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PHYSICAL CHARACTERISTICS OF MULTIFLORAL HONEY OF *APIS DORSATA* F. AND *APIS* CERANA *INDICA* FROM WESTERN GHATS OF KARNATAKA

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ABSTRACT
Multifloral honey of indigenous honeybee species, giant honeybee *Apis dorsata* and Indian hivebee *Apis cerana indica* from four districts of Western Ghats of Karnataka were determined during June 2010 to May 2011. Physical characteristics of moisture, viscosity, surface tension, optical density and refractive index were identified. Honey of *A. dorsata* display more moisture (23.55%), viscosity (78.41poise) and surface tension (108.56 dynes/cms) from Hassan and least of moisture (21.45%), viscosity (70.38poise) and surface tension (98.75 dynes/cms) from *A. cerana* in Madikeri. Optical density (0.54) was least for *A. cerana* honey from Chickamagalur and highest of 0.67 in *A. dorsata* honey from Dakshina Kannada. Refractive index (1.4832) was greatest for *A. cerana* honey from Madikeri and 1.4701 for *A. dorsata* honey from Hassan. The study confirms correlation among moisture, viscosity and surface tension of honey from honeybee species from geographical regions of Western Ghats. Variations occur in optical density of honey within honeybee species from different areas of Western Ghats. Refractive index of honey within honeybee species is inversely proportional to moisture. Apart from optical density and refractive index of honey all parameters tested were statistically significant at $p < 0.01$. Results of the study confirmed the quality of honey of *A. cerana* and *A. dorsata* were equally good in the physical compositions which are discussed in ensuing paper.

INTRODUCTION

Honeybees and flowers are classical examples of mutualism and co-evolution. Honeybees are bioindicators of environment. Honeybees are eusocial hymenopterans which are reliant on floral wealth like nectar and pollen. Nectar is dilute sugar-solution secreted by floral glands termed as nectaries. The amount of honey produced from the nectaries depends on the total quantity of nectar secreted and the sugar concentration of the nectar (Singh and Kanaujia, 2003). Nectar consists of ions, organic acids, terpenes, alkaloids, flavonoids, glycosides, vitamins, phenolics, volatile oils, and amino acids which are apparently found in honey. Because of this unique and complex composition, honey acquire position as antiseptic, laxative, antibiotic, pacifier, anti-oxidant and ingredient of variety of pharmaceutical, bakery, cosmetics, confectionary, and tobacco industry. Honey is truly remarkable product elaborated by honeybees to high-density and high-calorific food (Crane, 1990). Since times immemorial honey and milk are considered as symbol of prosperity and sanctity. Honey besides milk, curd, sugar and ghee are essential ingredients of panchamrutha, food offerings to God and religious ceremonies. Honey is as nectar gathered, modified, stored and sealed by honeybees in well planned and architected hexagonal comb cells.

Hitherto the quality of temperate honey of *A. mellifera* including its composition and physico-chemical properties has been well-known. On the contrary, information on composition of tropical honey is limited (Khatija and Ramanujan, 1993; Chunneja *et al.*, 1996; Shripad and Rangaswamy, 2001; Balasubramanyam and Reddy, 2011). Interestingly, no information is available on the composition including the physical characteristics of indigenous honeybee species of Western Ghats of Karnataka. The primary objective of the present study is to provide comprehensive information on the physical characteristics of honey of two indigenous honeybee species, *A. dorsata* and *A. cerana* from selected areas of Western Ghats of Karnataka.

MATERIALS AND METHODS

Study area

karnataka state extends from 11º5 N to 19ºNL and from 74ºE to 78ºEL. It lies in Deccan plateau with three major physical divisions' viz., coast, malnad and maidan. The total geographical area of the State is 1, 91,791 km^2, of which 54.70 % as net sown area, 16.14% forests, 10.66% not available for cultivation, 9.55% uncultivated land and 8.96% fallow land. The flora of Karnataka is rich and diversified, which includes agricultural, plantation, commercial, horticultural and forest flora. The temperature varied from 11ºC to 41ºC and the humidity ranges from 27.7% to 86.45%.

Western ghats

The Western Ghats popularly well-known as Sahyadri Hills are formed by the Malabar Plains and succession of mountains running parallel to Indian West Coast. Western Ghats covers

a large area from Southern region (Agastyamalay range to Kalakkad Mundantorai Hill ranges) to Gujarat (Surat Dings) in the North. The entire hill range is divided into three regions namely Southern Western Ghats (Kalakkad Mundantorai to Palghat), Central Western Ghats (Nilgiri- Wyanaad to Goa) and Northern Western Ghats (Northern Goa, Rathnagiri, Amboli to Dings in Gujarat). Western Ghats supports innumerable genera of Arthropoda including wild and domesticated honeybee species due to variety of forest, plantation, horticultural and agricultural bee flora which yield pollen and nectar throughout the year which are pre-requisite for survival, propagation and honey production in these regions.

