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Analysis of physical properties and biochemical components in few honey samples in Southern Karnataka, India

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Abstract
Honey is one of the insect products, produced by different species of honeybees using nectar and pollen from different flowers. Honey shows greater variation in its physical property and chemical composition. India has immense potential for the production of different type of honey in the wild as well as from beekeepers in apiary. Locally available different honey are lacking scientific information on physico-chemical parameters, hence present study was conducted by following the standard methods. The pH, electrical conductivity, specific gravity, absorbance and turbidity in Clover, Jamun, Lychee, Coorg and natural honey exhibited significant variation ($F=29.36$; $P>0.05$) excepting the specific gravity. Moreover, the fructose, glucose, total protein, minerals and moisture content revealed significant difference ($F=83.59$; $P>0.05$) between Clover, Jamun, Lychee, Coorg and natural honey. Further, Calcium, Chromium, Copper, Iron, Magnesium, Manganese, Phosphorus, Potassium, Sodium and Zinc concentration varied significantly ($F=4.81$; $P>0.05$) between these honey samples. All these results clearly indicated that Clover, Jamun, Lychee, Coorg and natural honey are characterized by specific physical property and chemical composition which is depended on geographical location, floral type and honey harvest cum processing methods at wild or domesticated conditions. Hence, locally available honey with different brand names is dissimilar, but with appropriate physical property and chemical composition, which is on par with the international standards and safe for human consumption in southern Karnataka, India.

Keywords: Honey samples, physical and chemical properties, southern Karnataka

1. Introduction
Honey is one of the animal products, produced by honeybees after feeding the nectar and pollen from various flowering plant species. Around 300 different honey types are recorded at various parts of the world and are known for their specific colour, flavor, carbohydrate, protein, mineral and vitamin contents (Yaghoobi *et al*., 2008) [1]. Obviously, there is a greater variation in physical property and chemical composition in different type of honey (Anupama *et al*., 2003, Tchoumboue *et al*., 2007, Anklam, 1998) [2-4]. Accordingly, several type of honey available with variously as unifloral, multifloral and honey with plant name in India and other parts of the world (Basavarajappa *et al*., 2011, Reshma *et al*., 2017) [5, 6]. In India there is a wide scope for the production of different type of honey under wild and domesticated conditions (Bogdanov *et al.*, 2004) [7] from *Apis dorsata, A. laboriosa A. florea* natural colonies and *A. cerana, A. mellifera, Trigona, Tetragona* colonies under domesticated beekeeping activities at different apiaries. The available honey is marketed with different brand names viz., Fssai Branded Honey (FBH), Agmark Branded Honey (ABH), Agmark & Fssai Branded Honey (AFBH), ISO, Agmark & Fssai Branded Honey (ISOAFBH), USDA-Branded Honey (USDA-BH), KVIC Branded Honey (KVIC-BH), Fssai and ISO Branded Honey (F&ISO-BH) and honey without any brand names or trademark (Reshma *et al*., 2017) [6]. Further, honey is also available with different local names viz., Coorg honey, B.R. Hills honey, Puttur honey, Honnavar honey, Malnad honey etc. Furthermore, honey is marketed by prefixing with the plant name as Lychee (honey from *Litchi chinensis*), Clover (honey from *Trifolium hybridum*), Jamun (honey from *Syzygium cumini*) Nilgiri (honey from *Eucalyptus* spp.) and Elachi (honey from *Elettaria cardamomum*) honey at different parts of southern Karnataka. Although, honey is marketed with different nomenclature, however scientific information on physical property, chemical composition of these honey are not available in this part of the state.

Several researchers have published reports on physico-chemical properties of different honey collected from various parts of the world. However, detailed reports on physico-chemical properties of Lychee, Clover, Jamun, Coorg and natural honey (honey from natural colonies of *A. dorsata*) are fragmentary in southern Karnataka (Basavarajappa *et al*., 2011) [5]. International Honey Commission (IHC) has earmarked certain constituents as honey quality parameters namely: the moisture content, electrical conductivity, specific gravity, sugar, protein, minerals and vitamins (Nanda *et al*., 2003) [8]. These characteristics are of great importance to decide the quality and type of honey. Hence, present study was conducted to record the physical properties, chemical constituents in commonly available honey in this part of the State.

