Honey Characterization Based on Physicochemical Parameters using GIS Techniques: A Case Study in Selected States of Northern India

Parvinder Kaur1*, Atul A Mishra1 and Deepak Lal2
1Department of Food Process Engineering, VSAET, SHIATS, (DU), Allahabad, India
2Remote Sensing & GIS Unit, VSAET, SHIATS, (DU), Allahabad, India

Abstract

Honey is considered as natural and healthy product that has a highly concentrated solution of a complex mixture of carbohydrates. The quality of a honey depends on its geographical and botanical origin. Therefore, classification of honey according to geographical origin is of great interest. In this study, it is aimed to develop classification models of honey harvested in India based on geographical and botanical origin via GIS analysis. Seventy-seven honey samples were taken from different regions of North India (Punjab, Uttar Pradesh and Rajasthan States) and characterization was carried out on the basis of their quality parameters (moisture content, color, hydroxymethylfurfural (HMF), total reducing sugars, sucrose and fructose/glucose ratio) and these parameters were mapped and interpolated with GIS technologies.

Keywords: Honey; Palynological analysis; GIS; Physicochemical parameter

Introduction

Honey has been consumed for its high nutritive value and its contribution in human health. The world’s annual honey production is about 1.2 million tons which account for about 1% of the total sugar production. Economically developed countries have higher consumption rate of honey. The Indian sub-continent alone with over 1000 million people is a huge market for honey. India is the important producer and exporter of honey. North East Region of India and Maharashtra are the key areas of honey production. The country had exported 29,578.52 MT of honey to the world for the worth of Rs. 535.07 crore during the year of 2014-15. India exports honey principally to USA, Saudi Arabia, United Arab Emirates, Libya and Morocco.

Honey is generally evaluated by a physico-chemical analysis of its constituents which is based on various physicochemical characteristics and these characters are important to determine quality and certification [1]. Moreover, the physicochemical data of any honey sample is essential for storage, granulation, texture, flavor, nutritional and medicinal quality and marketing [2].

The chemical composition of honey is dependent on the geographical location even for the same plant species, as accumulation of phytochemicals depends on climatic conditions (sunlight and moisture), soil characteristics, and the presence of different minerals arising from soil. This suggests that the chemical composition of the honeys even of the same floral origin may be quite different. Honey production in India, is largely reliant on access to native flora and various crops, such as mustard, eucalyptus, berries, litchi, khair, karanz fruits and vegetables. Particular flora species and crops produce honey with specific characteristics, in terms of colour, flavor and have unique chemical composition. Thus regional honey must be categorized and supported by analysis confirming its provenance. The determination of the geographical and botanical origin of honey is important not only because of specific legislation [3] but because of market demands.

The scope of the present investigation is confined in northeast sub-region of India, which includes (Punjab, Rajasthan and Uttar Pradesh). Honey varieties from these regions of India, by virtue of the special climate and vegetation of the area, exhibit chemical and physicochemical characteristics that facilitate their categorization from honey produced in other regions. Geographical information system (GIS) has been employed for performing investigations on physicochemical parameters of honey; including the determination of percentage area for physicochemical parameters variation and creating suitability maps for geographic and floral availability for honey. These maps have lot of statistical and data presentation options. Therefore, the model presented here is used for creating physicochemical parameters maps and physicochemical analysis using the ArcGIS. This would then serve not only as a characterization system, but also as reference system for ascertaining the floral and/or geographical source of a sample by the application of GIS technique. Therefore, the generation of information on honey from different regions where its characteristics are unknown, could be useful for the integration of a national map of honey quality and its characterization with the geographical area of its origin.

Aim of the study

The present study was conducted to evaluate the physicochemical parameters of honeys and to categorize honey according to its geographical origin and floral source of nectar, and to establish associations among quality parameters with the production zone. This study also aims organizing honey characterization and establishing links with the geographical area of its origin using a GIS system.

Materials and Methods

Collection of geographical information of sampling points

The research was begun by conducting a survey of the geographical locations of hives in the regions. The geographical locations of the selected hives were obtained using a Garmin Etrex Global Positioning System (GPS) unit and through Google earth.
Raw samples collection

The study was conducted on samples of *Apis mellifera* honey from different floral origins (designated as H1–H77) harvested in the Northeast sub-region (Punjab, Uttar Pradesh and Rajasthan) harvesting season of 2015-16. Samples were obtained from apiarists and beekeepers’ associations in different places in Northeast sub-region. Each honey sample was identified botanically (Berries Honey, Brassica Honey, Eucalyptus Honey, Multi-flora and Mixed Honey) in terms of its floral origin, site of collection and palynological analysis of the collected honeys. All samples were stored at refrigerator temperature (~4°C) until analysis.