Honey collection

Three study centres from each of four districts spreading over the Western Ghats were selected for honey samples collection *A. dorsata* and *A. cerana* from Madikeri, Dakshina Kannada, Hassan and Chickamagalur districts spreading over the Western Ghats of Karnataka. The study centres include Bhagamandala, Napoklu, Virajpet from Madikeri, Puttur, Sulya, Beltangadi from Dakshina Kannada, Sakaleshpur, Arekere, Arasikere from Hassan, and Balehonnur, Koppa, Mudigeri from Chickamagalur districts spreading over prime locality of Western Ghats of Karnataka. Abundant floral resources coupled with suitable environmental factors are mainly responsible for copious honey production in these regions. Honey samples of domesticated hive bee, *A. cerana* were collected from the beekeepers and that of the rock bee, *A. dorsata* was procured from tribals and honey hunters. The honey of *A. cerana* was extracted by honey extractor and that of *A.dorsata* was obtained by squeezing and filteration. All honey samples were raw and unprocessed. The honey sample size from each study centre was 20.

Preparation of honey samples

The honey samples were collected in sterilized polythene bottles from the place of honey extraction. The honey was filtered through single thickness fine cloth to remove suspended particles like dirt, beeswax and other impurities. Later it was stored in airtight container at room temperature under hygienic conditions.

Analysis of honey samples

Physical characteristics of moisture, viscosity, surface tension, optical density and refractive index were determined by the method followed by Balasubramanyam (2006).

Statistical analysis of Data

Data of the four physical characteristics of honey samples was analyzed by F-test. The analysis of variance (ANOVA) along the F-test was calculated and significant levels were determined using F-table ($p < 0.01$and $p < 0.05$).

RESULTS AND DISCUSSION

The moisture content of honey samples had a value of 21.45% to 23.55% in *A. cerana* and *A. dorsata* from Madikeri and Hassan respectively (Table 1, 4). The analysis of variance of moisture levels of honey from two honeybee species was significant at 1% level. Ahmed *et al*. (2007) reported moisture content to 20.12 ± 2.66% and 21.51± 2.38% in *A. cerana* and *A. dorsata* honey respectively. The moisture levels are one of most crucial parameter of honey which affects the optical density, refractive index, surface tension and viscosity (Oddo *et al.,* 1995). Sharma (1998) reported that moisture level of autumn honey was more than summer honey. Honey is an excellent hygroscopic product and has tendency to absorb atmospheric moisture and thus readily increase its moisture levels. Further, exceptionally high moisture content in *A.dorsata* honey is mainly due to unhygienic methods of honey extraction. The moisture levels may also largely depend on method of extraction of honey which may differ from region, species and practices. The moisture level of *A.dorsata* honey was highest which varied from 20.9 and 23.4% from Western Ghats and hills respectively (Balasubramanyam and Reddy, 2003).

Viscosity of *A.cerana* honey had a value of 70.38 poise of Madikeri and viscosity of *A.dorsata* honey was 78.41 poise of Hassan (Table 1, 4). The analysis of variance of moisture levels of honey from two honeybee species was significant at 1% level. Viscosity of honey also depends on the nature of nectar. The viscosity of honey is mainly due to high sugar concentration (White, 1975). Viscosity is measure of the resistance of fluid to flow caused by internal friction, which results in different rates of flow in different parts of the liquid, denoted by h (eta). Viscosity of honey samples decrease with the increase in temperature. Summer honey samples had more viscosity than autumn honey. Higher viscosity of honey causes severe problems during straining, processing and storage. The present study show that higher water content of *A.dorsata* honey resulted in viscosity and high surface tension. The viscosity of honey of unsealed honey cells was 34.77poise, while the honey of sealed honey cells was 76.94 poise. Surface tension of *A.cerana* honey was 98.75 dynes/cms from Madikeri and that of *A.dorsata* honey had a value of 108.56 dynes/cms from Hassan (Table 1, 4). The analysis of variance of moisture levels of honey from two honeybee species was significant at 1% level. Surface tension of surface honeys had a mean value of 108.87 dynes/cms ± 1.8 S.E, while bottom honey

Table 1: Chemical characteristics of honey[#] from Madikeri of Western Ghats of Karnataka

