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Original article

# Validation of botanical origins and geographical sources of some Saudi honeys using ultraviolet spectroscopy and chemometric analysis

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This study aims at distinguishing honey based on botanical and geographical sources. Different floral honey samples were collected from diverse geographical locations of Saudi Arabia. UV spectroscopy in combination with chemometric analysis including Hierarchical Cluster Analysis (HCA), Principal Component Analysis (PCA), and Soft Independent Modeling of Class Analogy (SIMCA) were used to classify honey samples. HCA and PCA presented the initial clustering pattern to differentiate between botanical as well as geographical sources. The SIMCA model clearly separated the *Ziziphus* sp. and other monofloral honey samples based on different locations and botanical sources. The results successfully discriminated the honey samples of different botanical and geographical sources validating the segregation observed using few physicochemical parameters that are regularly used for discrimination.


## 1. Introduction

Honey is an important food that is categorized as a functional food i.e. a class of foods that has health promoting and disease preventing properties in addition to multiple nutritional values. Honey is acknowledged as a natural product with tremendous medicinal values. Its properties can only be guaranteed if the honey is authentic. Many documented biological activities of honey include antioxidant, immunomodulatory, cancer prophylactic and curative properties (Al-yahya et al., 2013). Experimental evidence indicate that honey from variety of floral and geographical sources like Manuka, Saudi *Ziziphus*, Toulang, Chestnut, Rhododendron, Pasture, Jelly bush, Blossom, Sage and Neem may exert several beneficial health effects. These include gastroprotective, hepatoprotective, reproductive, hypoglycemic, antioxidant, antihypertensive, antibacterial, antifungal and anti-inflammatory effects (Erejuwa et al., 2012; Ansari et al., 2013; Noori et al., 2013; Can et al., 2015). Honey varies in its composition depending on several factors such as botanical source, geographical origin, and storage conditions (Gheldof et al., 2002; Yao et al., 2004; Khan et al., 2016; Kaygusuz et al., 2016). Bees forage different plants, and due to different proportions of the possible sources of nectar, honey is always a mixture of different sources (Oddo and Bogdanov, 2004). Monofloral honey is produced from nectar that mainly originates from a single plant species and possesses distinctive organoleptic characteristics. These honey types of distinct botanical origin are often traded at a higher price than honeys from mixed botanical origins and can thus be considered premium products (Donarski et al., 2010; Can et al., 2015).

In Saudi Arabia, honey is a highly regarded product. Honey is widely consumed in Saudi Arabia as a curative agent either alone or as a carrier for medicinal herbal mixtures and is used as the main constituent in several traditional foods throughout the country. The annual consumption of honey in the country is very high, over 39,000 tons. Honey produced in Saudi Arabia sells for 10–20 times more money than imported honeys. Moreover, limited availability and high pricing of monofloral honey especially *Ziziphus* honey in Saudi Arabia are probably the biggest temptations for its adulteration or admixture with other Kashmiri *Ziziphus* honey types. Hence, identification of authenticity is important for

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financial reasons in addition to consumer and producer protection. Honey authenticity is defined by the Codex Alimentarius standards, the European Union (EU) honey directives, and different national legislations. The authenticity of honey has two aspects: The first aspect concerns production, i.e. ensuring that the natural constituents of honey are not adulterated or altered during processing. The second aspect of authenticity pertains to its geographical and botanical origin.

Many different techniques are employed in authenticity testing of honey including physical and chemical parameters to characterize honeys (Alqarni et al., 2014; Khan et al., 2016). Pollen analysis (melissopalynology) was used as the traditional method to determine the honey's botanical origin (Arvanitoyannis et al., 2005; Adgaba et al., 2017). In the past few decades, more recent analytical techniques were implemented for the determination of honey's botanical origin in an effort to find alternative methods for honey authentication. These methods were based on statistical evaluation of their physicochemical data (Marini et al., 2004; Ruoff et al., 2007) or the determination of certain chemical constituents to be used as biomarkers by applying various chromatographic and spectroscopic techniques (Anklam, 1998; Yao et al., 2004; Kaskoniene and Venskutonis, 2010; Kaygusuz et al., 2016).

Recently, analytical techniques in conjunction with multivariate analysis and chemometrics have been widely implemented in the quality control of various foods and herbal drugs (Tistaert et al., 2011; Gad et al., 2013a). The application of UV spectroscopy in the analysis of food products has increased during the past decade, probably due to its advantage of being simple, quick, nondestructive, and relatively inexpensive to carry out (Souto et al., 2010; Gad et al., 2013b).

In this study, the validation of honey samples authenticity was based on chemometric analysis of UV spectroscopic data, to confirm the botanical source of Saudi honey samples. The model reported by Roshan et al. (2013) was employed for detection of authenticity of honey samples. The results obtained by this study will protect local honey producers and consumers from fraudulent honeys. The authentication of local honeys will promote the production and marketing of local honeys, and this in turn will encourage local beekeepers to increase their production.

