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Physicochemical Properties and Antioxidant Activity Characterization of Honey Brands Distributed in Tehran, Iran

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Abstract

Background: Honey, a naturally sweet food product, is accompanied by several health benefits. The quality of honey is determined by its microbiological, physicochemical and antioxidant properties which can greatly differ from brand to brand and country to country.

Objectives: To assess the physicochemical properties and antioxidant activity of honey brands distributed in Tehran and compare the parameters with national and international standards.

Methods: Five brands (Shakelli, Khansar, Golagin, Shafi, and Kral) of honey in Tehran were selected and five samples of each brand were collected from supermarkets and analyzed by standard methods for physicochemical properties and antioxidant activity. The collected data was analyzed by SPSS.

Results: The results depicted significant differences among studied honey brands in all physicochemical properties (except for ash, total reducing sugars and sucrose contents), and antioxidant activity ($P<0.05$). The moisture, ash, pH, free acidity, total reducing sugars, sucrose, diastase, and 5-Hydroxymethylfurfural (HMF) contents of honey brands ranged in 16.30-15.34%, 0.24-0.40%, 4.27-4.39 units, 9.15-10.68 meq/kg, 77.84-79.74 %, 3.66-4.57%, 2.28-3.28 DN, 6.67-11.84 mg/kg, respectively. Thus, the physicochemical properties of studied honey brands except for diastase activity were within national and international legal limits. Moreover, total phenolic contents (TPC) and radical scavenging activity (RSA) of 1, 1-diphenyl-2-picrylhydrazyl (DPPH) of honey brands ranged in 28.72-39.36 mgGAE/100gr and 63.83-

73.91%, respectively. Beyond that, highly significant positive correlation was observed between TPC and RSA of DPPH of honey samples (r=0.798, P<0.01).

Conclusion: The studied honey brands were of good quality and met the existent national and international standards at all.

Keywords: Antioxidant activity, Honey, Honey brands, Physicochemical Parameters, Standards

1. Introduction

Honey that is used as food and medicine (Cabrera and Santander, 2022) is defined by Codex Alimentarius as a "natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant-sucking insects on the living parts of plants, which the bees collect, transform by combining with specific substances of their own,

deposit, dehydrate, store and leave in the honeycomb to ripen and mature" (Codex Alimentarius Commission, 2001). Beyond sweetness, honey exerts health benefits such as antibacterial, antifungal, cytostatic, hepatoprotective, hypoglycemic, antihypertensive, gastroprotective, antitumor, anti-inflammatory, antioxidant and wound healing effects (Rahman *et al*., 2017; Soares *et al*., 2017).

The physicochemical parameters of honey as water activity, moisture, sugar contents, pH, acidity, ash, electrical conductivity, hydroxymethylfurfural, and color differ based on the type of botanical origin, geographical origin, handling (Sakač *et al*., 2019), beekeeping practices (Kamal *et al*., 2019) and even bee specie (Al-Farsi *et al*., 2018). The major components of honey are sugars (70–85%) mainly glucose and fructose and water (10–20%) (Al-Farsi *et al*., 2018; Pita-Calvo and Vázquez, 2017). Besides, more than 200 constituents consist of oligosaccharides, ploy saccharides, organic acids, lipids, phenolic compounds, flavonoids, vitamins, minerals, enzymes, amino acids, pollen grains, and other phytochemicals are present in honey (Amiry *et al*., 2017; Manzanares *et al*., 2014; Ramanauskiene *et al*., 2012; Roshan *et al*., 2017). Among these, enzymes (diastase and invertase), HMF (Kamboj *et al*., 2019), and amino acids are considered quality factors of honey. Storage and elevation in temperature affect the enzymes of honey (Belay *et al*., 2017). HMF, a cyclic aldehyde is mainly absent or present in quite lower quantities in fresh honey which can be raised by excessive heating, prolonged and poor storage (Shapla *et*

al., 2018), or by adulteration with inverted sugars (Ajlouni and Sujirapinyokul, 2010; Se *et al*., 2019).