2. Materials and methods

Different honey samples such as Lychee (*Litchi chinensis*), Clover (*Trifolium hybridum*), Jamun (*Syzygium cumini*) Niligiri (*Eucalyptus* spp.), Elachi (*Elettaria cardamomum*), Coorg honey (processed honey) and natural honey (honey from *A. dorsata* colonies) were collected from various beekeepers at different parts of southern Karnataka. Collected honey samples were stored in airtight plastic containers to record the physical properties and chemical constituents by following the standard methods.

2.1. Physical properties: The pH was measured by digital pH meter (CL54+, Toshcon Industries Pvt. Ltd. Hardwar) in a solution containing 5g of honey in 95ml of distilled water. The specific gravity of honey = C-A / D-A where, A = Weight of specific gravity of empty bottle, C = Weight of specific gravity of bottle with honey and D = Weight of specific gravity of bottle with water as per the description of Nanda *et al.* (2003) [8]. A solution of 20g dry matter of honey was taken in 100ml distilled water and measured the EC by using a digital electrical conductivity cell at 27^0C to record electrical conductivity. The results were expressed in millisiemens per centimeter as per Bogdanov *et al.* (2004) [7]. The absorbance and turbidity of different honey were determined in Elico Scanning Mini Spec, SL 177 Spectrophotometer as per Basavarajappa and Savanurmath (2001) [9].

2.2. Chemical components: The glucose content was estimated by using GOD/POD method as described by Barham and Trinder (1972) [10], Tenscher and Richterich (1971) [11]. The fructose content was estimated by using Resorcinol-HCl method as described by Ashwell (1957) [12]. Moreover, total protein content was determined by following the method of Lowry *et al*. (1951) [13]. Further, minerals and vitamins were analyzed by following standard methods as per Pratt and Chapman (1961) [14]. Furthermore, the moisture content was measured by using the method as described by Bogdanov *et al.* (2004) [7].

2.3. Statistical analysis: The collected data was analyzed by using windows based statistical package mainly MS EXCEL and ANOVA as described by Saha (2009) [15].

3. Results

3.1. Physical properties in different honey: The pH, electrical conductivity (EC), specific gravity, absorbance and turbidity in different honey are shown in Table 1. The pH was low in Lychee honey (3.96) and it was high in Coorg honey (4.78). However, the pH was 4.00, 4.52 and 4.55 respectively in Clover honey, Jamun Honey and natural honey (Table 1). Similarly, the EC was not alike and did vary considerably between different honeys. The Clover honey recorded lowest EC (0.19mS/cm) and it was high in natural honey and Jamun honey respectively 1.41 and 1.02mS/cm (Table 1). Moreover, the Lychee honey and Coorg honey have shown 0.40 and 0.20 mS/cm EC respectively (Table 1). However, the specific gravity didn't vary much between different honeys. It was almost similar in Clover, Jamun and Lychee honeys (1.4 each) and little less (1.39) in Coorg honey and slightly high (1.42) in natural honey (Table 1). Interestingly, the absorbance and turbidity varied considerably between different honeys. The absorbance was little high in Clover, Jamun and Lychee honey respectively 1.55, 1.52 and 1.50 at 359 nm compared to Coorg and natural honey (Table 1). The absorbance was 1.29 in Coorg honey and 1.28 in natural honey. Moreover, per cent turbidity was very high (6.33) in natural honey and less (3.10) in Clover honey. The Jamun, Lychee and Coorg honey have shown 3.23, 3.41 and 5.7% turbidity respectively (Table 1). Further, analysis of variance between pH, electrical conductivity, specific gravity, absorbance and turbidity exhibited significant variation ($F=29.36$; $P>0.05$) between different honeys (Table 1). It clearly indicated that nectar collected from various flowers by the honeybee species produce honey that show different physical properties which are little specific and helpful while distinguishing the locally available different honeys under wild and domesticated conditions.

