*., 2009 and Abd El-Wahab, 2011)**.

Table (3): Average weight of five berries, flesh weight of five berries, seeds weight of five berries, berry size, berry diameter and berry flesh thickness of studied grape (*Vitis vinifera* L.) cultivars.

No	Cultivar	Average weight of five berries (g)	Average flesh weight of five berries (g)	Average seeds weight of five berries (g)	Average berry size (cm^3)	Average berry diameter (cm)	Average berry flesh thickness (cm)
1	Italian	54^{a}	50.80^{a}	1.067^{a}	8.67^{a}	1.467^{a}	0.80^{a}
2	American	50^{b}	47.90^{b}	0.674^{e}	9.00^{a}	1.267^{b}	0.80^{a}
3	Taify (clone$_a$)	29^{e}	27.10^{e}	0.129^{j}	4.67^{bcd}	0.900^{def}	0.76^{a}
4	Lebanese	37^{c}	36.30^{c}	0.786^{c}	7.33^{ab}	1.100^{bc}	0.80^{a}
5	Syrian	35^{d}	33.50^{d}	0.709^{d}	6.67^{abc}	1.033^{cde}	0.70^{a}
6	Taify (clone$_b$)	35^{d}	33.70^{d}	0.817^{b}	6.67^{abc}	1.067^{cd}	0.70^{a}
7	Taify (clone$_c$)	26^{f}	24.40^{f}	0.588^{g}	5.00^{bcd}	0.867^{ef}	0.70^{a}
8	Taify (clone$_d$)	12^{i}	9.00^{i}	0.350^{i}	2.67^{d}	0.467^{h}	0.46^{b}
9	Taify (clone$_e$)	21^{g}	15.30^{g}	0.420^{h}	3.33^{d}	0.767^{fg}	0.46^{b}
10	Taify (clone$_f$)	16^{h}	12.20^{h}	0.640^{f}	4.00^{cd}	0.600^{gh}	0.50^{b}

Means having the same alphabetical letters within each column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Sensory evaluation

Sensory evaluation provides a good tool in the quick assessment of fruit quality. Several traits such as berry skin color, aroma and sweetness were visualized in table 4.

Concerning berry color, table (4) showed that, fruit of Italian, Lebanese, Syrian and Taify (clone$_d$) had redness skin color, while skin color of Taify (clone$_a$), Taify (clone$_b$), Taify (clone$_c$) and Taify (clone$_e$) cultivars were lightness. Only American cultivar was characterized with black color and Taify (clone$_f$) was characterized with yellowness. Concerning of fruit aroma, Syrian and Taify (clone$_f$) had strong aroma, while Taify (clone$_a$), Taify (clone$_b$) and Taify (clone$_d$) had a weak of aroma.

Concerning sweetness American, Taify (clone$_c$) and Taify (clone$_e$) had contained very sweet fruit, while other cultivars had acceptable and low sweetness. Therefore, it was concluded that aroma and sweetness varied among cultivars. The cultivar American, Taify (clone$_c$) and Taify (clone$_e$) showed the best sensory quality. However, the Syrian cultivar showed the low sensory quality (Table 4).

Table (4): Fruit berry color, aroma and sweetness of studied grape (*Vitis vinifera* L.) cultivars.

No.	Cultivar	Berry color	Aroma	Sweetness
1	Italian	R	3	4
2	American	B	3	5
3	Taify(clone$_a$)	L	4	2
4	Lebanese	R	2	3
5	Syrian	R	1	2
6	Taify(clone$_b$)	L	4	3
7	Taify (clone$_c$)	L	3	5
8	Taify(clone$_d$)	R	4	2
9	Taify (clone$_e$)	L	3	5
10	Taify (clone$_f$)	Y	1	3

Aroma: 5 natural; 4: loss of aroma; 3: no aroma; 2: light strange aroma; 1: strong strange aroma.
Sweetness: 5 very sweet; 4: sweet; 3: acceptable sweetness; 2: low in sweetness; 1: no sweetness at all.
Berry skin color: L: lightness, R, redness, Y, yellowness and B, black.