The antioxidant activity of honey mainly relies on both enzymatic and non-enzymatic antioxidants which include polyphenols, carotenoids, organic acids, vitamin C, vitamin E, enzymes (e.g., catalase, peroxidase), amino acids, proteins, trace elements and products of Millard reaction (Dżugan *et al*., 2018; Gül and Pehlivan, 2018; Karabagias *et al*., 2016; Smetanska *et al*., 2021). Among these compounds, polyphenols (flavonoids and phenolic acids) are mainly responsible for the antioxidant activity of honey (Dong *et al*., 2013). These constituents can be affected by their geographic and floral origin, environmental factors, storage, and maybe the processing of honey (Ramanauskiene *et al*., 2012). The correlation between phenolic compounds and the antioxidant activity of honey is important and could be assessed by several methods (Vasić *et al*., 2019). In this sense, several studies have reported a significant positive correlation between phenolic contents, antioxidant activity, and the color intensity of honey (Beretta *et al*., 2005; Bertoncelj *et al*., 2007).

The composition and quality factors of honey could be different from country to country and even within a country for its difference in the region, floral origin, and other factors (Alqarni *et al*., 2016). Data concerning the physicochemical properties and antioxidant activity of Iranian honey from different origins and floral sources are plenty, but information on the mentioned

characteristics of Iranian honey brands was not available. Thus, this study was designed to investigate the physicochemical and antioxidant properties of five well-known honey brands distributed in the Tehran province of Iran and as well as to compare the studied parameters with present national and international standards.

2. Materials and Methods

25 honey samples (5 samples from each brand and from different supermarkets) from five well-known brands namely Shakelli, Khansar, Golagin, Shafi, and Kral were collected from chain supermarkets of Tehran city through random sampling and were analyzed for physicochemical and antioxidant activity at the laboratory of food hygiene and quality control of veterinary medicine faculty/University of Tehran. All tests were performed in a duplicate fashion.

2.1. Physicochemical analysis

The physicochemical analysis included the examination of moisture, ash, pH, free acidity (Silva *et al*., 2009; Zarei *et al*., 2019), diastase activity (Bogdanov *et al*., 2002), hydroxymethylfurfural (Zarei *et al*., 2019) and sugar contents (Kamal *et al*., 2019).

2.1.1. Moisture Determination

The Moisture of honey samples was determined according to the refractometry using an Atago (Japan) model lT Abbe refractometer. All measurements were carried out at 25 °C.

2.1.2. Ash Determination

Ash content was measured using a muffle furnace. Five grams of honey were heated 550^{O}C until the constant weight was achieved. The Ash percentage was calculated using the following formula:

$$\text{Ash\%} = \frac{W1 - W2}{W0} \times 100$$

Where W1 is the weight of the crucible with ash content, W2 represents the weight of the empty crucible and W0 indicates the weight of the honey sample.

2.1.3. Measurement of pH and free acidity

A digital pH meter (Jenway, England) was used for the measurement of the pH of honey samples. For the determination of the pH, a solution of honey (10 gr of honey was dissolved in 75 ml of CO_2-free distilled water) was used. Free acidity was determined by the titrimetric method using 0.05 M NaOH for titration. The titration was continued until pH 8.50. A 1% alcoholic solution of phenolphthalein was used as an indicator. The results were reported as meq of acid /kg of honey. The free acidity of honey samples was calculated as follows:

$$\text{Free Acidity (meq/kg)} = \frac{\text{ml of NaOH used for sample} - \text{ml of NaOH used for blank}}{\text{Weigth of sample}} \times 0.05 \times 1000$$