3.2. Chemical components in different honeys: The fructose, glucose, total protein, minerals and moisture content in different honey revealed specific values (Table 2). The fructose, glucose and minerals content in Clover, Jamun, Lychee, Coorg and natural honeys show variations considerably (Table 2). Highest (81.16mg/g) fructose was recorded in natural honey and lowest (57.09mg/g) in Lychee honey. However, the fructose content was 67.90, 66.8 and 62.21mg/g recorded respectively in Coorg, Clover and Jamun honey (Table 2). Similarly, the glucose content was also not uniformly distributed among different honeys. It was highest 53.06mg/g in Jamun honey followed by Clover honey (50.77mg/g), Lychee honey (50.58mg/g) and Coorg honey (50.23mg/g). However, natural honey has recorded low quantity (49.01mg/g) of glucose and thus glucose content varied considerably in different honeys (Table 2). Further, the total protein content was not similar among different honey and highest (3.82mg/g) in Lychee honey followed by natural honey (3.65mg/g), Clover honey (3.61mg/g) and almost similar amount (2.5mg/g each) in Jamun honey and Coorg honey (Table 2). Surprisingly, the minerals content varied considerably among different honeys. Minerals content was very high (34.33µg/g) in Clover honey and very less (3.02µg/g) in natural honey (Table 2). However, the minerals content was almost similar (16.01µg/g each) in Jamun and Coorg honey, but little high (19.05µg/g) in Lychee honey and indicated considerable difference (Table 2). Further, moisture content was dissimilar and it was in between 19.5 and 17.5% among different honey. Highest (19.5%) moisture was recorded in Jamun honey and lowest (17.5%) in Clover honey. However, the moisture was almost similar in Lychee, Coorg and natural honey (Table 2). Obviously, the fructose, glucose, total protein, minerals and moisture contents did

significantly differed (F=83.59; *P*>0.05) between Clover, Jamun, Lychee, Coorg and natural honey and indicated specificity in their chemical composition.

3.3. Minerals content in different honeys: Ten minerals such as Calcium (Ca), Chromium (Cr), Copper (Cu), Iron (Fe), Magnesium (Mg), Manganese (Mn), Phosphorus (P), Potassium (K), Sodium (Na) and Zinc (Zn) and their quantity recorded in different honey are depicted in Table 3. The Ca was high (12.97µg/g) in Lychee honey and it was followed by Jamun honey (10.67µg/g), whereas, it was very less (0.61µg/g) in natural honey. However, Clover honey and Coorg honey indicated 8.28 and 5.51µg/g respectively. Average 7.60 ± 1.10µg/g Ca content was recorded in different honeys. Interestingly, the Cr and Cu were almost similar (0.10µg/g) and below detection level in different honeys. The Mg was high (2.68µg/g) in Lychee honey and it was followed by Jamun honey (10.67µg/g), whereas, it was very less (0.61µg/g) in natural honey. The Fe, Mg, Mn, P, Na and Zn contents were less than 3µg/g in different honeys (Table 3). The iron content was more (1.46µg/g) in Jamun honey and it was <1µg in Clover, Lychee, Coorg and natural honeys. Average 0.44 ± 0.26µg/g Fe content was recorded in different honeys. The Mg content was high (2.68µg/g) in Jamun honey compared to Clover honey (0.80µg/g), Lychee honey (0.68µg/g), Coorg honey (0.43µg/g) and natural honey (0.77µg/g). Thus, average 1.07 ± 0.41µg Mg content was recorded in different honeys (Table 3). Interestingly, the Mn content was very less and ranged in between 0.08 to 0.10µg/g with a mean 0.09 ± 0.12µg/g recorded in different honeys. Excepting Coorg honey and natural honey, the P content was >1µg/g recorded in Clover, Jamun and Lychee honeys. In general, the mean value of phosphorous content was 0.77 ± 0.35µg/g in different honeys. The Zn content was very less and it was ranged between 0.09 to 0.28µg/g with a mean of 0.14 ± 0.14µg/g in different honeys. However, Na and K contents were more compared to other minerals. The Na content was high (6.31µg/g) in Coorg honey and it was followed by 3.56, 3.52 and 2.97 µg/g in Lychee, Jamun and Clover honeys respectively. However, Na content was very less (0.25µg/g) in natural honey. Average 3.32 ± 0.72µg/g Na was recorded in different honeys. Interestingly, the K content was very high (20.44µg/g) in Clover honey compared to other honey. The K content was 8.31, 3.32 and 3.09µg/g respectively in Jamun, Litchi and Coorg honeys. However, it was less (0.82 µg/g) in natural honey. Average 7.19 ± 1.07µg/g K content was recorded in different honeys (Table 3). Further, statistical analysis (ANOVA) of different minerals did exhibit significant difference (F=4.81; *P*>0.05) between Clover, Jamun, Lychee, Coorg, natural honey and indicated specificity in their minerals composition (Table 3).