Sample preparation

The honey sample was homogenized by stirring thoroughly. Crystallized honey samples were previously softened by heating it on thermostatic bath at not more than 40°C. Unwanted materials such as wax sticks, dead bees and particles of combs were removed by straining the samples through muslin cloth before analysis.

Physicochemical properties of raw honey samples

Physicochemical parameters were analysed using The Official Methods of Analysis of Association of Official Analytical Chemists [4], The Harmonized Methods of the European Honey Commission [5] and the Codex Alimentarius Codex Alimentarius [6]. These methodologies were also recommended by BIS.

Moisture content

Moisture was determined using the indirect refractometric method. All measurements were taken using an Abbe refractometer, and the percentage of moisture obtained from the refractive index of the honey sample by consulting a standard table for the purpose [7]. The table is derived from a formula developed by Wedmore [8].

\[
W = \frac{1.73190 - \log[R1 - 1]}{0.002243} \quad \text{------------------------- (3.1)}
\]

W is the water content in g per 100 g honey and R.I. is the refractive index

Hydroxy methyl furfural (HMF) with sodium bisulphate after white method

HMF was determined spectrophotometrically according to the method of White as described in IHC. Briefly, five grams (5.0 g) of honey was dissolved in 25 ml of water, transferred quantitatively into a 50 ml volumetric flask, followed by the addition of 0.5 ml of Carrez solution I and 0.5 ml of Carrez II and made up to 50 ml mark with water. The solution was filtered, and the first 10 ml discarded. The absorbance values:

\[
A_{284} = \text{Absorbance at } 284 \text{ nm}
\]

\[
A_{336} = \text{Absorbance at } 336 \text{ nm}
\]

\[
14.97 \times \frac{136 \times 1000 \times 1000}{16830 \times 10^5} \times C \quad \text{Constant} \quad \text{------------------------- (3.3)}
\]

Where,

\[
C = \frac{25}{W_1} \times \frac{1000}{Y_1} \quad \text{------------------------- (3.5)}
\]

Where,

\[
Y_1 = \text{volume (ml) of diluted honey solution consumed.}
\]

\[
C = g \text{ invert sugar per } 100 \text{ g honey.}
\]

\[
W_1 = \text{weight (g) of honey sample.}
\]

HMF was determined spectrophotometrically (measure of the absorbance of 50% honey solution (w/v) at 635 nm). The colour was determined according to the Pfund scale after conversion of the absorbance values:

\[
\text{Pfund (mm)} = -38.70 + 371.39 \times \text{Abs function} \quad \text{------------------------- (3.4)}
\]

Total reducing sugars

This parameter was determined by potentiometric titration using the Fehling’s test (Lane and Eynon modified method).

\[
C = \frac{25}{W_1} \times \frac{1000}{Y_1} \quad \text{------------------------- (3.5)}
\]

Where,

\[
Y_1 = \text{volume (ml) of diluted honey solution consumed.}
\]

Apparent sucrose content

Apparent sucrose was determined by potentiometric titration using the Fehling’s test (Lane and Eynon modified method).

\[
\text{Apparent sucrose} = \left( \text{Invert sugar per } 100 \text{ g honey after inversion} \right)
\]

\[
= \left( \text{Sugar content before inversion} \right) \times 0.95 \quad \text{------------------------- (3.6)}
\]

The results were expressed as g apparent sucrose/100 g honey.

Fructose glucose ratio (Ref: IS 4941:1994)

Glucose % was determined iodimetrically in a weak alkaline medium and the value is subtracted from reducing sugars % to arrive at fructose % and fructose: glucose ratio.

\[
\text{Glucose} \% = \text{Normality of sodium thiosulphate solution} \times (B-S) \times 0.009005 \times (0.1N \times \text{weight of sample}) \times 100
\]

\[
\text{Fructose} \% = \text{Reducing sugars } \% - \text{glucose } \% \quad \text{------------------------- (3.8)}
\]

\[
\text{Fructose : glucose ratio} = \frac{\text{Fructose} \%}{\text{Glucose} \%} \quad \text{------------------------- (3.9)}
\]

Interpolation and mapping of quality parameters of honey producing areas using GIS

The spatial distribution of various physicochemical parameters (moisture, HMF, color, TRS, sucrose and fructose/glucose) of honey samples were analyzed by creating their respective maps in GIS environment. The new data which included values of physicochemical parameters for each respective honey sample along with its location information (latitude and longitude) were arranged in a database format. This database was then imported to GIS environment and converted into shapefile. Raster maps of individual physicochemical parameters were developed from the aforementioned shape file using the inverse distance weighted (IDW) routine in GIS. The present approach is similar to the one mentioned in Hossam and Abhou [9] for creating a suitability map for Honey availability under different vegetation and environmental conditions.

