Comparative analysis of physicochemical properties of honey from ecological zones and branded honey of Pakistan

Ammara Blouch¹, Rashid Mahmood¹, Khalid Rafique*, Farid Asif Shaheen⁴, Masooma Munir², Aqsa Qayyum², Rabia Ali³

¹Honeybee Research Institute, National Agricultural Research Centre (NARC), Islamabad, Pakistan
²Food Science and Product Development Institute, National Agricultural Research Centre (NARC), Islamabad, Pakistan
³Department of Plant and Environmental Protection, National Agricultural Research Centre (NARC), Islamabad, Pakistan
⁴Department of Entomology, PMAS Arid Agriculture, University Rawalpindi, Rawalpindi, Pakistan

Article published on October 30, 2016

Key words: Pakistan, Physicochemical properties, Codex alimentarius, Analysis, Honey quality

Abstract

The investigations were carried out in the Honey Analysis Laboratory of Honeybee Research Institute, National Agricultural Research Centre Islamabad, Pakistan, to determine the quality and Physico-chemical characteristics of honey samples from different localities of Pakistan. Physicochemical analysis of these samples was carried out using AOAC methods and Harmonised methods of International Honey Commission and results were compared with the standards of Codex Alimentarius and European Union Council Directive. The range of different parameters was 18.00±0.10-23.50±0.30% moisture, 3.67±0.006-7.07±0.006 pH, 8.03±0.35-35.66±2.51 meq/kg acidity, 6.76±0.05-7.90±0.10% sucrose, 75.00±0.20-81.00±0.10% total sugars and 0.11±0.01-0.92±0.01 mS/cm electrical conductivity, 0.01±0.003 -0.26±0.004% ash. Values for sucrose, acidity, total sugars and ash were within the normal ranges except for the moisture, pH and electrical conductivity. These parameter's values were found higher than the recommended ranges. One sample LB-19 had the highest value of 23.5±0.30% for moisture and 0.92±0.01 mS/cm for electrical conductivity, while LB-20 had the highest value of 7.07±0.006 for pH.

*Corresponding Author: Muhammad Khalid Rafique khalidento@gmail.com
Honey is a sweet viscous fluid made mostly from the nectar of plants and is among the major bee products. Honey is defined as “the sweet substance produced by the honeybees from the nectar of blossoms or from secretions on living plants, which the bees collect, transform and store in honey combs” (Codex Alimentarius, 2001). Blossom honey is derived from the nectarines of flowers, while honeydew honey is derived from the sugary excretion of some hemipterous insects on host plant or from the exudates of plants (Saxena et al., 2010). Honey is a concentrated invert sugars solution that contains a number of carbohydrates, aromatic substances, waxes, amino acids and organic acids, pollen grains, minerals and pigments (Bogdanov et al., 1998; Qiu et al., 1999). There are many reports on the presence of unstable compounds e.g. enzymes, vitamins and few minor compounds (Coco et al., 1996; Crews et al., 1997).

Honey composition and quality depends upon various factors such as, weather condition during honey production, composition of nectar, beekeeping practices and handling method during honey extraction and storage (Marchini et al., 2006; Iglesias et al., 2012).

Physicochemical characteristic of honey may also depend on the bee species as well as geographical origin. Honey has a long history of use as a medicine for the treatment of various diseases, ailments and wound (Abell et al., 1996 and Basualdo et al., 2007). Several researchers found out that the wound healing capacity of honey is greatly influenced by the physicochemical properties of honey (Mundu et al., 2001; Adenekan et al., 2010; Nwankwo et al., 2014).

Honey is usually evaluated through physicochemical analysis of its constituents. These constituents are very important for honey industry as they influence the texture, flavor, granulation, storage quality and the nutritional quality of honey and have been found to be greatly important to distinguish and comparison the natural honey from artificial honey. These physicochemical parameters are recognized as criteria for the characterization and identification of honey. A thorough knowledge of these characteristics also helps in the proper packaging and storage of honey, thus, preserving its quality and taste (Clement, 2002). Therefore, International Honey Commission (IHC) has proposed certain constituents as quality criteria of honey. These constituents include: moisture content, free acidity, electrical conductivity, reducing sugars, sucrose content and minerals (Bogdanov et al., 1999).