4. Discussion

Honey is one of the important international commodities, regular analysis is essential to maintain its quality standards as per Codex (2009) [16]. Honey produced by honeybees using single flora viz., Lychee (*Litchi chinensis*), Clover (*Trifolium hybridum*), Jamun (*Syzygium cumini*) Niligiri (*Eucalyptus* spp.), Elachi (*Elettaria cardamomum*) etc, show light to dark colour, whereas the natural honey and processed honey is usually light brown to dark brown in colour. Obviously, light and dark coloured honey samples exhibit variation in their physical and biochemical characteristics (Anupama *et al*., 2008 [2], Tchoumboue *et al*., 2007) [3]. The pH, electrical conductivity, specific gravity, turbidity and moisture contents are important physical parameters considered as important factors while certifying the honey quality as per Codex (2009) [16]. These parameters were exhibited significant difference among Lychee, Jamun, Clover, Coorg and natural honey collected from different parts of southern Karnataka. Honeybees collect pollen and nectar to produce honey from different flora which is grown at different geographical areas, where they experience varied climate. Perhaps, varied pedological parameters of different geographical areas, prevailed temperature, moisture and rainfall conditions might have influenced the locally grown flora to produce pollen and nectar with specific physical parameters and chemical composition. Accordingly, the carbohydrate, protein, minerals, vitamins, few organic acids and enzymes content are dissimilar in the nectar of various plant species grown amidst different geographical areas which experience different climate (Anklam, 1998, Saxena *et al*., 2010) [4, 17]. However, processed honey or natural honey (honey from *A. dorsata* colonies) is dark in colour and contains pollen grains and more beeswax particles (Rao, 1998) [18] compared to the honey produced from single flora. During the present investigation, recorded pH was in between 3.96 to 4.55, which is little less but, near to the range as prescribed by Codex (2009) [16]. Similar types of observations were made by Nanda *et al.* (2003) [8], Muli *et al.* (2007) [19], Juszczak *et al.* (2009) [20], Saxena *et al*. (2010) [17] in *Apis* and *Trigona* species honey. Moreover, Oddo *et al.* (2005) [21], Terrab *et al*. (2004) [22], Corbella and Cozzolino (2006) [23], Ahmad *et al.* (2007) [24], Feas *et al*. (2010) [25], Gomes *et al.* (2010) [26], Basavarajappa *et al.* (2011) [5], Idris *et al.* (2011) [27], Habib *et al.* (2014) [28], El Sohaimy *et al.* (2015) [29] have reported similar type of results in different type of honey samples. Further, pH in honey is depended on various factors such as floral source, nectar and pollen contents (Thrasyvoulou and Manikis 1995) [30], Conte *et al*. (1998) [31], Khalil *et al*. (2001) [32], Muli *et al.* (2007) [19] are related with honey storage and microbes contamination that commonly happens during transport from the site of collection to the hive. It could bring changes in the texture and quality in honey (Feas *et al*. 2010) [25]. Further, adulteration may bring pH variation (Da Silva *et al*. 2016) [33]. Perhaps, all these conditions which occur spontaneously at different geographical regions under natural ecosystem might have influenced the pH variation in different honeys. Several researchers have recorded EC in different honey samples in India and other parts of the world and it was in between 0.49 and 1.98 mS/cm (Oddo *et al*., 2004) [21], Terrab *et al*. (2004) [22], Sahinler and Gul (2004) [34], Guler *et al*. (2007) [35], Adenekan *et al*. (2010) [36], Kaskoniene and Venskutonis (2010) [37], Saxena *et al.* (2007) [17], Basavarajappa *et al.* (2011) [5], Idris *et al*. (2011) [27], Alqarni *et al*. (2014) [38], El Sohaimy *et al*. (2015) [29], Da Silva *et al*. (2016) [33]. However, in the present analysis, the EC was in between 0.20 to 1.41mS/cm in different honey samples and it is par with the EC values prescribed in Codex (2009) [16]. Since, EC is considered as a good benchmark for the honey source, regularly checked for minerals content (Adenekan *et al*., 2010) [36]. It helps detect the honey samples which show different minerals composition (Guler *et al*. 2007) [35] and specific minerals content Sahinler and Gul (2004) [34]. Hence, it is considered as a useful tool for classifying honeys as well help determines the botanical origin and geographical origin of honey (Acquarone *et al*., 2007) [39], because EC is closely related with the concentration of minerals, organic acids and

proteins of honey (Kaskoniene and Venskutonis 2010) [37].

