DETERMINATION OF COLOR QUALITY AND HMF CONTENT OF UNPROCESSED SULTANAS OBTAINED FROM DIFFERENT VINEYARDS

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ABSTRACT

Twenty sultana type raisin samples obtained from seedless grapes grown in three different altitudes in Denizli province in Aegean region of Turkey were analyzed for some important quality parameters for the sultanas such as pH, titratable acidity (TA), color quality as L*, a*, b*, a/b*, Chroma (C), hue angle (H°) and hydroxymethylfurfural (HMF) content. The effects of altitude of the vineyards on quality parameters of sultanas were also investigated. pH of the samples ranged from 3.31 to 4.21 and TA values ranged from 0.65 to 1.75 g 100 g-1 as tartaric acid. It was found that the effect of vineyard altitudes on the mean pH and TA acidity values of the samples were not significant (P>0.05). However, color analysis indicates that mean a* values of the samples increased with decrease of mean altitude of vineyards (P<0.05) but this inclination hadn’t seen on L*, b*, a/b*, H° and HMF values (P>0.05).

Keywords: Sultana, raisin, color, HMF, altitude, pH

1. INTRODUCTION

Grapes have been cultivated for thousands of years and were dried into raisins since at least 1000 B.C. (Parker et al., 2009). Due to the considerable high sugar and moisture content, seedless grapes are very susceptible to microbial spoilage during storage. Hence, in order to minimize economic losses, seedless grapes must be consumed or processed into several products within a few weeks. Raisin production is one of the most applied processing method among the grape producer countries (Bai et al., 2013). Viticulture is an important component of agriculture in Turkey, where grape production is 4.5 million tons with 462,302 hectare of land planted with vines (Geyikçi, 2013). Turkey is one of the most important producers of dried seedless raisins around the world with USA, Chile, China and Iran. Seedless grape production of Turkey is about 286,570 tons as dry basis (Şen and Nas, 2013). Sultana type grapes are an important grape cultivar in Aegean region of Turkey due to its adaptability to climate and soil and increased international demand.

In order to obtain desirable sensory or texture property or to provide microbiological safety as well as to eliminate enzymatic activities, food products are frequently subjected to thermal treatment such as, cooking, baking, drying, roasting, extrusion, pasteurization or sterilization, etc. The reactions related to the thermal treatment are very important for the production of sensory attributes such as flavor, taste and color (Kowalski et al., 2013). Drying fruit is an ancient practice for the preservation of food is still in use nowadays (Coimbra et al., 2011). Dried vine fruit is a term given to all varieties of dried grape produced and the process of drying fruit in the sun and which commercially classified into three groups as raisins (dried white grapes), sultanas or sultanina (dried white grapes from seedless varieties) and currants (are grown in the same way as Raisins and Sultanas although they are a much smaller fruit) (Covarelli et al., 2012).

The Sultanas are produced conventionally by dipping the grape in cold alkaline solution (usually 5-7% K2CO3 and 0.5% olive oil or 2.5% K2CO3 and 2% Ethyl oleate as surfactant) and then
Mong the PPO enzyme comes into contact with polyphenoloxidase (PPO) enzymes which initiates enzymatic browning and results in faster dehydration and less opportunity for initial browning reactions that accompany drying and as a result producing high quality raisins (Chayjan et al., 2011; Frank et al., 2004; Doymaz and Pala, 2002). After cold dipping process, bunches of grapes are hanging onto 2 rowed and 6-8 storey vertical wire or nylon hangers or layered onto horizontal wire racks. Both of the systems used for drying grapes are open- sided, sheltered drying sheds and allows cross- winds to accelerate drying process. On the other hand, small scale grape growers have been used concrete floors with polypropylene canvas for drying their grapes in Turkey. No matter which system used for drying, the grape bunches should be dried under the sun until the water content at least 16-18% (w/w) (Akdeniz, 2011).

The color is one of the most important characteristic that determines consumer admiration among the raisin quality parameters (Ozilgen et al., 1997; Bingol et. al., 2012; Ong and Law, 2010). Light golden to amber color characteristics are preferable by both local and export markets. It is thought that the enzymatic and non-enzymatic reactions are responsible for color change of the sultanas (Bahaabad and Esmaïli, 2012). During grape drying, endogenous phenolic compounds comes into contact with polyphenoloxidase (PPO) enzymes which initiates enzymatic browning and this reaction can occur in the presence of molecular oxygen. Normally, PPO is separated from the main grape phenolic substrate in healthy berry tissue. As a consequence of physical damage during drying due to berry shrinkage and tissue collapse by virtue of water loss, the PPO enzyme comes into contact with grape phenolic substrate mainly trans-caftaric acid (trans- ceffeyol tartaric acid). Also, color formation is the primary characteristic of Maillard reaction.