2.1.4. Diastase activity

The diastase activity of honey samples was carried out according to harmonized methods of the International Honey Commission (IHC) using buffered solutions of starch and honey. Briefly, 10 ml of prepared honey solution was transferred to a 50 ml flask and heated at 40^{O}C using a water bath (WiseBath, Daihan, Korea) for 15 minutes. Meanwhile, a flask containing 10 ml of starch solution was also heated in the same conditions. Afterward, 5 ml of starch solution was transferred to the honey solution and mixed well. After every five minutes, 0.5 ml aliquots were rapidly transferred to 5 ml diluted iodine solution. After that, 20, 21, 22, 23, 24, and 25 ml of distilled water were added to each mixture. The prepared mixtures' absorbance was read at 660 nm using a spectrophotometer (6100, Jenway, England) and water was used as blank. Finally, the absorption data from different time intervals was plotted using regression until the 0.235 absorbance was achieved and the outcomes were reported as diastase number (DN).

2.1.5. HMF content

For the determination of HMF content, five grams of honey samples were liquified in 25 ml of distilled water. The prepared solution was then treated with 0.5 ml of Carrez I (D-1600, Merck, Germany) and 0.5 ml of Carrez II (KGG9A, Merch, Germany) solutions, and the volume of the resultant solution was raised to 50 ml by distilled water. Afterward, the solution was filtered through a filter paper, and the first 10 ml has been discarded. The absorbance of the filtered solution was measured at 284 and 336 nm against the filtered solution treated with $NaHSO_3$ (GH5643F, Sigma-Aldrich, USA) using a spectrophotometer. HMF was determined using the following equation:

$$\text{HMF (mg/kg)} = [A284 - A336] \times 149.7 \times 5 \times \text{weight of sample}$$

2.1.6. Sugar analysis

The reducing sugar contents of honey samples were estimated according to the Layne–Enyon technique. Concisely, five ml of Fehling A and five ml of Fehling B solutions were transferred to a 250 ml Erlenmeyer flask which contained 7 ml H_2O and 15 ml of honey sample. Consequently, 1 ml of 0.2% methylene blue indicator was added to the solution prepared in an Erlenmeyer flask and titrated with heating until the decolorization of the indicator. The inversion process was used for the determination of sucrose. Briefly, 50 ml of honey sample was taken in a 100 ml volumetric flask, 10 ml of dilute HCL was added to the flask and heated in a water bath, and the

volume was made up to the mark. Again, the Layne–Enyon procedure was applied to this solution. The sucrose contents were calculated using the following equation:

$$\text{Sucrose \%} = (\text{Total sugar} - \text{Total reducing sugar}) \times 0.95$$

2.2. Antioxidant characterization

The total phenolic contents (TPC) and radical scavenging activity (RSA) of 1, 1-diphenyl-2-picrylhydrazyl (DPPH) was determined according to the methods reported by Vela, de Lorenzo, and Perez, (Vela, de Lorenzo, & Perez, 2007) and Duzgan *et al*. (Dżugan *et al*., 2018), respectively.

2.2.1. TPC measurement

The Folin-Ciocalteu reagent (53H5010, Sigma-Aldrich, USA) was used for the determination of total phenolic contents (TPC). Briefly, 0.2 ml of honey solution was added to 1 ml of 10 % Folin-Ciocalteu reagent and 0.8 ml of 7.5 % w/v sodium carbonate (Na_2CO_3;) (SLBL4377V, Sigma-Aldrich, USA). The mixture was incubated at room temperature for 120 min. After incubation, a spectrophotometer was used for the measurement of absorbance at 760 nm against

the blank. TPC was calculated based on a calibration curve prepared for gallic acid. Results were reported as mg of gallic acid equivalents (GAE) per 100gr of honey.