The specific gravity is another physical parameter, used to determine honey quality (Rehman, *et al*., 2008) [40]. Singh and Bath (1997) [41], Khalil *et al*. (2001) [32], Gidamis *et al*. (2004) [42], Tumin *et al.* (2005) [43], Ahmad *et al*. (2007) [24], Chanchao (2009) [44], Ouchemoukh *et al*. (2007) [45], Saxena *et al*. (2010) [17] have analyzed the specific gravity and recorded in between 1.33 and 1.56 g/cm² in different honey samples collected from various parts of the world. During the present investigation, 1.4 g/cm² specific gravity obtained in different honey samples excepting Coorg honey and this indicated not much variation in specific gravity and it is near to the earlier published reports. Similar types of observations were reported by Khalil *et al*. (2001) [32], Nanda *et al*. (2003) [8] and Basavarajappa *et al.* (2011) [5] in different honey samples. Further, the absorbance was in between 1.28 to 1.55 in different honey and it is little less compared to earlier reports. Basavarajappa *et al*. (2011) [5] have recorded the absorbance in multifloral honey collected from arid, semi-arid and malnad regions of Karnataka respectively 2.63, 2.17 and 1.88. Absorbance is considered as a vital parameter for honey trade. Indeed, absorbance measurement is used to reveal the colour of honey and in turn help distinguish the honey status (i.e., fluid state or crystal state) or origin Juszczak *et al*. (2009) [20] or as unifloral and multifloral honey. Accordingly, colour varies greatly between different honeys which is influenced by the flora, geographical region and prevailed local climate (Tchoumboue *et al*., 2007 [3], Muli *et al.,* 2007) [19]. Furthermore, turbidity indicates the honey colour that indirectly helps identify the quality and status of honey. Obviously, turbidity is not alike in between different honeys. During the present investigation, Clover, Jamun, Lychee honey showed less turbidity (3.10 to 3.41%) compared to Coorg and natural honey (5.7 to 6.33%) and it was more compared to earlier reports in this part of the state. Basavarajappa *et al*. (2011) [5] have recorded 0.27% turbidity in the honey collected from semi-arid region followed by the honey of malnad region (0.24%) and arid region (0.22%). Singh and Bath (1997) [41] have recorded 0.82 to 1.65% turbidity in Indian unifloral honey. Turbidity was highest in multifloral honey due to the presence of more pollen grains and beeswax particles (Rao, 1998) [18] and makes honey more turbid. As it is one of the indicators of honey color, its analysis help identifies the honey type. Changes in color might be attributed to beekeeper intervention and honey comb handling methods, use of old wax combs for producing honey, adulteration and exposure to high temperature or light (Moniruzzaman *et al*., 2013) [46].