Maillard reactions defines as non-enzymatic browning reactions are a hierarchy of phenomena that start with the reaction of amino acid or protein group with glycoside hydroxyl of sugar, reducing sugars and finish by formation of nitrogen polymers (Bahaabad and Esmaïli, 2012; Çalılarırmak, 2006; Frank et al., 2004; Burdurlu and Karadeniz, 2002). Thus, the sultanas are susceptible to the Maillard reactions because of high content of both reducing sugars and amino acids (Zhao and Hall III, 2008). The occurrence of Maillard reactions is normally detected by means of measurement of decreases in free-amino acids over time and subsequent appearance of specific sugar fragmentation intermediates such as 5-HMF which is produced via 1,2 enolisation of glucose derived Amadori intermediates. Chemical and physical factors such as pH, aw and temperature affect both Maillard and PPO processes (Frank et al., 2004; Nursten, 2005).

In this study, some chemical and physical quality parameters such as color and HMF content of the sultanas are evaluated. By this way, quality parameters of the sultanas produced in Turkey may be exposed.

2. MATERIALS AND METHODS

Sultana Samples

Three districts located within the boundary of Denizli province, Bekilli, Buldan and Honaz were chosen for this study since intensive grape cultivation and seedless raisin production. 20 vineyards belonging to study area were chosen. From each vineyard, sun- dried sultanas were collected on January 2011 after 4 months of vintage and drying season of the region. 10 samples from Bekilli, 4 samples from Honaz, and 6 samples from Buldan districts were collected. Altitude, Latitude and Longitude parameters of the vineyards is demonstrated in Table 1 and Figure 1. All of the sultana samples were dried within or near the vineyards by grape producers and stored at room temperatures. For physical and chemical analysis, 3x 1000 g samples of seedless raisins were taken from each vineyard and kept in plastic bags and put in cooled boxes (4 °C) and transferred to the laboratory within a day. Back-propagation is an iterative, gradient search, supervised algorithm which can be viewed as multiplayer non-linear method that can re-code its input space in the hidden layers and thereby solve hard learning problems. The network is trained using ANN technique until a good agreement between predicted gain settings and actual gains is reached.

pH

200 grams of sample was put in blender jar (Waring 8011S, Torrington, CT) and homogenized at high speed for 2 minute and homogenate was used to determine pH. The pH meter (WTW, pH720, USA) was calibrated with standart buffers 4, 7 and 10 (Merck, Darmstadt, Germany) before use (Mahmutoglu et al., 1990).
Figure 1. Map of the Denizli state, located in southern Aegean region of Turkey, with demonstration of the studied area.

Table 1. Altitude, latitude and longitude parameters of the studied vineyards.