One of the main factors that determine the characteristic value of honey is its floral and geographical origin (Estevinho et al., 2012). Therefore, Honey’s composition also depends on the botanical origin, environment, climate and weather conditions, as well as handling and processing techniques (Küçük et al., 2007). Although major constituents of honey are almost the same in all honey samples still the chemical and physical properties of natural honeys differ depending on the floral type (Estupinon, 1998; Sa-nguandeegul, 2003; Mendes et al., 1998). Furthermore, variable climatic conditions are also an important factor that can also affect the honey properties.
Significant differences may exist between honeys not only due to floral types but also due to geographical differences. Most of the people don’t know much about the honey that they consume. So, it is important to perform a comparative test of honey from different areas to find out the problems related to adulteration of honeys. Therefore a study was conducted to test the quality of different honey types from different localities for comparison with International Honey Standards to have a useful data for the honey consumers.

Materials and methods

The present study was conducted in the Honey analysis laboratory of Honeybee Research Institute, (NARC) Islamabad. The study was designed to compare the physicochemical properties of 20 honey samples including some local branded honey samples collected from different areas of Pakistan by Honeybee Research Institute (NARC) and following parameters were evaluated: water content (g per 100 g), pH, electrical conductivity (mS/cm), free acidity (meq/kg), reducing sugars (g per 100 g), apparent sucrose (g per 100 g) and Ash % determination. Physicochemical parameters were analyzed using “The Official Methods of Analysis of Association of Official Analytical Chemists” (AOAC, 2002) and “The Harmonised Methods of the European Honey Commission” (Bogdanov et al., 1997).

Determination of Moisture Content

The moisture content of honey is the only compositional criteria, which has to be met as Honey Standard and is regulated for safety against fermentation for all the world trade honeys. It is also a useful parameter for describing honey moistness and viscosity. The moisture content of honey depends on various factors, for example, the harvesting season, the degree of maturity reached in the hive and the environmental factors (Acquarone et al., 2007).

According to Evangelista-Rodrigues et al. (2005), Apis bees operculate the combs only, when the honey moisture content ranges between 17% and 18%.

The moisture content influences some important characteristics of honey, such as viscosity and ⁰Brix (Anupama et al., 2003) The moisture content also influences the specific weight, crystallization, flavor, palatability and preservation also contributes to the development of fermenting microorganisms (Abramovic et al., 2008; Almeida, 2002; Araújo et al., 2006; Silva, 2007) According to some studies, the higher the moisture level the greater the development of microorganisms ( Özcan et al., 2006).

In this study, Moisture content of honey samples was determined by using ATC digital Refractometer. One drop of honey was taken on the glass surface of Refractometer. The sample was covered on the surface of the prism evenly; after two minutes the reading of refractive index was recorded from the lens with the help of eye.

Determination of pH

pH of the honey samples was determined by using pH meter (Milwaukee-102). pH meter was calibrated by using standard buffers of pH 4 and 7. Each Honey sample (10g) was weighed accurately and dissolved in 75 ml distilled water. Honey solution was taken in a 250 ml beaker. The solution was stirred and pH electrode was immersed in it, when the meter got stable, readings were taken directly from the pH meter and pH was recorded. The pH values are important during honey extraction and storage as acidity influences the texture stability and shelf life of honey (Terrab et al., 2003). The low pH of honey inhibits the growth and presence of microorganisms and makes it compatible with many food products.