Fruit Chemical characteristics

Table 5 presents the mean values of Total Soluble Solids (TSS) (%), pH analysis, total Titratable Acidity (TA) (%), sugar/acid ratio and total anthocyanins (mg/100ml).

Total soluble solids (TSS, predominantly consisting of sugars and measured as °Brix or Balling) and acidity, measured as pH and titratable acidity (TA), are widely accepted as broad indicators of grape maturity **(Zoecklein, 2001)**.

In general, Taify (clone$_d$) received high rating for chemical parameters, which it showed the highest TSS content and the lowest acidity**.** However, the Italian cultivar showed the lowest ratio between TSS content and acidity (Table 5). Data in table 5 showed that there was a significant difference among sampled local grape cultivars for TSS (%) records. The obtained result indicated that, Taify (clone$_d$) had the highest record (25 %), followed by Lebanese cultivar, Taify (clone$_e$) and Taify (clone$_f$) with TSS record 21%. Both Italian and American cultivars had the lowest TSS records (12 and 14 %) respectively. The result in table 5 indicated that the TSS increases and TA decreases, and then the ratio between these values increases over time. This result was very harmony with **Crisosto (2002)**, who mentioned that, commercial harvest of table grapes is reached when the quotient TSS/TA has a value close to 20. This value has been defined as the lowest one for consumer preference **(Jayasena and Cameron, 2009)**. **Du Plessis (1977)** suggested that the TSS/TA ratio is a good indicator of grape ripeness due to the changes in the concentration of sugars and organic acids from one year to another under similar conditions.

Differences in the acidity of the table grape at harvest can be due to differences among varieties, environmental conditions, storage time, and other factors **(Diakou *et al*., 1997; Navarro *et al*., 2001; Liu *et al*., 2006)**.

As for the anthocyanins parameter the Italian cultivar showed the highest value for the content of anthocyanins (Table 5), while the Taify (clone$_d$) and Taify (clone$_f$) showed the lowest values. The range of the anthocyanins values was very wide (0.6 – 7.4 mg/100ml). This data indicated that the cultivars were varied markedly. The dark red coloration is a relevant factor in the quality of fruits and fruit derivate. However, the coloration is affected by the total content of anthocyanins and its distribution is affected by other factors: the amount of chloroplasts that store such pigments, the formation of anthocyanin-metal complexes and also by pH **(Chitarra and Chitarra, 2005)**.

Malacrida and Motta (2006) evaluated the content of monomer anthocyanins in reconstituted and simple grape juices of different trademarks and obtained a mean content of 17.31 mg L^{-1} for reconstituted grape juice and 28.70 mg L^{-1} for sample juice. **Falcao *et al.* (2004)** and **Provenzi *et al*. (2006)** analyzed the concentration of total anthocyanins in Cabernet Sauvignon grape raw extracts obtained a concentration of anthocyanins of 95 and of 237 mg/100g of grape peel.

Table (5): Total Soluble Solids (ºBrix), acidity, titratable acidity (%), ºBrix/ titratable acidity (%) ratio total anthocyanins content (mg/100ml juice) of studied grape (*Vitis vinifera* L.) cultivars.

No.	Cultivar	TSS ºBrix (%)	Acidity		ºBrix/acid ratio	Anthocyanins (mg/100ml juice)
			pH	Titratable acidity (Citric acid %)		
1	Italian	12^f	4.18	0.37^b	32.88^i	6.3^b
2	American	14^e	4.24	0.23^e	62.22^f	2.3^d
3	Taify (clone$_a$)	20^{bc}	3.99	0.23^e	88.89^c	0.9^f
4	Lebanese	21^b	4.02	0.34^c	62.13^f	1.6^e
5	Syrian	19^{cd}	3.97	0.21^f	92.23^b	3.2^c
6	Taify (clone$_b$)	18^d	4.21	0.28^d	64.06^e	1.0^f
7	Taify (clone$_c$)	18^d	3.87	0.45^a	40.00^h	1.9^{de}
8	Taify (clone$_d$)	25^a	4.03	0.21^f	121.36^a	0.6^f
9	Taify (clone$_e$)	21^b	3.81	0.45^a	46.67^g	7.4^a
10	Taify (clone$_f$)	21^b	4.22	0.24^e	86.07^d	0.8^f

Means having the same alphabetical letters within each column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Grape juice mineral contents

Elemental concentrations in all studied grape cultivars determined by ICP-OES are listed in Tables 6 and 7. Of the elements, potassium was the mineral element with the highest concentration in all grape juice samples, while Na was the lowest.