Importing XY data from text files

To create map using the ArcGIS, the data were arranged in three main columns (1: for honey sample Points, 2: for x and 3: for y) and six columns for selected physicochemical parameters in the form
of a database. Then the database was saved as Tab delimited file. The database was then added to ArcMap using “Add X4” data option.

Creation of shape files and database in GIS domain

Shape file was created for all collected samples in GIS domain. The latitude/longitude of the apiaries obtained from the GPS was imported to Arc GIS environment in the form of shape files.

Interpolation and mapping

Interpolation was done and map was created. Geo statistical analyst was used to create a predicted distribution of the attribute data. The Inverse distance weighted (IDW) method was used for interpolation. It was used for constructing new data points within the range of a discrete set of known data points. The basic idea of IDW is to predict the value of a function at a given point by computing inverse distance weightage of the known values of the function in the neighborhood of the point. The method is mathematically closely related to regression analysis. Microsoft Office Excel and Access was used to organize the Geographic Information System (GIS) database. Locations of data sampling are vector (point) data.

Results and Discussion

The data collected on different aspects were tabulated and analyzed using GIS technologies.

Study area

The Figure 1 depicts the study area. 77 raw honey samples were harvested from three different states (Punjab, Uttar Pradesh and Rajasthan). The 37 samples containing mustard (n = 6), eucalyptus (n = 4), EuM (n = 11), berries (n = 3), multilora (n = 12) and one mixed floral honey were harvested from Punjab. 22 samples from Uttar Pradesh consisting mustard (n = 5), eucalyptus (n = 4), EuM (n = 7), multilora (n = 3) and three mix honey samples. 18 from Rajasthan containing (n = 13), EuM (n = 3) and two multiloral honey samples. Physio chemical characteristics and analysis of raw honey samples were presented in Tables 1 and 2.

Moisture content

Water is the second largest constituent of honey. The moisture content is one of the most important characteristics, influencing physical properties of honey such as viscosity and crystallization, as well as other parameters: color, flavor, taste, specific gravity, solubility and conservation. The moisture percentage of honey was observed between 18.0% to 24.5% having mean 21.3% and standard deviation 1.641. Generally, the Indian honey has significantly higher moisture content in comparison to the Western honeys and it is hygroscopic i.e. absorbs moisture from the atmosphere in case of inadequate storage conditions [10]. These findings along with results from this study clearly show that moisture content in honey is influenced by botanical source, geographical region, climatic conditions and the season. High moisture indicates a premature extraction or extraction under high humidity conditions and could lead to undesirable honey fermentation and granulation during storage [11-13]

Hydroxymethylfurfural (HMF)

HMF is formed via dehydration of hexose sugars in acid medium. Several factors, such as temperature and time of heating during extraction and processing: storage conditions; aging of honey product and sources of flora, were found to influence the HMF in honey. The HMF is widely recognized as a parameter in evaluating the freshness of honey. The higher value of HMF indicates overheating during processing, prolonged storage or adulteration with invert sugar. In present investigation the HMF values were in the range of 0.24-58 ppm having mean 5.827 and standard deviation 7.209 (Table 1). These results were in agreement with those reported by other researchers, who indicated HMFS were below 10 mg/kg in freshly extracted honey. HMF values of all honey samples except one of mustard honey sample from Punjab region were found in the acceptable standard (< 40 mg/kg).