Determination of Acidity

The acidity in honey is due to the presence of organic acids, mainly gluconic acid and inorganic ions such as phosphate and chloride (Nanda et al., 2003). Honey is generally acidic in nature irrespective of its geographical origins. Free acidity was determined by titrimetric method. For all the samples, Honey (10g) was weighed with the help of digital balance and dissolved into 75 ml distilled water.
The solution was then titrated against 0.1 N NaOH solutions in a burette using phenolphthalein as an indicator. The titration was carried out till the solution turns to pink from colorless. The acidity was determined by using the formula: 

\[
\% \text{ Acidity} = \frac{\text{Vol. of NaOH used} \times \text{Weight of Honey}}{\text{Volume of solution}}
\]

**Determination of Sugars**

The main source of the sugar in honey is nectar or honeydew. It was determined by potentiometric titration using the Fehling’s test (Lane and Eynon modified method). Honey (5.00g) was taken in a beaker, distilled water was added and dissolved in it to make volume up to 100 ml. 2-3 drops of phenolphthalein were added then NaOH solution was added till the solution turned to pink color. Then HCl was added to the solution till it turned to its original color and then distilled water was again added to make total volume 200ml (honey solution). Fehling solution A (5ml) + Fehling solution B (5ml) were taken in a conical flask and boiled for 2 minutes. During boiling 3 drops of Methylene blue indicator were added and then titrated with honey solution till brick red color appeared and noted as end point. The volume of honey solution used in titration was noted and following formula was used to calculate the percentage of reducing sugars in the sample.

\[
\text{Reducing Sugar} \% = \frac{\text{Fehling solution constant (0.05) x total volume of solution x 100}}{\text{Wt of sample solution x volume of titrate}}
\]

Again (5.00g) of honey was taken in a beaker distilled water was added to bring volume up to 100 ml. 2-3 drops of phenolphthalein were added then NaOH solution was added till the solution turns in to pink color. After that HCl was added to the solution till it turns to its original color and then distilled water was added again to make total volume 200 ml (v1). Took 50ml (w2) from the above solution and 50 ml distilled water was added to it to make volume up to 100 ml then 5g citric acid was added to it and solution was boiled for 10 minutes and then cooled. Then it was neutralized as in reducing sugars and distilled water was added again to make total volume up to 200 ml (v2). Then 5ml Fehling solution A and 5ml Fehling solution B was taken and boiled for 2 min, Methylene blue 2-3 drops were added and titrated with honey solution till it turns in to brick red color. The volume of honey solution used in titration was noted and following formula was used to calculate the percentage of total sugars in the sample.

\[
\text{Total sugars} = \frac{\text{Fehling solution constant (0.051) x 200 x 100}}{5 \times 50 x \text{Vol.of Honey Solution used for titration}}
\]

**Sucrose**

The percentage of sucrose was worked out as follows:

Non-reducing sugars = total sugars – reducing sugars

**Determination of Electrical Conductivity**

Electrical conductivity values depend on the mineral content of honey and measures all the ionisable organic and inorganic substances. The Electrical Conductivity was determined by using conductivity meter (Milwaukee-301). Electrical Conductivity meter was first calibrated with distilled water and then the conductance cell was dipped into honey Solution (10.0%) and reading was noted in mS/cm after the stabilization of instrument. Electrical Conductivity depends on the mineral content, polyol content, protein, organic acid and complex sugars of honey and varies with its botanical origin (Terrab et al., 2003).

**Determination of ash**

Honey (5g) was weighed accurately into a pre-weighed silica dish and was gently pre-heated on a hot plate until the sample turned black and dry so that there is no danger of loss by foaming and overflowing. The sample was then ignited at 550°c to constant weight. The sample was cooled in a dessicator before weighing. The results are expressed as % Ash and were calculated according to following formula:

\[
\text{Ash} \% = \frac{W_3 - W_1 \times 100}{W_2}
\]

Where,

- \( W_3 \) = weight of dish + ash
- \( W_1 \) = weight of dish only
- \( W_2 \) = weight of honey sample
**Statistical analysis**

Complete randomized experimental design was used. Difference among the twenty honey samples collected from the different localities was determined by one-way Analysis of Variance (ANOVA) (Arora *et al*., 2007) using the General Linear Model (GLM) in the PC Statistical Software Statistix version 8.1. All the tests were performed in triplicates and standard deviation was calculated. Comparison between the means was done using the least significant difference (LSD) at alpha=0.05.