<table>
<thead>
<tr>
<th>Location</th>
<th>Altitude(^a)</th>
<th>Latitude</th>
<th>Longitude</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK1</td>
<td>861</td>
<td>38° 14’ 04’</td>
<td>29° 24’ 36’</td>
</tr>
<tr>
<td>BK2</td>
<td>832</td>
<td>38° 13’ 38’</td>
<td>29° 24’ 58’</td>
</tr>
<tr>
<td>BK3</td>
<td>819</td>
<td>38° 13’ 33’</td>
<td>29° 25’ 29’</td>
</tr>
<tr>
<td>BK4</td>
<td>828</td>
<td>38° 13’ 14’</td>
<td>29° 24’ 52’</td>
</tr>
<tr>
<td>BK5</td>
<td>864</td>
<td>38° 14’ 13’</td>
<td>29° 25’ 37’</td>
</tr>
<tr>
<td>BK6</td>
<td>746</td>
<td>38° 16’ 50’</td>
<td>29° 20’ 57’</td>
</tr>
<tr>
<td>BK7</td>
<td>744</td>
<td>38° 17’ 21’</td>
<td>29° 21’ 11’</td>
</tr>
<tr>
<td>BK8</td>
<td>698</td>
<td>38° 14’ 29’</td>
<td>29° 18’ 20’</td>
</tr>
<tr>
<td>BK9</td>
<td>703</td>
<td>38° 14’ 26’</td>
<td>29° 18’ 11’</td>
</tr>
<tr>
<td>BK10</td>
<td>696</td>
<td>38° 14’ 21’</td>
<td>29° 17’ 41’</td>
</tr>
<tr>
<td>HN1</td>
<td>523</td>
<td>37° 49’ 48’</td>
<td>29° 24’ 20’</td>
</tr>
<tr>
<td>HN2</td>
<td>526</td>
<td>37° 49’ 28’</td>
<td>29° 24’ 21’</td>
</tr>
<tr>
<td>HN3</td>
<td>537</td>
<td>37° 45’ 40’</td>
<td>29° 17’ 18’</td>
</tr>
<tr>
<td>HN4</td>
<td>551</td>
<td>37° 44’ 59’</td>
<td>29° 18’ 27’</td>
</tr>
<tr>
<td>BL1</td>
<td>257</td>
<td>38° 02’ 55’</td>
<td>28° 55’ 14’</td>
</tr>
<tr>
<td>BL2</td>
<td>250</td>
<td>38° 02’ 41’</td>
<td>28° 55’ 20’</td>
</tr>
<tr>
<td>BL3</td>
<td>737</td>
<td>38° 07’ 47’</td>
<td>28° 54’ 39’</td>
</tr>
<tr>
<td>BL4</td>
<td>723</td>
<td>38° 07’ 53’</td>
<td>28° 53’ 56’</td>
</tr>
<tr>
<td>BL5</td>
<td>235</td>
<td>38° 02’ 40’</td>
<td>28° 55’ 39’</td>
</tr>
<tr>
<td>BL6</td>
<td>208</td>
<td>38° 02’ 23’</td>
<td>28° 56’ 11’</td>
</tr>
</tbody>
</table>

\(^a\)Meters above sea level
3. RESULTS

pH and Titratable Acidity (TA)

It is known that tartaric acid is the most abundant organic acid in grape varieties. The summary of pH and TA results of the samples belonging to 20 different vineyards and the vineyards results according to the location are presented in Table 2 and Table 3 respectively. In comparison to pH and TA levels among the samples belonging to different vineyards, significant differences (P<0.05) were detected for some samples but the mean pH and TA results according to location altitude were not significant (P>0.05). In sun-dried raisin samples, pH values ranged from 3.31 to 4.21 (mean 3.84). The highest pH results were found in BK8, BK9 and BL1 samples whereas, the lowest results were found in BK1, BK3 and BK6 samples respectively. On the other hand, TA values ranged from 0.65 to 1.75 g L\(^{-1}\) (mean 1.070). BL2, BK1 and BL6 vineyards have the highest TA results, but BK9, BK5 and HN3 have the lowest ones.

Color

Color is one of the most important factors among the food acceptability parameters and undesirable changes in color may cause a decrease in marketing value of the product. Hunter L\(^*\) (lightness), a\(^*\) (redness), b\(^*\) (yellowness) and a/b\(^*\) (redness/yellowness) values of the sun-dried raisins belong to different vineyards were in most cases significantly different (P<0.05) from each other (Table 4 and Table 5). L\(^*\), a\(^*\), b\(^*\), C and H\(^\circ\) angles of the samples are also presented in Figure 2. In sun-dried raisin samples L\(^*\) values were ranged from 15.94 to 35.91 (mean 27.72). Lowest L\(^*\) results were found in HN3, BK4 and HN4 samples, however, highest L\(^*\) results were found in BL5, BL4 and BK7 samples respectively. On the other hand, minimum and maximum Hunter a\(^*\) values were detected as 7.40 and 13.88 for BK4 and BL2 samples respectively. Furthermore, the value of b\(^*\), which is a measurement of yellowness color, was 6.29 (BK4 sample) as minimum and 20.74 (BK1 sample) as maximum (mean 14.11). The value of a/b\(^*\), indicator of the redness/yellowness color, ranged from 0.52 to 1.24 (mean 0.82). BK6, BK1 and BK7 samples had minimum a/b\(^*\) results, while, HN1, BK4 and BK3 samples had maximum a/b\(^*\) results respectively.