Honey contains fructose and glucose as major carbohydrates (Nanda *et al*., 2003) [8]. The fructose content was in between 57.09 to 81.16mg/g with a mean 67.04 ± 3.27mg/g, whereas the glucose was in between 49.01 to 53.06mg/g with a mean 50.73 ± 2.84mg/g in different honey samples and thus the glucose content was less compared to fructose. Similar type of observations was reported by Williams *et al*. (2009) [47]. The fructose and glucose are easily digestible and supply substantial energy (Kamal *et al*., 2002) [48] and more fructose help maintain fluidity in the honey. Similar types of observations were made by Manzoor *et al*. (2013) [49], Buba *et al.* (2013) [50], Da Silva *et al*. (2016) [33]. Since, the wide variation in fructose and glucose contents is directly related with the floral sources from which the nectar and pollen are gathered by honeybees to make honey. The different weather conditions which could influence the growth of different plant species, naturally they produce flowers with nectar of specific chemical composition (Anklam, 1998, Nanda *et al*. 2003, Juszczak *et al*., 2009, Manzoor *et al*., 2013, Buba *et al*., 2013, Da Silva *et al*., 2016) [4, 8, 20, 49, 50, 33]. Perhaps, this might be one of the main reasons for substantial variation in fructose and glucose contents in different honey samples. Hence, fructose and glucose contents in honey matters much, their analysis help reveal the comestible quality of honey. The protein is less in honey compared to carbohydrates; total protein content was in between 2.56 to 3.82mg/g and varied considerably between different honeys. However, the mean total protein content was 3.25 ± 0.72mg/g recorded in different honeys. Generally, Indian honey contains <5mg/g protein (Anklam, 1998) [4]. Khalil *et al*. (2001) [32] have recorded 0.69 to 0.74mg/g protein content in unifloral honey and it was little less compared to earlier reports. Similarly, Chanchao (2009) [44] has recorded 1.6mg/100g in multifloral (*A. dorsata*) honey. Saxena *et al*. (2010) [17] have recorded 0.8 to 2.2mg/g in commercial brand honey. However, honey collected from arid, semi-arid and malnad regions in south-western Karnataka showed very low level of proteins (1.68 and 3.11 mg/g) (Basavarajappa *et al*., 2011) [5]. All these observations indicated the considerable variation in protein content of honey. It differs among various honey samples derived from different *Apis* species. *A. cerana* honey contains 0.1 to 3.3% protein, while *A. mellifera* honey contains 0.2 to 1.6% protein (Won, *et al*., 2009) [51]. Thus, honey produced by different honeybee species should also be considered while assessing the protein content. Further, natural honey exhibit low level of proteins (Juszczak *et al*., 2009) [20], which is depended on the local flora (Saxena *et al*., 2010) [17] availed by the honeybees during their foraging. Therefore, total protein content analysis could help identify the geographical origin of honey (Mohammed and Babiker, 2009) [52]. Perhaps, all these conditions might have altered the quantity of total proteins in unifloral and multifloral honey samples collected from southern Karnataka.

The minerals content is important index in honey samples. On an average 17.68 ± 1.68µg minerals were recorded in different honeys. However, the mineral composition was dissimilar; it was in between 3.02 to 34.33µg and did vary considerably between different honeys. During the present investigation, ten minerals were recorded in honey samples and their concentration varied significantly between different honeys. The minerals such as calcium (Ca), iron (Fe), magnesium (Mg), sodium (Na) and potassium (K) enhance the nutritional value of honey and hence considered as potential indicator to identify the geographical origin of honey (Alqarni, *et al*., 2014) [38]. Nevertheless, the mineral content is not a quality parameter (Codex, 2009) [16], however, it helps to distinguish the botanical origin of honey. Habib *et al*. (2014) [28] have analyzed more quantity of K, P, Ca and Na, while Mg, Fe, Zn and Cu were recorded low quantity in honey samples derived from arid regions of United Arab Emirates. However, the Mn and Cr content was 0.01 mg/ml (Below Detection Limit). Mohammed and Babiker (2009) [52], Batista *et al*., (2012) [53] have reported similar type of observations in Turkey and Brazil. Some minerals were found in very small quantity and were below detection limit (BDL). The results indicated that K was the predominant mineral followed by Ca, Na, Mg, Fe, P, Mn and Zn. The Cr and Cu were below detection level. These results are in agreement with the previous studies made by Vanhanen *et al.* (2011) [54]. Vanhanen *et al*. (2011) [54], Boussaid *et al*. (2013) [55] have

reported the mineral contents in honey samples collected from New Zealand, Tunisia and Hungary. The concentration of minerals ranged from 62.4 to 1158 mg/kg in unifloral honey and 372 mg/kg in forest honey (Boussaid *et al*., 2013) [55]. In India, Conte *et al*. (1998) [31], Nanda *et al.* (2003) [8] have recorded high quantity of calcium, sodium, potassium, zinc, iron and copper in different honey. Czipa, *et al.* (2015) [56], Bogdanov *et al*. (2007) [57] have recorded higher concentration of cadmium, chromium, manganese, iron, copper and zinc in both multifloral and unifloral samples. Hence, all these observations clearly indicated that minerals content is dissimilar and influenced by the local flora on which honeybees depended for their forage. Further, moisture content didn't vary much between different honey samples and fulfilled the requirement of international standards as per Codex (2009) [16]. Although different honeybee species share common foraging ground, the frequency of visits to specific flora, the quantity of nectar and pollen collected by these bee species for honey production varies greatly. Accordingly, there is a variation in physico-chemical characteristics and hence different honeys available in the nature.