The present data in table 6 indicated that, Taify (clone$_d$) contained significantly higher juice Cu, Mn and Se values as compared to those of other grape cultivars. As for Fe content, the result indicated that Taify (clone$_a$) had the highest value comparing with the rest studied cultivars, while Italian cultivar had the lowest value of Fe and Mn contents.

Table 6: Micro elements content (mg/ L) of studied grape (*Vitis vinifera* L.) cultivars.

No.	Cultivar	Fe	Cu	Zn	Mn	Se
1	Italian	0.023^{i}	0.064^{f}	0.017^{h}	0.052^{i}	0.143^{h}
2	American	0.049^{e}	0.032^{i}	0.048^{d}	0.059^{g}	0.121^{i}
3	Taify (clone$_a$)	0.093^{a}	0.044^{h}	0.017^{h}	0.057^{h}	0.373^{f}
4	Lebanese	0.035^{h}	0.062^{g}	0.073^{c}	0.090^{d}	0.450^{c}
5	Syrian	0.050^{d}	0.116^{b}	0.025^{g}	0.066^{f}	0.370^{f}
6	Taify (clone$_b$)	0.039^{g}	0.074^{d}	0.033^{f}	0.038^{j}	0.200^{g}
7	Taify (clone$_c$)	0.066^{b}	0.073^{de}	0.082^{a}	0.099^{c}	0.390^{e}
8	Taify (clone$_d$)	0.044^{f}	0.146^{a}	0.080^{b}	0.122^{a}	0.521^{a}
9	Taify (clone$_e$)	0.058^{c}	0.076^{c}	0.044^{e}	0.102^{b}	0.407^{d}
10	Taify (clone$_f$)	0.021^{j}	0.072^{e}	0.007^{i}	0.074^{e}	0.487^{b}

Means having the same alphabetical letters within each column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

The result in table 7 indicated that all studied cultivars had highest potassium values, while they had the lowest sodium values. These results agreed with **(Gurak *et al*., 2010)** who mentioned that grape juice has a high potassium value and low sodium value. Taify (clone$_b$) had significantly higher potassium and sodium content as compared to rest studied cultivars. In the mean time, Taify (clone$_c$) had the highest values from magnesium and calcium as compared to the rest studies cultivars.

On the other hand, the results revealed that American cultivar had significantly lower potassium, magnesium and calcium content as compared with the rest studied cultivars. The obtained data in this connection are in harmony with those mentioned by **Akpinar-Bayizit *et al*. (2010)** which they determined major and minor elements in 35 commercial vinger samples using ICP-OES and they found that the elements with the highest concentrations were K, Ca, Mg and P.

Table 7: Macro elements content (mg/ L) of studied grape (*Vitis vinifera* L.) cultivars.

No.	Cultivar	K	Na	Mg	Ca
1	Italian	148.10^{e}	0.469^{h}	6.521^{f}	6.809^{g}
2	American	115.30^{i}	0.889^{e}	4.505^{h}	4.661^{j}
3	Taify (clone$_a$)	120.70^{h}	3.302^{b}	5.781^{g}	8.375^{c}
4	Lebanese	128.40^{g}	0.791^{f}	7.105^{d}	7.365^{f}
5	Syrian	129.20^{g}	0.010^{i}	6.884^{e}	7.632^{e}
6	Taify (clone$_b$)	224.20^{a}	4.768^{a}	7.053^{d}	8.211^{d}
7	Taify (clone$_c$)	176.60^{c}	3.275^{b}	10.150^{a}	11.48^{a}
8	Taify (clone$_d$)	187.90^{b}	0.557^{g}	8.667^{c}	5.292^{i}
9	Taify (clone$_e$)	150.90^{d}	2.928^{c}	9.088^{b}	9.626^{b}
10	Taify (clone$_f$)	137.50^{f}	1.231^{d}	5.670^{g}	6.026^{h}