There were no significant differences (P>0.05) determined among the samples located in different districts in terms of mean Hunter L\(^*\), Hunter b\(^*\) and a/b\(^*\) values except for Honaz samples (Table 4). Indeed, mean a\(^*\) value of the Bekilli and Honaz samples were significantly different from Buldan...
samples. Then, Buldan samples were found to have highest mean L*, a* and b* values compared to Bekilli and Honaz samples. Furthermore, mean a/b* value of Honaz samples were higher than the other samples.

The C value in the analyzed vineyards were changed between 9.71 (BK4) to 24.28 (BL4). There were significant differences (P<0.05) detected among the samples located in different districts in terms of C values. BK3, HN4 and BL6 samples had minimum C results, while, BK1, BL4 and BL5 samples had maximum C results respectively. Apart from C value, Hue angle (H°) is also used to

**Figure 2.** Color parameters of sultana samples from different vineyards
characterize color of food products. Red-purple, yellow, green and blue color characteristics is defined Hue angles as 0°, 60°, 120° and 240° respectively. In sun-dried raisin samples H° values ranged from 39.62 to 69.72 (mean 51.58). The highest results were found in BK1 and BK6 samples, however, lowest results were found in BK3, BK4 and HN1 respectively. Mean H° values of Honaz samples were significantly lower than the Bekilli and Buldan samples (P<0.05).

HMF

HMF is one of the most known Amadori compounds that in most cases can be used as a quality indicator in foods exposing to heat treatment. Relative levels of HMF in dried raisin samples belonging different vineyards are shown in Table 5. Significant differences (P<0.05) were detected among most of the samples in terms of HMF concentrations. HMF was detected all of the samples ranged from 3.576 mg/kg (BK3) to 37.846 mg/kg (BL3) as minimum and maximum levels (mean 17.888). 6 of the 20 samples had lower (<10 mg/kg), 6 samples had from 10 to 20 mg/kg and 8 of the samples had highest (up to 20 mg/kg) HMF levels. On the other hand, the samples were classified according to the producing region and Table 6 and Table 7 was obtained. Mean HMF contents of the Buldan samples were significantly (P<0.05) different from Bekilli and Honaz samples. On the other hand, no significant differences were detected between Bekilli and Honaz samples in terms of mean HMF contents. Most of the Buldan samples had higher HMF content and increased the mean HMF value.

4. DISCUSSION

With the comparison of literature, pH results were similar but TA results were lower than the findings of Soyer et al. (2003) and Özilgen et al. (1997). However, Soyer et al. (2003) were studied only with fresh grape juices obtained from 11 different white grape cultivars including Sultana. However, our TA results might be lower than the other study results because of our study was relevant to sun-dried grapes. Indeed, Chkaiban et al. (2007) reported that TA was decreased during the drying process of the grapes. Mahmutoğlu et al., 1996 were investigated the effect of different dipping solutions and various drying conditions on storage stability of Sultanas. After the drying procedure, obtained pH and TA values were similar to our findings. Furthermore, pH and acidity of the samples according to the location, it was thought that mean pH and TA results (Table 3) weren’t affected by vineyard locations (P>0.05).

During sun drying, heat is transferred by convection from air to crop and absorption of radiation. Then heat is partially conducted to the inside of the crop and caused to increase the temperature and migration of water vapor from inside to the surface of the crop. The evaporated water vapor is to be removed by natural convection supported by wind forces. Özilgen et al. (1997) reported that during the drying process, diffusion of the sugars with water vapor to the surface for trying to constitute equilibrium structure is the key factor of the color change of the sun-dried raisins. Color change may be also supported by the reactions participated in reducing sugars. Because, sugar progressively dissolves in water, diffuses to the surface of the product and then crystallization occurs on the surface. Also, browning or blackening of raisins can be caused by enzymatic oxidation of polyphenols to tannins. In grapes catechins are naturally-occurring polyphenolic substrates for enzymatic oxidation (Myburgh, 2003). Hunter Lab color scale measurements are very useful to determine the sun-drying raisin quality. Previous reports have shown that in terms of desired color properties, higher L* and lower a/b* ratio are preferred. A high redness (a*) value is not desired because it occurs as a result of excessive caramelization of sugars, enzymatic and nonenzymatic browning reactions. With the comparison of previous studies, our L* measurements were higher and a/b* results were similar to the findings of Doymaz et al., 2002 and Özilgen et al., 1997. The color saturation of the food samples is generally indicated by the C value which varies from dull (low value) to vivid color (high value). In the case of C, it was observed that C value of the raisins didn’t change with vineyard altitude or vineyard location. On the other hand, as can be seen in Table 5, vineyard positions had a significant effect on a* values of raisin samples (P<0.05) and mean a* values of the samples increased with the decrease of mean altitude of vineyards but this inclination hadn’t seen on L*, b*, a/b* and H° values.