**Results and discussion**

The results of physicochemical analysis of twenty honey samples are given in the tables 1-2. All the analysis tests were done in triplicates. All of twenty samples were tested for moisture, electrical conductivity, pH, Ash, acidity, total sugars and sucrose. ANOVA was used to find out the significance difference among various variables.

**Table 1.** F-values (the statistic used to determine if the effects of location significantly impact the measurement from the Analysis of Variance for different physicochemical properties of honey samples.

<table>
<thead>
<tr>
<th>Source of variation</th>
<th>Moisture %</th>
<th>Electrical conductivity mS/cm</th>
<th>pH</th>
<th>Acidity meq/kg</th>
<th>Total sugars %</th>
<th>Sucrose %</th>
<th>Ash %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>118**</td>
<td>3596**</td>
<td>4630**</td>
<td>116**</td>
<td>298**</td>
<td>23.9**</td>
<td>1876**</td>
</tr>
<tr>
<td>Error</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>59</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***= highly significant at (p>0.01).

The results (Table 1) indicate significant statistical difference among different types of honey from different locations. Means were separated using least significant difference (LSD) test (table 2).

The results of all the parameters of honey samples collected from the different areas of Pakistan were compared with the European and Codex Alimentarius Standards (Codex Alimentarius, 2001; EU Council Directive, 2002). Variable means sharing same or a common letter show statistically no difference between any of the two means using LSD (p<0.05). Least significant difference (LSD) method compares the means for each pair of factor levels. If the difference of the two means appears greater than the LSD value than it means that they are significantly different from each other.

Acidity value of all the samples found to be well within the range of 50 milliequiv acid/kg as proposed by Codex Alimentarius (2001) and showed acidity values in the range of 8.03±0.35-35.66±2.51. Nasiruddin *et al*., (2006) reported acidity value in the range of 23.55-58.52 meq/kg for local honeys, whereas, Kamal *et al*., (2002) reported just 6.73-22.9 meq/kg of acidity in different honey samples.

The variations in acidity may be due to different nectar sources from different areas of Pakistan. As a general rule, honey irrespective of its geographical origin, is naturally acidic (Adebiyi *et al*., 2004; Khalil *et al*., 2010).

Similarly, sucrose, total sugars and ash% values were also within the standard range, as for sucrose (not more than 8 %), sum of reducing sugars (not less than 65 %) and ash % (not more than 0.6%) proposed by Codex Alimentarius and International honey commission.

Kamal *et al*., (2002) conducted a comparative study of different floral honeys of Pakistan and reported 77 and 71% total sugar in different honey varieties. Joshi (1997) also reported total sugar in the range of 53.30 to 80.70% in different honeys. Latif *et al*., (1956) studied composition of native honey and found 65 to 76% sugar in different honey varieties.
Values of Ash % are similar to those of Ihtisham-Ulhaoq (1997) who determined ash content of different types of honey and draw an ash % range of 0.008 to 0.49% in honey samples. These results are also in accordance with those of White (1975) who obtained ash content of different varieties of honey in the range of 0.020 to 1.028%. The variation may be due to many factors such as soil composition, atmospheric conditions and floral type. The mineral content of honey differ according to the plant species that honey bees visit during nectar collection, and also the soil type in which the plant is located. These contents play a major role in biochemical and physiological functions of human body and some are essential for the growth and development of bones and muscles (Turan et al., 2003).

All the tested honeys except five samples showed moisture below 20%, which is the maximum limit for moisture content according to Codex honey standard (Codex Alimentarius, 2001). In the Codex Alimentarius Standards (2001) and EU Council directives (2002), the maximum moisture value of pure floral honey is generally less than 20%.

Moisture of five honey samples L9, L10, L13, L15 and L19 was much higher than the maximum moisture limit of 20%. Two samples L5 and L8 had lowest value of moisture i.e 18.0%, which is significantly different from all the other samples.