Means having the same alphabetical letters within each column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Organic acids content

In this study, the organic acid composition of five grape cultivars was determined by HPLC. Organic acids content of different grape cultivars are presented in figure 1 and table 9. Representative chromatograms of organic acids in grape juice samples of the understudied grape cultivars are shown in Fig. 1. Tartaric, malic, citric and succinic acids were identified by comparing their retention times with those of authentic standards (table 8).

Table 9 summarized the content of organic acids in the samples analyzed by the proposed method. The values were within the range of values previously described in the literature, but obviously depend on the origin, type and ageing of grapevine.

The highest tartaric, malic, citric acids and succinic content were found in Syrian (3.65mg/ml), Taify (clone$_a$) (4.44 mg/ml), Italian (0.41mg/ml) and Taify (clone$_b$) (2.32 mg/ml) cultivars, respectively. In all grape cultivars, tartaric acid was the most abundant acid. These results agreed with **Nelson (1985)**. Who found that, organic acids do not exceed more than 1%

of the total juice weight, with tartaric acid usually the most important acid followed by malic, citric, succinic, and other acids. The ratio of tartaric to malic acid is cultivar-specific and depends on the genetic background. In respect of tartaric acid concentration, an important criterion for grape juice Syrian cultivar had the highest content.

Interestingly, Taify (clone$_c$), had one of the lowest tartaric acid content (0.17mg/ml). On the other hand, the lowest malic, citric acids and succinic content were found in Syrian (0.68 mg/ml), Taify (clone$_b$) (0.09 mg/ml) and American (0.87mg/ml) cultivars, respectively. As for the total organic acids Taify (clone$_d$) had the hight significant value (9.11mg/ml) compared to the rest studied cultivars, while Taify (clone$_c$) had the lowest value (0.17 mg/ml) compared to the other cultivars.

It is well known that organic acids contribute to the sourness of a fruit, while tartaric acid has a more important role in determining both concentration and palatable acidity **(Liu *et al*., 2006)**.

These results are similar to the observations made by **Mato *et al*. (2007),** which they mentioned that the determination of organic acids in grape juices is important because they have influence on the organoleptic properties (flavour, colour, and aroma) and on the stability and microbiological control of the products. In the mean time, Tartaric and malic acids are the predominant organic acids in grape juices and succinic and citric acids are present in minor proportion. Also, the evolution of tartaric and malic acids in grapes is useful for checking their processes of maturation **(Lamikanra *et al*., 1995)**.

Table 8: Standards concentration and their retention time

Standard name	Concentration (mg/ml)	Retention Time (min)
Tartaric acid	1.25	3.094
Malic acid	1.25	3.592
Citric acid	1.25	5.447
Succinic acid	1.25	6.048