2.2.2. Radical Scavenging Activity of DPPH

The antioxidant activity of honey samples was measured spectrophotometrically using the stable free radical DPPH (DG9132-1G, Sigma-Aldrich, USA). In short, 1.25 ml of honey solution in deionized water (0.025 gr/ml) was added to 1.5 ml of DPPH in methanol (90 µg/ml) solution. The prepared solution was incubated for 5 minutes. After incubation, the absorbance was read at 517 nm against a water/methanol (1:1 v/v) blank. A standard curve of ascorbic acid was used for the estimation of the scavenging activity of each honey sample. The results were reported as % equivalent of ascorbic acid in the terms of DPPH depletion which was calculated using the following formula:

$$\text{Radical scavenging activity \%} = \frac{[Aa - (Ab - Ac)]}{(Aa - Ao)} \times 100$$

Where, Aa= the absorbance obtained without the honey sample (DPPH and methanol only), Ab= the absorbance of the incubation mixture of DPPH and honey solution, Ac= the absorbance of the blank solution, and Ao= the minimum absorbance obtained when DPPH was completely scavenged.

2.3. Statistical analysis

The collected data was subject to IBM SPSS V.20 (SPSS Inc., Chicago, IL, USA) for statistical analysis. The difference among honey brands was analyzed using one-way Analysis of Variance (ANOVA) followed by the Tukey multiple comparison test (MCT). The correlation between TPC and the radical scavenging activity of DPPH was analyzed using the Pearson correlation. The difference between the physicochemical properties and antioxidant activity of honey brands and the correlation between TPC and RSA of DPPH were considered statistically significant when $P<0.05$.

3. Results

3. 1. Physiochemical analysis

The analysis of the physicochemical properties of five well-known honey brands distributed in the Tehran city of Iran is presented in Table 1. As the results depict, a statistically significant ($P<0.05$) difference was observed between all honey brands except in ash, total reducing sugars, and sucrose contents ($P>0.05$). According to the results, the higher moisture and ash contents were 16.30 % (0.40 %), respectively. Moreover, pH and acidity ranged from 4.27 to 4.39 and from 9.15 to 10.68 meq/kg, respectively. The higher diastase enzyme activity and HMF contents were 3.28 DN and 11.84 mg/kg, respectively.

3. 2. Antioxidant Characterization

Table 2 represents the results of TPC and RSA of DPPH of five honey brands that were gathered from the Tehran city of Iran. The results showed a significant difference between honey brands in term of TPC (P<0.05). Based on the results, the TPC of brand A (39.36 mgGAE/kg) brand was higher compared to the other four honey brands. After brand A, the high TPC was recorded for brand B, C, D, and E, respectively.

The results of the present study concerning antioxidant properties of investigated honey samples are shown Table 2. As per results, the antioxidant property of honey brands was significantly different (P<0.05). In addition, the RSA of DPPH of studied Iranian honey brands ranged from 63.83 to 73. 91 %. Among these, Brand A touched the peak in term of antioxidant activity followed by band B, C, D, and E.

The results of the present study also showed a strong significant positive correlation (r=0.798, P<0.05) between TPC and RSA of DPPH as portrayed in Figure 1.