According to moisture % the honey samples can be categorized into three groups. One group had moisture in the range of 18.0-19.5% the other have 20.0-22.5% moisture. One sample L15 had 23.0% moisture, while L19 showed highest moisture of 23.5%. Fredes and Montenegro (2006) concluded that honeys having low moisture content will exhibit a better shelf life. Usually ripe honey has moisture content below 18.6% (Bogdanov et al., 1999). Joshi et al., 2000 found out that moisture content in A. dorsata honey was higher (21.5%) than that of A. mellifera (17.1%).

### Table 2. Means difference in physicochemical properties of honey samples from different locations.

<table>
<thead>
<tr>
<th>Sample Number</th>
<th>Moisture %</th>
<th>Electrical conductivity ms/cm</th>
<th>pH</th>
<th>Acidity meq/kg</th>
<th>Total sugars %</th>
<th>Sucrose %</th>
<th>Ash %</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>19.00±0.10 g</td>
<td>0.70±0.10 c</td>
<td>5.44±0.1 f</td>
<td>30.00±1.00 h</td>
<td>79.50±1.00 c</td>
<td>7.80±0.10 a</td>
<td>0.14±0.002 d</td>
</tr>
<tr>
<td>L2</td>
<td>19.50±0.10 f</td>
<td>0.56±0.00 e</td>
<td>6.66±0.02 b</td>
<td>24.66±2.51 c</td>
<td>78.50±1.00 e</td>
<td>7.86±0.05 a</td>
<td>0.04±0.001 i</td>
</tr>
<tr>
<td>L3</td>
<td>18.50±0.20 h</td>
<td>0.77±0.00 b</td>
<td>5.71±0.06 e</td>
<td>22.33±1.52 d</td>
<td>79.50±1.00 c</td>
<td>7.50±0.10 ed</td>
<td>0.17±0.001 c</td>
</tr>
<tr>
<td>L4</td>
<td>19.00±0.20 g</td>
<td>0.61±0.01 d</td>
<td>5.03±0.03 g</td>
<td>21.00±1.00 ef</td>
<td>79.00±1.00 d</td>
<td>6.76±0.05 i</td>
<td>0.11±0.003 e</td>
</tr>
<tr>
<td>L5</td>
<td>18.00±0.30 i</td>
<td>0.38±0.006 f</td>
<td>5.78±0.03 d</td>
<td>12.00±2.00 i</td>
<td>81.00±1.00 a</td>
<td>7.80±0.10 a</td>
<td>0.08±0.002 f</td>
</tr>
<tr>
<td>L6</td>
<td>18.96±0.05 g</td>
<td>0.77±0.00 b</td>
<td>6.62±0.02 b</td>
<td>8.66±1.52 j</td>
<td>79.00±1.00 d</td>
<td>7.76±0.05 ab</td>
<td>0.18±0.004 b</td>
</tr>
<tr>
<td>L7</td>
<td>19.00±0.30 g</td>
<td>0.24±0.006 h</td>
<td>3.78±0.06 m</td>
<td>35.66±2.31 a</td>
<td>80.00±1.00 b</td>
<td>7.80±0.20 a</td>
<td>0.03±0.002 j</td>
</tr>
<tr>
<td>L8</td>
<td>19.00±1.0 i</td>
<td>0.29±0.006 g</td>
<td>3.81±0.01 lm</td>
<td>21.00±1.00 ef</td>
<td>81.00±1.00 a</td>
<td>7.20±0.20 fg</td>
<td>0.07±0.001 g</td>
</tr>
<tr>
<td>L9</td>
<td>21.23±0.25 d</td>
<td>0.23±0.01 i</td>
<td>3.85±0.06 jkl</td>
<td>18.00±2.00 jh</td>
<td>77.00±1.00 g</td>
<td>7.16±0.05 fg</td>
<td>0.03±0.004 j</td>