It is known that HMF is forming during thermal treatment of carbohydrate containing foods. According to the Abraham et al. (2011), some dried fruits such as apples and pears can contain high levels (5.5 to 3500 mg/kg) of HMF. However, lower values can be found in dates and raisins. Indeed, our search results were slightly lower than the findings of Zhao et al. (2008) and Frank, et al. (2004), but similar to Çağlarırmak (2006). In Turkey, raisins are usually dipped into 5-6 K2CO3 and % 0.5-1.0 olive oil solution 8-10 times by using special baskets called “kelter” and then...
dried under the sun. The main aim of using this solution is to remove waxy layer surrounding the skin of the fruit and to facilitate the drying process and brown color formation. Frank, et al. (2004) reported that free-arginine and free-proline were the most abundant amino acids in sultana grapes and during drying process, free-arginin were the main aminocacid participated in Maillard reactions. This was the evidence the occurrence of HMF in dried raisins. In the case of HMF values of the samples according to vineyards belonging to different locations, it seemed altitude or location of the vineyards didn’t effect HMF values of the samples.

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REFERENCES


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Table 2. pH and titratable acidity of the samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>pH</th>
<th>Acidity (g.100 g⁻¹ as tartaric acid)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK1</td>
<td>3.31a</td>
<td>1.67c</td>
</tr>
<tr>
<td>BK2</td>
<td>3.82d</td>
<td>0.83bc</td>
</tr>
<tr>
<td>BK3</td>
<td>3.69b</td>
<td>0.89cd</td>
</tr>
<tr>
<td>BK4</td>
<td>3.82d</td>
<td>1.09f</td>
</tr>
<tr>
<td>BK5</td>
<td>3.82d</td>
<td>0.77b</td>
</tr>
<tr>
<td>BK6</td>
<td>3.75c</td>
<td>0.91ed</td>
</tr>
<tr>
<td>BK7</td>
<td>3.70b</td>
<td>1.58h</td>
</tr>
<tr>
<td>BK8</td>
<td>4.21l</td>
<td>0.81b</td>
</tr>
<tr>
<td>BK9</td>
<td>4.17j</td>
<td>0.65a</td>
</tr>
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</tr>
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</tr>
<tr>
<td>HN2</td>
<td>3.82d</td>
<td>1.07ef</td>
</tr>
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<td>BL1</td>
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<tr>
<td>BL2</td>
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<td>1.75j</td>
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<td>BL3</td>
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<td>BL5</td>
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<td>BL6</td>
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<tr>
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<td>1.75</td>
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<tr>
<td>SD</td>
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<td>0.3151</td>
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</table>

Data are mean (±SD) of readings recorded. Different letters (a, b, c...) in the same row indicate significant difference for each variable (P < 0.05).

Table 3. pH and acidity of the samples according to the location

<table>
<thead>
<tr>
<th>Location</th>
<th>pH</th>
<th>Min</th>
<th>Max</th>
<th>Acidity (g.100 g⁻¹ as tartaric acid)</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bekilli (n=10)</td>
<td>3.80±0.246</td>
<td>3.31</td>
<td>4.21</td>
<td>1.01±0.34</td>
<td>0.65</td>
<td>1.67</td>
</tr>
<tr>
<td>Honaz (n=4)</td>
<td>3.86±0.06</td>
<td>3.82</td>
<td>3.94</td>
<td>1.07±0.22</td>
<td>0.80</td>
<td>1.38</td>
</tr>
<tr>
<td>Buldan (n=6)</td>
<td>3.91±0.19</td>
<td>3.73</td>
<td>4.13</td>
<td>1.17±0.32</td>
<td>0.85</td>
<td>1.75</td>
</tr>
</tbody>
</table>

Data are mean (±SD) of readings recorded. Different letters (a and b) in the same row indicate significant difference for each variable (P < 0.05)
Table 4. Color measurements for sultans (cie L* a* b* C and H° values)*