Color analysis

Honey color is one of the most variable physical components, which varies according to the geographical origin and botanical varieties visited by the bees with the most common being yellowish, reddish or greenish. It also depends on its ash content, temperature, and time of storage, as well as the presence of antioxidant pigments such as carotenoids and flavonoids [14,15]. Browning/darkening of honey occurs due to Maillard reactions, caramelisation of fructose and polyphenolic reactions, depending on storage or extraction or

| S.no | Physicochemical parameters | Technique/Instrument |
|------|---------------------------|---------------------|
| 1    | Moisture content          | Refractometry, IHC 2009 |
| 2    | Color analysis            | Spectrophotometry method |
| 3    | Reducing sugars           | Fehling’s test (Lane and Eyon modified method) (IS 4941:1994) |
| 4    | Apparent sucrose          | Fehling’s test (Lane and Eyon modified method) (IS 4941:1994) |
| 5    | Fructose/glucose ratio    |iodometrically, (IS 4941:1994) |
| 6    | Hydroxymethylfurfural (HMF) | Spectrophotometry, White Method, IHC 2009 |
| 7    | Palynological analysis    |Microscope method. International Commission for Bee Botany (ICBB) |

Table 1: Physico-chemical characteristics of honey, and their determination to assess quality attributes.

Table 2: Physico-chemical analysis.

![Figure 1: Map showing the study area (India).](image-url)
processing temperature and/or duration [16]. It is the first property perceived by the consumers, which could determine its market value. In many countries, the price of honey is related to its color. Lightly colored honeys generally have a higher value, although dark honeys are liked in certain regions such as India. Honey samples color ranges between 22-80 mm, Pfund scale with a mean of 46 mm and standard deviation of 12.3.

**Total reducing sugars**

The total reducing sugars was around 65.58% to 78.51% with the mean of 73.04 and standard deviation of 2.581. Bureau of Indian Standards (BIS) in its specification for honey has prescribed the minimum level of 65% total reducing sugars.

**Apparent sucrose**

Sucrose content was low and within range of 0.41% to 3.01% with the mean of 1.14 and standard deviation of 0.689 which was as per the prescribed limit of Bureau of Indian Standards. This result was in agreement with the results from Argentina-4.05% [17], Turkey-3.03% [18] and France-0.74% [19]. The upper limit of 5.0% sucrose has been defined in the specification for honey by the (BIS).

**Fructose glucose ratio**

The range of the calculated ratio of fructose: glucose was from 0.92-1.18 with the mean of 1.065 and standard deviation of 0.056. This general trend of fructose glucose ratios in honey from different sources has been well documented. Honey with high fructose: glucose ratio would remain liquid for longer periods because of the modification of the saturated level of glucose by the presence of the larger amount of fructose [20]. The actual proportion of fructose to glucose in any particular honey depends largely on the source of the nectar. The fructose: glucose ratio may also have an impact on honey flavour since fructose is much sweeter than glucose. These results are in agreement with those reported by Terrab et al. [21] who indicated that fructose and glucose represented 92% of the total quantified sugars, in comparison to 73% of the disaccharides.

F/G ratio also indicates the ability of honey to crystallize, since the glucose is less soluble in water than fructose. Honey crystallization is faster when the F/G ratio is below 1.0 and is slower when this ratio is more than 1.0. Accordingly, Mustard honey had faster crystallization rate than other types of honey and Berries honey had slowest crystallization rate. Nearly all honey types, fructose predominates; a few honeys appeared to contain more glucose than fructose. Honey, which contains less glucose than fructose has ability to fluid [22].

**Moisture content in different honey samples**

The distribution of moisture content in honey samples of Punjab region in Figures 2 and 3 depict that moisture content ranged between 18% to 24% with major distribution 83% area between 19% to 22%. About 51.8% area of Punjab honey contain moisture between 20% to 21%. The highest moisture content of 23% to 24% was in 0.41% area containing mustard flora. The lowest moisture content was found between 18% to 19% in berries samples (1.51% area.). As depicted in Figures 2 and 3 in Uttar Pradesh region the distribution of moisture content in honey samples showed different trend. The major distribution of moisture content range between 20% to 23%. Thus 54.8%, 23% and 16% area contain moisture content between 21% to 22%, 22% to 23% and 20% to 21% respectively [23-27]. The major honey variety in Uttar Pradesh was EuM (Eucalyptus + mustard) because of same flowering period of both the nectars as shown in Figures 3 and 4. Rajasthan predominates in mustard honey. Major distribution of moisture content in honey samples was between 21% to 24%. Honey samples in about 56%area had moisture content between 22% to 23% followed by 21% to 22% in 36% area of Rajasthan. In Ganganagar and Kota regions some honey samples had moisture between 23% to 24%.