</tr>
<tr>
<td>L10</td>
<td>22.50±0.50 c</td>
<td>0.39±0.006 f</td>
<td>4.25±0.06 h</td>
<td>17.03±1.5 h</td>
<td>76.00±1.00 h</td>
<td>7.50±0.20 ed</td>
<td>0.08±0.003 f</td>
</tr>
<tr>
<td>L11</td>
<td>18.50±0.10 h</td>
<td>0.11±0.01 m</td>
<td>3.78±0.01 m</td>
<td>12.36±0.35 h</td>
<td>79.00±1.00 d</td>
<td>7.40±0.10 de</td>
<td>0.02±0.002 k</td>
</tr>
<tr>
<td>L12</td>
<td>19.50±0.50 f</td>
<td>0.24±0.01 hi</td>
<td>3.91±0.01 j</td>
<td>18.00±2.00 g</td>
<td>78.50±1.00 e</td>
<td>7.26±0.05 ef</td>
<td>0.05±0.005 h</td>
</tr>
<tr>
<td>L13</td>
<td>21.00±0.50 d</td>
<td>0.44±0.01 kl</td>
<td>3.87±0.06 jk</td>
<td>24.33±2.08 ed</td>
<td>78.50±1.00 e</td>
<td>7.60±0.10 bc</td>
<td>0.08±0.004 f</td>
</tr>
<tr>
<td>LB14</td>
<td>20.00±0.20 c</td>
<td>0.16±0.006 j</td>
<td>3.67±0.06 n</td>
<td>35.00±2.5 a</td>
<td>78.50±1.00 e</td>
<td>7.30±0.20 ef</td>
<td>0.03±0.004 j</td>
</tr>
<tr>
<td>LB15</td>
<td>23.00±0.10 b</td>
<td>0.15±0.01 k</td>
<td>3.83±0.02 km</td>
<td>20.03±2.5</td>
<td>75.50±1.0 i</td>
<td>7.16±0.05 fgh</td>
<td>0.02±0.004 k</td>
</tr>
<tr>
<td>LB16</td>
<td>19.00±0.10 g</td>
<td>0.13±0.01 i</td>
<td>3.81±0.01 lm</td>
<td>24.96±2.5 c</td>
<td>79.50±1.00 c</td>
<td>7.20±0.10 fg</td>
<td>0.01±0.004 l</td>
</tr>
<tr>
<td>LB17</td>
<td>18.96±1.15 g</td>
<td>0.24±0.006 h</td>
<td>3.86±0.01 jkl</td>
<td>21.03±2.5 ef</td>
<td>79.50±1.00 c</td>
<td>7.30±0.10 ef</td>
<td>0.08±0.005 f</td>
</tr>
<tr>
<td>LB18</td>
<td>20.00±1.00 e</td>
<td>0.11±0.01 m</td>
<td>4.14±0.12 i</td>
<td>20.56±2.5 ef</td>
<td>78.00±1.00 e</td>
<td>7.20±0.30 fg</td>
<td>0.01±0.004 l</td>
</tr>
<tr>
<td>LB19</td>
<td>23.50±0.30 a</td>
<td>0.92±0.01 a</td>
<td>6.52±0.06 c</td>
<td>8.96±1.5 j</td>
<td>75.00±1.0 j</td>
<td>7.90±0.10 a</td>
<td>0.26±0.004 a</td>
</tr>
<tr>
<td>LB20</td>
<td>19.50±1.0 f</td>
<td>0.90±0.006 a</td>
<td>7.07±0.06 a</td>
<td>8.03±0.35 j</td>
<td>78.50±1.0 e</td>
<td>7.06±0.05 gh</td>
<td>0.25±0.003 a</td>
</tr>
<tr>
<td>LSD(p&lt;0.05)</td>
<td>0.4223</td>
<td>0.0136</td>
<td>0.0506</td>
<td>2.0501</td>
<td>0.2669</td>
<td>0.1929</td>
<td>4.069</td>
</tr>
</tbody>
</table>

Mean differences in physicochemical properties of honey samples from different locations.
National beekeeping organizations of some countries (e.g. Germany, Belgium, Austria, Italy and Switzerland) have set a maximum range of 18%–18.5%, while the European Union has set a maximum value of 20% moisture content (Codex Alimentarius Commission, 2001).