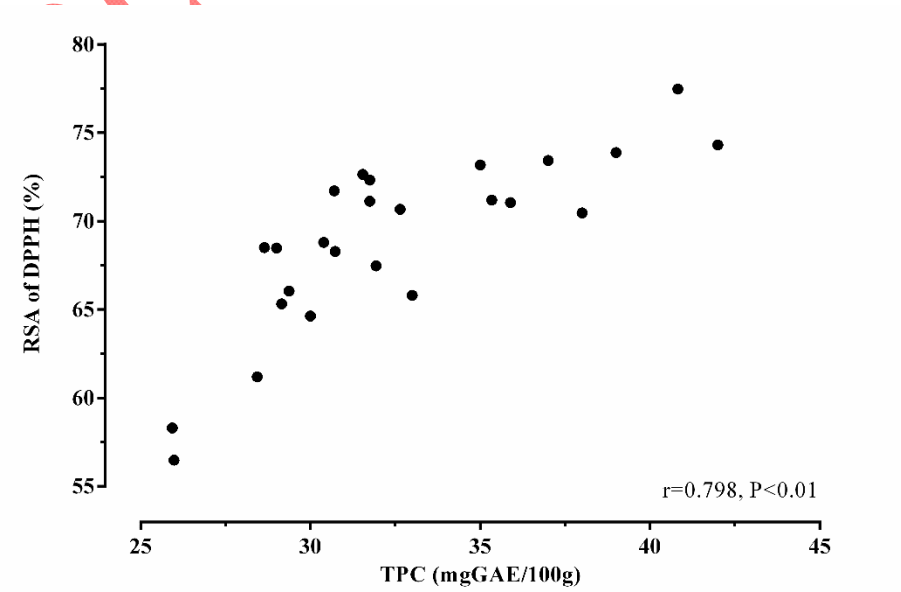

Figure 1 shows the correlation between TPC and RSA of DPPH of 25 honey samples. $P<0.05$ was considered significant. Results show a positive significant correlation between TPC and RSA of DPPH.

4. Discussion

4. 1. Physiochemical analysis

The results of present the study obtained from the analysis of honey brands showed significant differences except in ash, total reducing sugars, and sucrose contents. These findings agreed with present national and international standards except for diastase activity as the diastase activity should not be less than 8 DN. According to the national standards of Iran, honey with acceptable parameters should have <20% moisture, < 0.6% Ash contents, >3.5 pH, <40 meq/kg free acidity, <5% sucrose, >8 DN and <40 mg/kg HMF contents (INSO, 2013). Similarly, the physicochemical properties of honey are stated in some international standards

(CAC, 2001; EU, 2002) and as well as reported by several authors (Nordin *et al*., 2018; Thrasyvoulou *et al*., 2018). However, free acidity is stated as <50 meq/kg by international standards. The possible reason for the lower diastase number of honey samples could be improper heat treatment during honey processing and might be due to inappropriate storage. Similarly, the quality of Omani honey was evaluated, and reported the diastase activity in the range of 1.46-18.4 Schade units and reported that the diastase activity could be altered by botanical origin, climate conditions, heat treatment, and storage (Al-Farsi., 2018). Ajlouni and Sujirapinyoku, (2010) reported a positive correlation between heat treatment and amylase destruction level. Wang and Li, (2011) stated that the time of storage and heat treatment strongly contribute to the alteration of diastase activity. Furthermore, the pH of honey also affects the diastase activity as an increase in pH decreases the level of diastase activity. Beyond that, Zarei *et al*. (2019) reported a lower effect (P>0.05) of thermal treatment on moisture, pH, and free acidity of honey samples.

So far, several studies have been carried out to investigate the physicochemical properties of honey in Iran and from different parts of the world and studied the effective parameters. Jahed Khaniki and Kamkar (2005) studied the physicochemical properties of honey samples in Garmsar city of Iran. The results of their study indicated that the pH, free acidity, ash, and solid matter of the honey samples were 4.54, 16.33 meq/kg, and 0.287%, respectively. Likewise, the

honey samples of Tehran city of Iran were studied for some physicochemical properties by Kamkar *et al*. (2012). The results of their study showed that most of the studied parameters of honey samples were within the desired range. According to their results, 3.3% and 33.3% of honey samples were positive for HMF and diastase, respectively. Moreover, the pH, acidity, solid matter, moisture, and reducing and non-reducing sugars of the samples were 3.84, 16.80 meq/kg, 84%, 15.7%, 66.54%, and 4.38%, respectively. The results of the present study also documented that the physicochemical properties of collected honey samples from different supermarkets were within the present national and international standards. In another research, the physicochemical properties of Harenna forest honey were investigated. Based on their results, hive type had a significant effect on moisture, reducing sugars, ash, and HMF contents. However, moisture, water-insoluble solids, ash, electrical conductivity, and specific rotation of honey samples were significantly altered by sampling location (Belay *et al*., 2013). Moniruzzaman *et al*. (2013) studied the physicochemical and antioxidant properties of Malaysian honey from different botanical and entomological sources. Based on their results, the physical properties of four Malaysian honey types namely acacia (*A. mellifera*), pineapple (*A. mellifera*), borneo (*A. cerana*) and tualang (*A. dorsata*) were significantly different ($P<0.05$). The physicochemical and antioxidant properties of Bangladeshi honey samples that were stored for more than one year were investigated. The results of their study showed that HMF content remained at the recommended level (10.93 mg/kg) after 1.5-year storage at 20-25^{O}C. They