**HMF (ppm) in different honey samples**

In Punjab, variety of floral vegetation are available i.e. mustard,
eucalyptus, eucalyptus and mustard mix, berries and multiflora. The major vegetation is of multifloral honey and unifloral honey containing mustard, eucalyptus and EauM. As depicted in Figures 4 and 5, the HMF of honey samples of Punjab varied between 0.24-58 ppm. Only one sample of mustard had 58 ppm and it was adulterated with water and invert sugar. 79% area of Punjab samples had HMF between 0.24-10 ppm followed by 19% samples containing HMF between 10-20 ppm.

Honey samples in Uttar Pradesh of 96% area contained HMF 0.95-10 ppm and only 4% area showed HMF between 10-18 ppm. A small number of samples were of mixed honey (vegetables pollen honey) and multifloral honey. Rajasthan honey samples had HMF between 0.95-11 ppm, in which only one sample of Kota region had 11 ppm HMF and the remaining 99.99% range between 0.95-10 ppm [28-31]. Rajasthan samples had lower HMF followed by Uttar Pradesh but due to floral variation in Punjab different levels of HMF were found. As HMF values depends on chemical composition of particular flora least variation was in Rajasthan which predominated in mustard cropping. This suggest that botanical origin had a major impact on HMF level and mustard honey showed least initial HMF level and mixed honey showed the highest HMF level.

**Color (mm, Pfund) in different honey samples**

Botanical origin is the major factor which showed the variation in chemical composition of honey and had a positive impact on physical parameter thus on color of honey. Due to wide floral variation in Punjab region color varied from 30-67 mm. Light amber color was in multifloral honey from 30-51 mm and darker amber color between 65-67 mm was in berries honey. The color of mustard and eucalyptus varied between 30-60 mm. Thus 75% area of Punjab samples varied between 40-55 mm, followed by 21% area which had color between 30-40 mm.

Uttar Pradesh had lower floral variation, predominating being the eucalyptus followed by mustard and the color varied between 39-80 mm. Due to unique chemical composition of eucalyptus honey it had dark amber color which had higher market value in Indian market. The major honey samples varied between 40-60 mm, 56% area containing honey had color between 40-55 mm followed by 38% being 55-60 mm [32-36]. In Rajasthan, major cropping pattern was of mustard which had lighter color and creamy texture. 93% area of Rajasthan honey samples varied between 30-40 mm. A white colored honey has a great demand in European countries for the preparation of creamed honey. Thus pure mustard honey can be harvested in Kota region of Rajasthan for export purposes. After comparing three states, it was observed that botanical origin and the geographical region due to the variation in cropping pattern and vegetation available influenced the color or indirectly the market value of honey. Lighter colored honey has higher value in European honey and have an export potential thus honey extracted from Rajasthan basically Kota and Ganganagar region can be protected as production zone of unifloral mustard honey [35,37]. Currently the honey market has a tendency to establish geographical protection a production zone that has developed to market a particular standard of honey. Unifloral types honey has higher market value due to its limited production and availability.

**Total reducing sugar in different honey samples**

Honey production in India is largely reliant on access to native flora and various crops, such as mustard, eucalyptus, berries, khair, fruit and vegetables. Particular flora species and crops produce honey with specific characteristics and chemical composition which affect the sugar composition of honey. In Punjab total reducing sugars varied between 65.58% to 78.5%. About 83% areas of samples vary between 72% to 75% followed by 10% area between 75% to 78%. Only 6% and 1% area of Punjab honey samples varied between 69% to 72% and 66% to 69% respectively. In Uttar Pradesh total reducing sugars range between 66.64% to 75.39%. The maximum percentage of TRS found to be 69% to 72% in 62% area. About 72% to 75% TRS was obtained in 35% area. The lower percentage of TRS between 66% to 69% was found only in 3% area. In Rajasthan 99% area of honey samples had TRS between 72% to 75%. Only 0.5% area followed by 0.3% area of Rajasthan had...
TRS between 69% to 72% and 75% to 78% respectively [38-41]. After comparing the three states it was observed that total reducing sugars in honey samples falls between 65% to 78.5%. The mustard honey samples which were harvested from Rajasthan had TRS between 72% to 75% in 99% area. But in case of Uttar Pradesh due to predominance of eucalyptus and mustard (EuM) honey samples TRS varied between 69% to 72%. Due to diverse floral variation obtained in Punjab, 83% area of Punjab had TRS between 72% to 75%. Honey can be classified by the floral source of the nectar from which it was made, most of the natural honey is produced using a particular flora as the main source of nectar for example mustard, eucalyptus and berries.