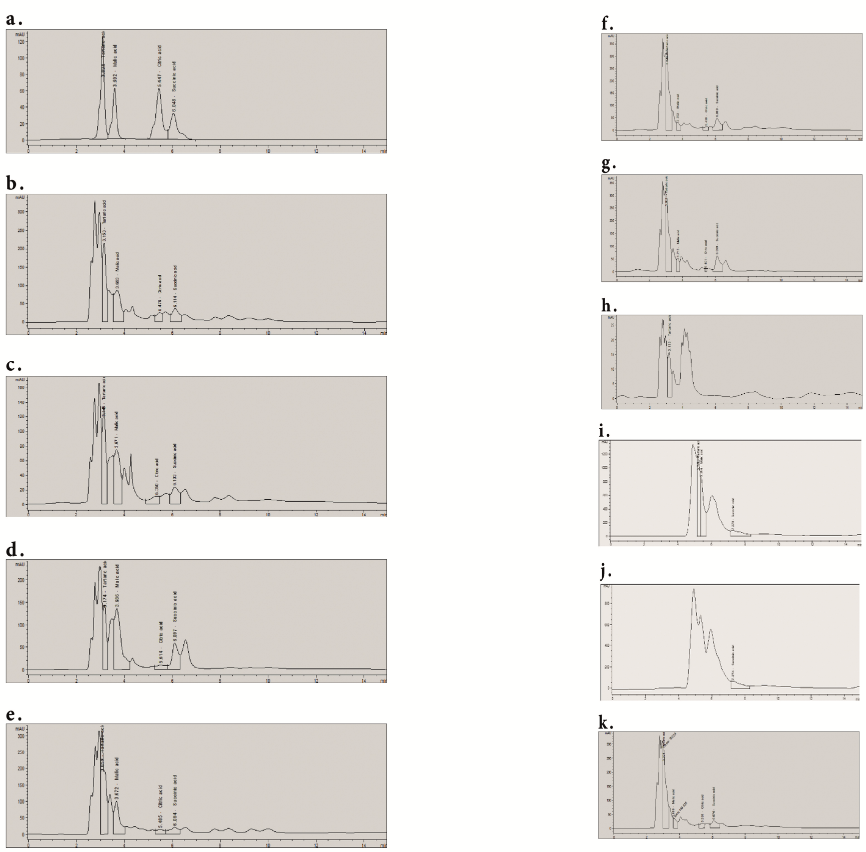

Figure 1: HPLC chromatograms of organic acids in grape juice of cultivars understudy: (a) Standards mixture, (b) Italian, (c) American, (d) Taify(clone$_a$), (e) Lebanese, (f) Syrian, (g) Taify(clone$_b$), (h) Taify(clone$_c$), (i) Taify(clone$_d$), (j) Taify(clone$_e$) and (k) Taify(clone$_f$).

Table 9: Organic acids content of studied grape (*Vitis vinifera* L.) cultivars

No.	Cultivar	Tartaric acid (mg/ml)	Malic acid (mg/ml)	Citric acid (mg/ml)	Succinic acid (mg/ml)	Total (mg/ml)
1	Italian	1.98874^{f}	2.7622^{c}	0.41492^{a}	1.33208^{e}	6.49794^{d}
2	American	1.18355^{g}	2.07783^{e}	0.29755^{d}	0.87634^{h}	4.43528^{f}
3	Taify (clone$_a$)	1.17341^{g}	4.44171^{a}	0.28558^{de}	1.89026^{b}	7.79096^{b}
4	Lebanese	3.47469^{b}	2.60369^{d}	0.32173^{c}	0.92049^{g}	7.32061^{c}
5	Syrian	3.65586^{a}	0.68876^{h}	0.2706^{e}	1.90189^{b}	6.51712^{d}
6	Taify (clone$_b$)	3.15396^{d}	0.88534^{f}	0.09948^{f}	2.32557^{a}	6.46436^{d}
7	Taify (clone$_c$)	0.17057^{h}	0	0	0	0.17057^{h}
8	Taify (clone$_d$)	3.09162^{e}	4.20661^{b}	0	1.82092^{c}	9.11915^{a}
9	Taify (clone$_e$)	0	0	0	1.46977^{d}	1.46977^{g}
10	Taify (clone$_f$)	3.17913^{c}	0.79177^{g}	0.35217^{b}	1.28005^{f}	5.60312^{e}

Means having the same alphabetical letters within each column are not significantly different at $P \leq 0.05$ according to Duncan's multiple range test.

Conclusion

This research indicated that obtained physical and chemical characteristics were clear measurement of fruit quality of Taif grape cultivars. Therefore, it can be recommended to be used as potential bench marks for fruit quality of local grapes in Saudi Arabia and specifically in Taif region. Also, according to the measured parameters, Taify clones showed the best quality for chemical composition while American and Italian cultivars showed the best quality for physical parameters. Therefore, it can be concluded that Taify clones are better candidate for industrial food processing than other cultivars.

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