reported that the low moisture and low pH may contribute to the low HMF content (Islam *et al*., 2012). Manzanares *et al*. (2014) physicochemically characterized some minor monofloral honey from Tenerife of Spain. The results of their study showed a significant difference between monofloral honey samples. Moreover, the HMF contents were within the range of 0.4-27.7 mg/kg which is in agreement with international standards. They further stated Honey with HMF contents lower than 15 mg/kg is considered quality honey. Thus, the studied Iranian honey brands in the present study could be considered quality honey for their lower HMF contents.

4. 2. Antioxidant Characterization

The results of the present study outlined a significant difference between the studied honey brands in terms of TPC content. The content could be significantly altered and reduced by thermal processing. Based on Zarei *et al*. (2019) results, the phenolic contents were not significantly reduced in the first 20 minutes of thermal processing but become significant after 30 minutes of thermal processing. Moreover, the TPC is a good criterion for the determination of the quality and curative properties of honey (Al-Mamary *et al*., 2002). Some Suadi Arabian and international honey samples were investigated for TPC. The results showed a significant difference between honey samples as the TPC values ranged from 0.44 to 0.84 mg/gr. They reported that the TPC of honey samples could be altered according to their floral source and are positively correlated to the darkness of honey (Alqarni *et al*., 2016). Gül and Pehlivan (2018)

investigated some monofloral Turkish honey for its antioxidant activities. According to their results, the TPC content of different Turkish honey ranged from 34. 37 to 470.70 mgGAE/100gr. The highest amount of TPC was recorded for Parsely (470.70 mgGAE/100gr) followed by rhododendron, carob, and chestnut honey. The lowest phenolic content was recorded for wild mint (34.37 mgGAE/100gr) and acacia (51.91 mgGAE/100gr) honey. In another study, lower TPC was recorded for *Agastache* honey (853.6 µg GAE/gr) compared to other commercial Australian honey (Anand, Pang, Livanos, & Mantri, 2018). Do Nascimento *et al*. (2018) analyzed Brazilian *Apis mellifera* honey for phenolic compounds, antioxidant activity, and physicochemical properties. Based on their results, The TPC values were in the range of 26-100 mgGAE/100gr for eucalyptus, mastic, wildflower, Japanese grape, Quitoco, and poly floral honey as higher TPC values were documented for eucalyptus (66.45), mastic (63.5) and wildflower (56.50) honey compared to others.

The antioxidant activity of the studied honey brand was significantly different. These findings were similar to Noor *et al*. (2014) research findings. They reported the DPPH radical scavenging activity in the range of 30.50 - 77.43 for natural Pakistani honey. The RSA of DPPH for honeydew, linden, and acacia was reported 86.91, 62.37 and 23.96%, respectively (Kowalski, 2013). In another study, the antioxidant activity of some Portuguese monofloral honey was investigated by Alves *et al*. (2013). Their results reported DPPH inhibition (%) beyond 50 % for

studied honey samples while the DPPH inhibition (%) of some honey samples like rosemary (4.5–59.3%), orange (8.8–23.2%), thyme (35.8–47.3%) and eucalypt (27.7%) were below 50%. Moreover, honey samples of arbutus (64.2%), locust podshrub (61.6%), and some heather samples showed higher DPPH inhibition (%). The DPPH inhibition (%) is correlated to the darkness of honey as dark honey showed 70% DPPH inhibition whereas the DPPH inhibition for light honey was below 40% (Estevinho *et al*., 2008).