## 2. Materials and methods

### 2.1. Sample collection

A total of eighteen honey samples were used in this study. Eight samples belonged to *Ziziphus* (Sidr) honey of which five (K7, K13, K17, K21 and K30) represented *Ziziphus spina-christi* while, the remaining three (K37, K45 and K61) were from *Z. nummularia*. Similarly, nine samples were *Acacia* honey, of which four samples (K49, K57, K85, and K97) represented *Acacia gerrardii* (Talah), three sample (K4, K26, and K28) belonged to *A. tortlis* (Sumra), and two samples (K9, K23) were from *A. origena* (Talah). Only one sample (K150) represented multifloral honey. All samples were collected from different geographical locations of Saudi Arabia. Sample codes, botanical and geographical origins, and collection season are shown in Table 1. A map of Saudi Arabia showing collection sites of different honey samples is represented in Fig. 1. Physicochemical (refractive index, water content, pH, free acid content, and electrical conductivity) and sensory analyses were carried out at Bee research chair, King Saud University Riyadh. The physicochemical data for all samples (unpublished) show that all the honey sample are genuine and fall in the criteria set by codex Alimentarius.

### 2.2. Sample preparation

The method reported by Roshan et al. (2013) was followed in the preparation of the samples. To dissolve most of the honey

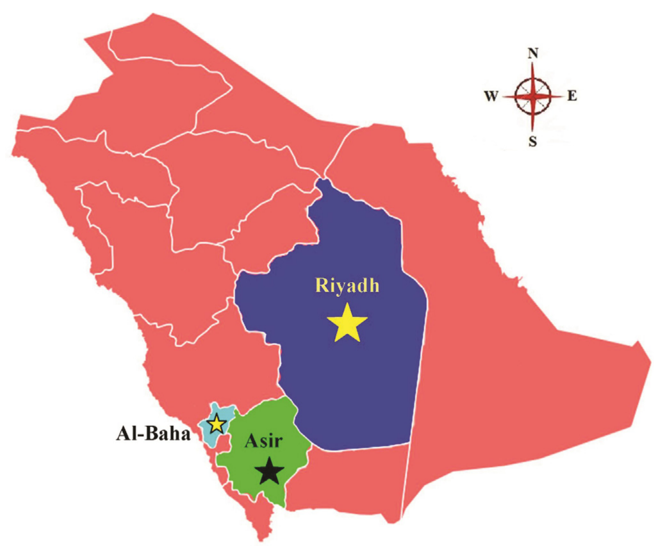


**Fig. 1.** Map of Saudi Arabia showing the regions Al-Baha, Asir, and Riyadh used to collect honey samples.

**Table 1**
Plant origin, area of collection, area description, harvesting season, and code designated for collected honey samples.

| Sample code | Plant origin | Area of collection | Area description | Harvesting season (2016) |
|---|---|---|---|---|
| K4 | *Acacia tortolis* | Mashooqa, Al-Baha | Mountainous wild forest | March |
| K7 | *Ziziphus spina-christi* | Al-Baha | Mountainous wild forest | October |
| K9 | *A. origena* | Al-Baha | Mountainous wild forest | June |
| K13 | *Z. spina-christi* | Asir | Mountainous wild forest | October |
| K17 | *Z. spina-christi* | Asir | Mountainous wild forest | October |
| K21 | *Z. spina-christi* | Mashooqa, Al-Baha | Mountainous wild forest | September |
| K23 | *A. origena* | Baljurashi, Al-Baha | Mountainous wild forest | June |
| K26 | *A. tortolis* | Al-Baha | Mountainous wild forest | April |
| K28 | *A. tortolis* | Al-Baha | Mountainous wild forest | April |
| K30 | *Z. spina-christi* | Al-Baha | Mountainous wild forest | September |
| K37 | *Z .nummularia* | Rawdhat-Khoraim | Subtropical oasis | June |
| K45 | *Z .nummularia* | Rawdhat-Khoraim | Subtropical oasis | July |
| K49 | *A. gerrardii* | Rawdhat-Khoraim | Subtropical oasis | June |
| K57 | *A. gerrardii* | Rawdhat-Khoraim | Subtropical oasis, irrigated fields | August |
| K61 | *Z .nummularia* | Rawdhat-Khoraim | Subtropical oasis | July |
| K85 | *A. gerrardii* | Rawdhat-Khoraim | Subtropical oasis, irrigated fields | August |
| K97 | *A. gerrardii* | Rawdhat-Khoraim | Subtropical oasis | July |
| K150 | *Multifloral* | Al-Kharj | Plains with irrigated field | July |

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