<table>
<thead>
<tr>
<th>Sample</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>a/b*</th>
<th>C</th>
<th>H°</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK1</td>
<td>29.73e-f</td>
<td>10.84e-z</td>
<td>20.74f</td>
<td>0.52g</td>
<td>23.46h</td>
<td>62.66h</td>
</tr>
<tr>
<td>BK2</td>
<td>26.84e-f</td>
<td>10.58f-e</td>
<td>15.88g</td>
<td>0.67h-d</td>
<td>19.09f-e</td>
<td>56.30f-c</td>
</tr>
<tr>
<td>BK3</td>
<td>22.91b-d</td>
<td>8.83c-c</td>
<td>7.80h-b</td>
<td>1.14b-h</td>
<td>11.81ab</td>
<td>41.44h</td>
</tr>
<tr>
<td>BK4</td>
<td>20.85h-b</td>
<td>7.40e</td>
<td>6.29f</td>
<td>1.13h-b</td>
<td>9.71a</td>
<td>40.17h</td>
</tr>
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<td>BK5</td>
<td>26.57e-f</td>
<td>9.64e-e</td>
<td>16.12e-g</td>
<td>0.60f-h</td>
<td>18.80c-e</td>
<td>58.95ef</td>
</tr>
<tr>
<td>BK6</td>
<td>30.20f-d</td>
<td>9.05d-e</td>
<td>17.64h-b</td>
<td>0.52c-e</td>
<td>19.86d-g</td>
<td>62.72f</td>
</tr>
<tr>
<td>BK7</td>
<td>32.80h-b</td>
<td>9.57e-e</td>
<td>16.35g-g</td>
<td>0.62d-f</td>
<td>19.12c-f</td>
<td>59.06ef</td>
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<tr>
<td>BK8</td>
<td>31.10h-b</td>
<td>9.34e-e</td>
<td>13.57h-e</td>
<td>0.70f-e</td>
<td>16.49d-e</td>
<td>55.12e-f</td>
</tr>
<tr>
<td>BK9</td>
<td>27.43f-e</td>
<td>11.64h-h</td>
<td>14.37h-f</td>
<td>0.83c-f</td>
<td>18.55c-e</td>
<td>50.67h-d</td>
</tr>
<tr>
<td>BK10</td>
<td>28.07d-g</td>
<td>11.79h-h</td>
<td>13.60d-e</td>
<td>0.87f-e</td>
<td>18.06c-e</td>
<td>49.25bc</td>
</tr>
<tr>
<td>HN1</td>
<td>29.33e-g</td>
<td>11.50h-h</td>
<td>9.56h-c</td>
<td>1.24h</td>
<td>15.07bc</td>
<td>39.62a</td>
</tr>
<tr>
<td>HN2</td>
<td>28.85e-g</td>
<td>10.87h-g</td>
<td>11.34k-d</td>
<td>0.97g-h</td>
<td>15.73b-d</td>
<td>46.00ab</td>
</tr>
<tr>
<td>HN3</td>
<td>15.94e</td>
<td>8.34h-b</td>
<td>8.63c-e</td>
<td>0.97g-h</td>
<td>12.01ab</td>
<td>45.94ab</td>
</tr>
<tr>
<td>HN4</td>
<td>21.51k-c</td>
<td>10.32f-e</td>
<td>11.94d-d</td>
<td>0.86g-f</td>
<td>15.81b-d</td>
<td>43.34bc</td>
</tr>
<tr>
<td>BL1</td>
<td>27.53f-e</td>
<td>11.07g-g</td>
<td>15.96h-g</td>
<td>0.69a-e</td>
<td>19.45d-g</td>
<td>55.13c-e</td>
</tr>
<tr>
<td>BL2</td>
<td>26.70e-f</td>
<td>13.88h-h</td>
<td>13.930-f</td>
<td>1.00f-g</td>
<td>19.70d-g</td>
<td>45.25ab</td>
</tr>
<tr>
<td>BL3</td>
<td>28.96d-h</td>
<td>13.38h-h</td>
<td>17.678-h</td>
<td>0.76c-e</td>
<td>22.18c-h</td>
<td>52.88e-e</td>
</tr>
<tr>
<td>BL4</td>
<td>33.66b-h</td>
<td>12.70h-h</td>
<td>20.60h-h</td>
<td>0.63c-e</td>
<td>24.28h</td>
<td>58.21ef</td>
</tr>
<tr>
<td>BL5</td>
<td>35.91h-b</td>
<td>11.89h-h</td>
<td>19.52h-h</td>
<td>0.66a-d</td>
<td>23.10f-h</td>
<td>57.33ef</td>
</tr>
<tr>
<td>BL6</td>
<td>29.42e-f</td>
<td>10.41h-h</td>
<td>10.702c-d</td>
<td>0.98f-g</td>
<td>14.95bc</td>
<td>45.59hb</td>
</tr>
<tr>
<td>Min</td>
<td>15.94</td>
<td>7.40</td>
<td>6.29</td>
<td>0.52</td>
<td>9.71</td>
<td>39.62</td>
</tr>
<tr>
<td>Max</td>
<td>35.91</td>
<td>13.88</td>
<td>20.74</td>
<td>1.24</td>
<td>24.28</td>
<td>62.72</td>
</tr>
<tr>
<td>Mean</td>
<td>27.72</td>
<td>10.65</td>
<td>14.11</td>
<td>0.82</td>
<td>17.86</td>
<td>51.58</td>
</tr>
<tr>
<td>Standart Deviation (SD)</td>
<td>5.78</td>
<td>2.33</td>
<td>4.75</td>
<td>0.25</td>
<td>4.63</td>
<td>8.28</td>
</tr>
</tbody>
</table>