The results of the present study depicted a strong positive and significant correlation between TPC and the antioxidant activity of honey. These findings are supported by those that were reported by Berreta *et al*. (2005). According to their results, the phenolic content and DPPH radical savaging activity had a strong positive correlation (r= 0.918). In another study, it was reported that the antioxidant activity of honey is dependent on TPC. Their results showed a positive correlation between TPC and RSA of DPPH (r=0.826) (Anand *et al*., 2018), which is similar to our research findings. Likewise, similar results were obtained by Gül and Pehlivan, (2018) as they documented a significant positive correlation between TPC and DPPH radical scavenging activity (r=0.704, $P<0.01$). Beyond that, several authors indicated that TPC and antioxidant activity of honey are positively correlated (Alvarez-Suarez *et al*., 2010; Alves *et al*., 2013; Bertoncelj *et al*., 2007; Chua *et al*., 2013; da Silva *et al*., 2013; Silici *et al*., 2010).

5. Conclusion

In the present study, the five well-known Iranian honey brands that were distributed in the Tehran province of Iran were analyzed for their physicochemical properties and antioxidant activity and compared the studied parameters with existent national and international standards. Based on the results, all brands were within legal limits except diastase activity as this parameter was lower than those presented in national and international standards. This inconsistency could be attributed to improper heat treatment in honey industries and inappropriate storage in chain supermarkets. From the HMF content point of view, it could be claimed that all brands were in the category of quality honey as the HMF contents of all samples were lower than 15 mg/kg. Moreover, all brands obtained good values in terms of TPC and RSA of DPPH as brand A touched the peak for both characteristics. As expected, a strong significant positive correlation was observed between TPC and RSA of DPPH of honey samples. Collectively, it can be argued that the studied Iranian honey brands were of good quality from the physicochemical properties and antioxidant activity point of view.

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Conflict of Interests: The authors declare that they do not have conflict of interests.

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ویژگی های فیزیکوشیمیایی و فعالیت فعالیت آنتی اکسیدانی برندهای عسل توزیع شده در تهران، ایران

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چکیده

زمینه مطالعه: عسل یک فرآورده غذایی شیرین طبیعی است که با فواید سلامتی متعددی همراه است. کیفیت عسل با خواص میکروبیولوژیکی، فیزیکوشیمیایی و آنتی اکسیدانی آن تعیین می شود که می تواند تا حد زیادی از برند به برند و کشور به کشور متفاوت باشد.

هدف: بررسی خواص فیزیکوشیمیایی و فعالیت آنتی اکسیدانی برندهای عسل توزیع شده در تهران و مقایسه پارامترهای مطالعه شده با استانداردهای ملی و بین المللی.

روش کار: پنج برند عسل معروف (شاکلی، خوانسار، گلاگین، شافی و کرال) توزیع‌شده در تهران انتخاب و پنج نمونه از هر برند از فروشگاه‌های زنجیره‌ای جمع‌آوری و با روش‌های استاندارد خواص فیزیکوشیمیایی و فعالیت آنتی‌اکسیدانی آن آنالیز شدند. داده های جمع آوری شده با استفاده از نرم افزار SPSS مورد تجزیه و تحلیل قرار گرفت.