Sucrose in different honey samples

Sucrose percentage is a minor component in honey varied between 0.45% to 3.0%. About 49% area of Punjab range between 1% to 1.5% followed by 42% area falls between 0.5-1.0 percent. Sucrose percentage ranges between 1.5% to 2%, 2% to 2.5% and 2.5% to 3% in 5%, 2% and 1% area respectively. In Uttar Pradesh, about 66% area of honey samples had sucrose content between 1% to 1.5% and 20% area had sucrose between 1.5% to 2%. Thus the major distribution was between 1% to 2% of sucrose. In Rajasthan, 83% area of honey samples varied between 0.5% to 1% sucrose percentages. Only 16% area of honey samples had sucrose above 1% i.e. 1% to 1.5%. Due to predominance of mustard flora in Rajasthan, it was observed that mustard honey had lower amount of sucrose compare to other floral honeys. After comparing three states, it was observed that sucrose percentage varied between 0.45% to 2% with small number of samples falls between 2% to 3% of sucrose in all three states [42]. The lower percentage of sucrose was in Rajasthan followed by Punjab. The higher percentages of sucrose as compared to Punjab and Rajasthan were in Uttar Pradesh. The created physicochemical map showed the highest means for the analyzed characters in three States (Punjab, Uttar Pradesh and Rajasthan). The lowest sucrose was in one region (Rajasthan) while the highest sucrose in honey samples was in two regions (Punjab and Uttar Pradesh).

Fructose/glucose in different honey samples

Fructose and glucose ratio indicates the degree of crystallization, above 1.0 the samples had lower tendency to crystallize. About 32% area of Punjab honey samples had F/G ratio between 1-1.15. These samples are highly suitable for Indian market due to higher F/G ratio. 64% area of Punjab samples had F/G ratio between 1.05-1.1. Thus in Punjab F/G falls between 1-1.18 and had lower tendency to crystallize. In Uttar Pradesh, due to intermixing of eucalyptus and mustard nectar F/G range between 1.05-1.1 in 79% area of Uttar Pradesh Only 7% area of Uttar Pradesh had F/G falls between 1.1% to 1.15% and 13% area between 1-1.05. Thus Uttar Pradesh honey samples had higher tendency to crystallize. In Rajasthan as depicted in Figures 6 and 7 the lower F/G honey was obtained and had a higher tendency to crystallize. About 46% area of Rajasthan had F/G falls between 0.95-1.0 followed by 31% and 21% area which had F/G between 1-1.05 and 1.05-1.1 respectively. Only 1% area of Rajasthan had F/G above 1.1 i.e., between 1.1-1.15. Thus 99% area of Rajasthan samples had higher tendency for crystallization due to higher amount of glucose and lower proportion of F/G. After comparing three states, the results showed that Punjab honey samples which lower tendency towards crystallization had compared to Rajasthan which had higher tendency for crystallization and Uttar Pradesh honey samples had intermediate crystallization tendency [43-45]. Thus Uttar Pradesh honey samples can be blended with Punjab honey samples to get higher F/G or liquefied honey. The method for physicochemical analysis showed high sensitivity to minor differences between honey quality parameters. It is worth to mention that the method can be used alone or in combination with other statistical methods. After GIS analysis [9], categorization was done by principal component analysis (PCA) by using factor analysis, cluster analysis and linear discriminant analysis.

Conclusion

The result of this study indicated that honey samples derived from...
three different States of India, were of good quality. This is the first study attempted to investigate the physicochemical properties of different regions of Indian honeys elaborately through GIS. The presented model for creating physicochemical maps helps in performing regional and statistical classification. Also, the physicochemical analysis by using the ArcGIS is simple, effective and very sensitive method for detection of the differences between datasets. The transformation of the physicochemical parameters of honey data into raster layers allows the use of the ArcGIS in performing the quality analysis which can be considered as a new trend in quality analysis using geographical software. This method also can be employed for the other quality analysis (biochemical and mineral composition) of honey. Finally, the study highlights the effect of regional flora on the physicochemical composition of honey. The most revealing feature of the study was that mustard honey sample from Kota region of Rajasthan, Eucalyptus honey samples of Uttar Pradesh and multiflora and honey samples of Punjab were unique. These honeys have higher market value due to its limited production and availability. This study also inspires further research to exploit Honey from other regions in India for categorization.

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