Table 1: Physical properties of different honeys in southern Karnataka

Sl. No.	Physical properties	Clover Honey	Jamun Honey	Lychee Honey	Coorg Honey	Natural Honey	Mean ±SD	'F' value
1.	pH	4.00	4.52	3.96	4.78	4.55	4.36 ± 0.83	29.36 S (P>0.05)
2.	Electrical Conductivity (mS/cm)	0.19	1.02	0.40	0.20	1.41	0.64 ± 0.32	
3.	Specific gravity (g/cm^2)	1.40	1.40	1.40	1.39	1.42	1.40 ± 0.47	
4.	Absorbance at 359 nm	1.55	1.52	1.50	1.29	1.28	1.42 ± 0.47	
5.	Turbidity (%)	3.10	3.23	3.41	5.70	6.33	4.35 ± 0.83	

Note: Each value is a mean of five observations.
S: Value is significant; NS: Value is note significant.

Table 2: Chemical properties of different honeys in southern Karnataka

Sl. No.	Chemical properties	Clover Honey	Jamun Honey	Lychee Honey	Coorg Honey	Natural Honey	Mean ±SD	'F' value
1.	Fructose conent (mg/g)	67.90	62.21	57.09	66.86	81.16	67.04 ± 3.27	83.59 S (P>0.05)
2.	Glucose content (mg/g)	50.77	53.06	50.58	50.23	49.01	50.73 ± 2.84	
3.	Total Protein content (mg/g)	3.61	2.56	3.82	2.56	3.65	3.25 ± 0.72	
4.	Minerals content (µg/g)	34.33	16.01	19.05	16.01	3.02	17.68 ± 1.68	
5.	Moisture (%)	17.50	19.50	18.30	18.60	18.90	18.56 ± 1.72	

Note: Each value is a mean of five observations.
S: Value is significant; NS: Value is note significant.

Table 3: Mineral components in different honeys in southern Karnataka

Sl. No.	Minerals (in µg)	Clover Honey	Jamun Honey	Lychee Honey	Coorg Honey	Natural Honey	Mean ±SD	'F' value
1.	Calcium (Ca)	8.28	10.67	12.97	5.51	0.61	7.60 ± 1.10	4.81S (P>0.05)
2.	Chromium (Cr)	0.10	0.10	0.10	0.10	0.10	0.10 ± 0.00	
3.	Copper (Cu)	0.10	0.10	0.10	0.10	0.10	0.10 ± 0.00	
4.	Iron (Fe)	0.21	1.46	0.31	0.13	0.10	0.44 ± 0.26	
5.	Magnesium (Mg)	0.80	2.68	0.68	0.43	0.77	1.07 ± 0.41	
6.	Manganese (Mn)	0.10	0.08	0.08	0.10	0.10	0.09 ± 0.12	
7.	Phosphorus (P)	1.05	1.02	1.59	0.14	0.07	0.77 ± 0.35	
8.	Potassium (K)	20.44	8.31	3.32	3.09	0.82	7.19 ± 1.07	
9.	Sodium (Na)	2.97	3.52	3.56	6.31	0.25	3.32 ± 0.72	
10.	Zinc (Zn)	0.28	0.09	0.13	0.10	0.10	0.14 ± 0.14	

Note: Each value is a mean of five observations.
S: Value is significant; NS: Value is note significant.

5. Conclusion

Honey is one of the nutritionally rich foods, produced by honeybee species and processed under human control before it is being marketed for domestic use. The physical properties and chemical composition in different honey samples indicated variations which are statistically significant and suggested that honey produced form different geographical regions are different. Every geographical region is characterized by specific flora and local climate, which could directly or indirectly, influences the local flora to produce nectar and pollen with specific concentration of carbohydrates, proteins and minerals which are species specific. Obviously, honey collected from different geographical regions exhibit different physical and chemical properties and hence different type of honey with unique traits could be observed at different parts of southern Karnataka. Results of the present investigation help check the physical parameters and chemical constituents which are necessitated ensuring quality for human consumption. Hence, regular analysis of different honey is essential to avoid the chances of contamination during harvesting, transportation and processing of honey under man-made environment.

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