نتایج: نتایج نشان‌دهنده تفاوت معنی‌دار بین برندهای عسل مورد مطالعه در تمامی ویژگی‌های فیزیکوشیمیایی (به جز خاکستر، کل قندهای احیاکننده و ساکارز) و فعالیت آنتی‌اکسیدانی بود ($P<0/05$). رطوبت، خاکستر، pH، اسیدیته آزاد، کل قندهای احیاکننده، ساکارز، دیاستاز و 5-هیدروکسی متیل فورفورال در برندهای عسل به ترتیب در محدوده 16.30-15.34٪، 0.24-0.40٪، 4.27-4.39 واحد، 9.15-10.68 میلی اکی والان/کیلوگرم، 77.84-79.74٪، 3.66-4.57٪، 2.28-3.28 واحد

دیاستاز، 6.67-11.84 میلی‌گرم /کیلوگرم بود. بنابراین، ویژگی های فیزیکوشیمیایی برندهای عسل مورد مطالعه به جز فعالیت دیاستاز در محدوده قانونی ملی و بین المللی قرار داشت. علاوه بر این، محتوای فنلی تام و فعالیت مهار رادیکالDPPH برندهای عسل به ترتیب در محدوده 28.72-39.36 میلی‌گرم اسیدگالیک/100گرم، و 63.83-73.91 درصد بود. علاوه بر این، بین محتوای فنلی تام و فعالیت مهار رادیکالDPPH نمونه‌های عسل همبستگی مثبت و بسیار معنی‌داری مشاهده شد (r=0/798، P<0/01).

نتیجه گیری نهایی: برندهای عسل مورد مطالعه از کیفیت خوبی برخوردار بوده و در کل استانداردهای موجود ملی و بین المللی را دارا می باشند.

کلیدواژه‌ها: فعالیت آنتی اکسیدانی، عسل، برندهای عسل، پارامترهای فیزیکوشیمیایی، استانداردها

560 **Tables**

Table 1. Mean of physiochemical parameters of five honey brands (Mean ± SD) *.

Physiochemical parameters	Brand				
	A	B	C	D	E
Moisture (%)	15.36±0.19^{b}	15.50±0.22^{b}	16.30±0.074^{a}	15.42±0.39^{b}	15.34±0.36^{b}
Ash (%)	0.28±0.10^{a}	0.32±0.10^{a}	0.24±0.08^{a}	0.40±0.13^{a}	0.24±0.08^{a}
pH	4.37±0.05^{ab}	4.32±0.03^{bc}	4.37±0.02^{ab}	4.39±0.04^{a}	4.27±0.07^{c}
Free acidity (meq/kg)	10.41±0.89^{ab}	9.15±0.84^{b}	10.68±0.73^{a}	9.17±1.17^{b}	10.61±1.38^{a}
Total reducing sugars (%)	77.84±1.89^{a}	78.01±1.76^{a}	79.08±1.34^{a}	79.74±1.89^{a}	77.99±2.02^{a}
Sucrose (%)	4.57±1.06^{a}	4.22±0.41^{a}	4.08±1.04^{a}	4.40±0.77^{a}	3.66±0.46^{a}
Diastase (DN)	2.67±0.18^{b}	2.49±0.09^{bc}	2.44±0.12^{bc}	3.28±0.72^{a}	2.28±0.23^{c}

HMF (mg/kg)	7.51±0.43^{c}	6.67±0.90^{c}	9.06±1.94^{b}	11.84±0.82^{a}	6.74±0.38^{c}

* Mean of 5 honey samples with standard deviation.

$^{a-c}$ Mean in the same row with lowercase superscript followed by different letters are significantly different ($P<0.05$).

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Table 2. Phenolic content and DPPH scavenging activity of five honey brands (Mean ± SD) *.

Antioxidant parameters	Brand				
	A	B	C	D	E
Total phenolic contents	39.36±1.92^{a}	33.69±1.58^{b}	30.95±2.58^{bc}	30.07±2.22^{bc}	28.72±1.69^{c}

(mgGAE/100gr)					
DPPH scavenging activity (%)	73.91±2.50[a]	69.63±2.96[ab]	68.79±2.68[ab]	68.39±6.83[ab]	63.83±4.01[b]

* Mean of 5 honey samples with standard deviation.

[a-c] Mean in the same row with lowercase superscript followed by different letters are significantly different ($P<0.05$).