Parameters	Honeybee species		F-ratio
	A. dorsata	*A. cerana*	
Moisture (%)	23.04	21.45	5.33*
Viscosity (Poise)	76.35	73.83	2.76*
Surface tension (dynes/cms)	105.90	100.07	16.55*
Optical density	0.61	0.55	0.21[+]
Refractive index	1.4712	1.4832	0.0034 [+]

[#] Sample size = 20; * Significant at $p < 0.01$; [+] Non-significant at $p < 0.01$

Table 2: Chemical characteristics of honey[#] from Dakshina Kannada of Western Ghats of Karnataka

Parameters	Honeybee species		F-ratio
	A. dorsata	*A. cerana*	
Moisture (%)	22.03	21.73	6.73*
Viscosity (Poise)	76.64	74.30	1.90*
Surface tension (dynes/cms)	107.88	99. 79	8.03*
Optical density	0.67	0.57	0.30[+]
Refractive index	1.4793	1.4822	0.0022 [+]

[#] Sample size = 20; * Significant at $p < 0.01$; [+] Non-significant at $p < 0.01$

Table 3: Chemical characteristics of honey# from Chickamagalur of Western Ghats of Karnataka

Parameters	Honeybee species		F-ratio
	A. dorsata	*A. cerana*	
Moisture (%)	22.90	21.67	1.13*
Viscosity (Poise)	77.09	73.87	4.07*
Surface tension (dynes/cms)	106. 05	102.87	5.44*
Optical density	0.60	0.54	0.098+
Refractive index	1.4753	1.4820	0.0067 +

Sample size = 20; * Significant at $p < 0.01$; + Non-significant at $p < 0.01$

Table 4: Chemical characteristics of honey# from Hassan of Western Ghats of Karnataka

Parameters	Honeybee species		F-ratio
	A. dorsata	*A. cerana*	
Moisture (%)	23.55	21.55	4.09*
Viscosity (Poise)	78.41	70.38	2.67*
Surface tension (dynes/cms)	108.56	98.75	15.40*
Optical density	0.64	0.58	0.098+
Refractive index	1.4701	1.4830	0.0067 +

Sample size = 20;* Significant at $p < 0.01$; + Non-significant at $p < 0.01$

samples had slightly lower surface tension having mean value of 107.97 dynes/cms ± 1.63 (Joshi *et al.*, 2000). Surface tension is film-like tension on the surface of honey that is caused by the cohesion of its sugars and other constituents, which has the effect of minimizing its surface area. Generally honeys with higher water levels have higher surface tension than honeys with lower water levels (Crane, 1992).

Optical density of *A.dorsata* honey had a value of 0.67 from Dakshina Kannada and *A.cerana* honey was 0.54 from Chickmagalur (Table 2, 3). The analysis of variance of optical density levels of honey from two honeybee species was not significant at 1% level. The optical densities of all honey samples are laevorotatory because of high levels of laevulose. The O.D of three different ecosystems ranged from 0.38 to 0.77 (Balasubramanyam, 1999). Fresh and lighter honeys have less O.D compared to dark and stored honey samples. Generally, lighter honeys have more consumer demand than darker honey (Wakhle, 1997). Colors of honey vary from pale yellow to dark brown. Colour variation of honey is entirely due to presence of pigments in the nectar like carotenoids, pinocembrin, xanthophylls and anthocyanin. Color variation changes the flavor and aroma of honey, which in turn depends on floral sources. In general, light floral honeys are mild in flavor than darker honey. Heating of honeys results in the considerable damage to optical density. Honey should be heated indirectly by hot water or air in order to retain the original colour and flavour.

Refractive index of *A.cerana* honey was 1.4832 from Madikeri and *A.dorsata* honey had a value of 1.4701 from Hassan (Table 1, 4). The analysis of variance of refractive index of honey from two honeybee species was not significant at 1% level. Refractive index is the measure of ratio of velocity of light in free space to that of honey. Similar results were reported by Vit *et al.* (1994) in Venezuelan honeys where the refractive index was 1.499. Further, results suggest that all physical and chemical characteristics of honey differ with variations in refractive index. Refractive index increases due to the presence of sugars like laevulose and dextrose besides minerals and amino acids in honey samples. There is no significant correlation between refractive index of honey and altitude (Soni, 1993). Lesser refractive index indicates higher moisture content and higher refractive index denotes lower moisture content of honey (Poncini and Wimmer, 1983). Tidle and Payawal, (1992) reported that slight decrease in refractive index due to rise in temperature of 20ºC.

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