Mostly the samples had pH in the normal range of 3.0-6.4. Three samples L2, L6 and L19 have pH 6.66, 6.62 and 6.52 respectively. While one sample showed highest pH value of 7.07. All of them are significantly different from each other (statistical significance is mainly determined by the p-value of a hypothesis test. If the p-value is low, then the statistic is considered to be statistically significant). The pH (means) of eight samples that is L7, L8, L9, L11, L12, L13, L15, L16 and L17 are 3.78, 3.81, 3.85, 3.78, 3.90, 3.87, 3.83, 3.81 and 3.86 respectively. They do not show statistically significant differences. Ten samples L1, L2, L3, L4, L5, L6, L10, L14, L18 and L19 have pH means of 5.44, 6.66, 5.71, 5.03, 5.78, 6.62, 4.25, 3.76, 4.14 and 6.52 respectively. Which are significantly very different from the above eight samples. While one sample L20 had a significantly highly different pH as compared to others (7.07). The difference in pH values can be due to the fact that the growing season and geographical locations affect the percentage of different elements in honey. These results are also in accordance with those of Hussain (1989) who reported pH in the range of 3.0 to 5.0 for pure honey. Honeys with a pH range of 3.5 to 4.5 are considered to have originated from nectar (Amir et al., 2010).

**Table 3.** Geographical origins of honey samples (N = 20) used in this study.

<table>
<thead>
<tr>
<th>Sample code</th>
<th>Geographical origin</th>
</tr>
</thead>
<tbody>
<tr>
<td>L1</td>
<td>Chakwal</td>
</tr>
<tr>
<td>L2</td>
<td>Karak</td>
</tr>
<tr>
<td>L3</td>
<td>Mianwali</td>
</tr>
<tr>
<td>L4</td>
<td>Bannu</td>
</tr>
<tr>
<td>L5</td>
<td>Peshawar</td>
</tr>
<tr>
<td>L6</td>
<td>Fateh Jhang</td>
</tr>
<tr>
<td>L7</td>
<td>Toba Tek Singh</td>
</tr>
<tr>
<td>L8</td>
<td>Chitral</td>
</tr>
<tr>
<td>L9</td>
<td>Margalla</td>
</tr>
<tr>
<td>L10</td>
<td>Satra mile, Islamabad</td>
</tr>
<tr>
<td>L11</td>
<td>Dina, Jehlum</td>
</tr>
<tr>
<td>L12</td>
<td>Haripur</td>
</tr>
<tr>
<td>L13</td>
<td>Peshawar</td>
</tr>
<tr>
<td>LB14</td>
<td>Branded</td>
</tr>
<tr>
<td>LB15</td>
<td>Branded</td>
</tr>
<tr>
<td>LB16</td>
<td>Branded</td>
</tr>
<tr>
<td>LB17</td>
<td>Branded</td>
</tr>
<tr>
<td>LB18</td>
<td>Branded</td>
</tr>
<tr>
<td>LB19</td>
<td>Branded</td>
</tr>
<tr>
<td>LB20</td>
<td>Branded</td>
</tr>
</tbody>
</table>

The electrical conductivity (EC) values of most of the honey samples were in the range of 0.1-0.80 mS/cm. Two samples L19 and L20 had highest electrical conductivity of 0.92 and 0.90, which is more than the normal range (0.8mS/cm).

The electrical conductivity is a good indicator of the honey’s botanical origin. Its measurement depends upon the acid and ash content of the honey, so higher the acid and ash content, higher will be the conductivity.
Acknowledgements
Author is heartily thankful to Dr. Saeeda Raza PSO, Dr. Nouman Rashid PSO, Amir Mumtaz SSO, Naeem Saifdor SSO and Dr. Saqib Jabbar, SSO, Department of Food Science and Product Development Institute (NARC) for their help and support in providing technical assistance.

References