*Data are mean of readings recorded. Different letters (a, b, c,...) in the same row indicate significant difference for each variable (P < 0.05).

Table 5. L*, a*, b* and a/b*, C and H° angle values of the samples according to the location*

<table>
<thead>
<tr>
<th>Location</th>
<th>L*</th>
<th>a*</th>
<th>b*</th>
<th>a/b*</th>
<th>C</th>
<th>H°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bekilli (n=10)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>780m</td>
<td>27.65±4.96</td>
<td>9.87±2.08</td>
<td>14.24±4.71</td>
<td>0.77±0.26</td>
<td>17.49±4.52</td>
<td>53.63±8.75</td>
</tr>
<tr>
<td>Honaz (n=4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>534 m</td>
<td>23.91±6.43</td>
<td>10.26±2.15</td>
<td>10.37±2.32</td>
<td>1.01h-b</td>
<td>14.66±2.82</td>
<td>45.22±5.53</td>
</tr>
<tr>
<td>Buldan (n=6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>402 m</td>
<td>30.36±5.29</td>
<td>12.23b±2.10</td>
<td>16.40±4.56</td>
<td>0.79±0.20</td>
<td>20.61±4.32</td>
<td>52.40±7.00</td>
</tr>
</tbody>
</table>

*Data are mean (±SD) of readings recorded. Different letters (a and b) in the same row indicate significant difference for each variable (P<0.05)
Table 6. Hydroxymethylfurfural (HMF) levels of samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>HMF (mg.kg⁻¹)</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BK1</td>
<td>22.425±0.3725</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK2</td>
<td>37.625±0.3725</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK3</td>
<td>3.576±0.1490</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK4</td>
<td>10.728±0.2980</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK5</td>
<td>33.153±0.6705</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK7</td>
<td>6.556±1.390</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK8</td>
<td>6.705±3.725</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK9</td>
<td>24.585±0.4470</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BK10</td>
<td>6.184±0.3725</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>HN1</td>
<td>10.430±0.5960</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>HN2</td>
<td>11.101±2.1605</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>HN4</td>
<td>4.843±0.3725</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BL1</td>
<td>33.823±11.7917</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BL2</td>
<td>12.032±6.8129</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BL3</td>
<td>23.976±12.8230</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BL4</td>
<td>37.846±0.1490</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BL5</td>
<td>5.364±0.2980</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>BL6</td>
<td>35.462±0.7450</td>
<td>3.576</td>
<td>37.625</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
</tbody>
</table>

Data are mean of readings recorded. Different letters (a, b, c,…) in the same row indicate significant difference for each variable ($P < 0.05$).

Table 7. Hydroxymethylfurfural (HMF) levels of samples according to the location

<table>
<thead>
<tr>
<th>Sample</th>
<th>HMF (mg.kg⁻¹)</th>
<th>Min</th>
<th>Max</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Honaz (n=4)</td>
<td>12.032±6.8129</td>
<td>4.843</td>
<td>33.823</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
<tr>
<td>Buldan (n=6)</td>
<td>23.976±12.8230</td>
<td>5.364</td>
<td>37.846</td>
<td>17.888</td>
<td>11.9806</td>
</tr>
</tbody>
</table>

Data are mean (±SD) of readings recorded. Different letters (a and b) in the same row indicate significant difference for each variable ($P < 0.05$).