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Physico-chemical characterization of local honey collected from different villages in northern hill zone of Chhattisgarh

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Abstract
The present study was undertaken to determine the physico-chemical properties of bee-honey obtained from different villages of Northern Hill of Chhattisgarh region during 2017-18. The 14 honey samples were analyzed for their quality parameters *i.e*., moisture, pH, total soluble solids (TSS), ash, colour, specific gravity, viscosity, Hydroxymethylfurfural (HMF), total reducing sugars (TRS), fructose, glucose and sucrose. The result showed that the quality parameters of 14 honey samples were recorded within acceptable ranges of moisture, pH, total soluble solids (TSS), ash, color, specific gravity, viscosity, Hydroxymethylfurfural (HMF), total reducing sugars (TRS), non-reducing sugar, glucose, fructose and sucrose with values of 18.27-24.64%, 3.71-5.13, 76.02-81.72%, 0.18-0.44%, 0.32-3.91mPfund, 1.37-1.47g/cm^3, 2.80-3.30cPoise, 5.52-37.88 mg kg^{-1}, 65.52-70.99%, 2.35-5.59%, 32.67-36.75%, 35.40-38.45% and 2.47-5.88%, respectively. Based on sucrose content, only 13 honeys sample *i.e*. Bhitthikala, Rampur Lodhima, Ranpur, Mendrakala, Mangari, Sitapur, Devgarh, Lamgaon, Mudesa, Amgaon, Sukhari, Ajirma (RMD -I) and Ajirma (RMD-II) were found accepted level with minimum (2.47-5.01%) sucrose, except Ajirma (KVK) honey which was recorded higher percentage of (5.88) sucrose. Apart from that, in the analysis of quality parameters, all honey samples satisfied the allowable limit as adherence to Indian Standard. High sucrose content in the honey sample may be due to early harvesting as sucrose is not converted to glucose and fructose. The study indicated that the honey samples had good quality and will be important for the commercialization of regional honey.

Keywords: Quality analysis, local honey, northern hill, Chhattisgarh

Introduction
Beekeeping plays an important role in Indian economy, as it directly impacts agricultural sector through pollination. As per report published for the year 2019-20 by the Ministry of Agriculture and Farmer's Welfare, Govt. of India, the total geographical area of India is 328.7 million hectares, out of which 198.4 million hectares is the gross cropped area and 140.1 million hectares is the net sown area (source: http://agricoop.nic.in/ sites/default/ files/Annual rpt 2016-17 E.pdf). As per an estimate, it requires approximately 50 million honey bee colonies to pollinate this crop area, but we have only 30 lac bee-colonies in our country (source: http://pib.nic.in/newsite/printrelease.aspx?relid). India has huge potential of natural and cultivated vegetation that have great possibilities for beekeeping. Five species of honeybees are commonly recognized *i.e*. rock bee (*Apis dorsata*), Indian bee (*Apis cerana indica*), little bee (*Apis florea*), stingless bee (*Tetragonula* sp.) and European bee (*Apis mellifera*). Among these five, only *Apis cerana indica* and *Apis mellifera* are domesticated by bee farmers (Akratanakul, 1990) [1].

India is an important honey producer, in the financial year 2015–16 about 38177.08 metric tons natural honey worth of Rs. 705.87 Crore (US $110.20 Million) have been exported to the world as reported by Agricultural and Processed Food Products Export Development Authority (APEDA), Government of India. The export of natural honey from India, has recorded 32% growth, in the financial year 2015–16. The major states of honey production in India are Punjab, Haryana, Rajasthan, Himachal Pradesh, Uttar Pradesh, Bihar, Tamil Nadu and West Bengal.

The physic-chemical analysis of honey is important to the honey industry, as these factors are intimately related to storage quality, granulation, texture, flavor, and the nutritional and medicinal qualities of honey. In Surguja district of Chhattisgarh state, the consumption of honey as food has increased considerably in recent years due to changing trends.

Unfortunately, no any data is available on the potentially physical and chemical properties of honeys produced in different localities of this region. Therefore, the present study was carried out to provide information on the some physico-chemical properties of various honey samples collected from different villages in northern hill region of Chhattisgarh by using different honey analysis tests *viz.*, moisture, pH, ash content, color, viscosity, HMF and reducing sugar contents. These determinations are highly useful for determining the quality of honey, which is needed for medicinal treatment and international trade.

Materials and Methods

Sample collection and preparation

Fourteen (14) honey samples were collected from the apiary of RMD CARS Ambikapur, KVK Ambikapur and from beekeepers of adjoining villages of Northern Hill Zone of Chhattisgarh. Honey samples from each village were collected and stored in clean glass bottles and tightly sealed. The tightly sealed bottles containing the samples were delivered to the lab for analysis. The study covers the physico-chemical characterization *i.e.* Moisture, pH, Total Soluble Solids (TSS), Ash, Color, Specific gravity, Viscosity, HMF, Reducing sugar, Non-reducing sugar, Glucose, Fructose and Sucrose of local honey as per method described by AOAC (1990:2000) [5, 4] and others.

1. Determination of Moisture

The moisture of honey was determined by measuring 10 g of each honey sample putting in a flat dish and dried in the hot air oven at 105ºC for three hours. It was then covered, cooled in desiccators and weighed. The sample was re-dried for one hour in the oven, cooled and reweighed. The process was repeated at one hour during intervals until a constant weight was obtained (William *et al.* 2009) [30]. Now weight of the dish was recorded to obtain the final weight.

$$\text{Moisture content (\%)} = \frac{M_1 - M_2}{M_1 - M_0} \times 100$$

Where

M_0 = Weight of dish
M_1 = Weight of the fresh sample + dish
M_2 = Weight of the dried sample + dish

2. Determination of pH

The pH of honey was determined according to the method described by the AOAC, (1990) [5]. Ten grams of each honey sample were diluted with 75ml distilled water. The pH was measured using a digital pH meter which was calibrated at room temperature using buffer solutions at pH 4 and 7.

3. Determination of Total Soluble Solids (TSS)

Total Soluble Solid (TSS) content of the honey samples was estimated by the Abbe's hand refractometer method. The hand refractometer (Model - Erma Tokyo) with ranges of 58 – 92% first standardized. The prism was then washed with distilled water and dried off with a soft tissue. A drop of honey sample was placed on the hand refractometer prism and the reading was noted.

4. Determination of Ash

The ash content was determined as per the procedure described by Association of Official Analytical Chemists (1990) [5] accordingly accurately 5g of honey sample was kept in a previously weighed silica dish which was dried and weighted the sample. Charring was done on a burner followed by transferring the dish to muffle furnace maintained at 550ºC till formation of ash. Thereafter the dish was kept in desiccators followed by weighing of dish. The ash content was obtained by subtracting the final weight of dish with initial weight. The percentage ash content on dry basis was calculated according to the following equation:

$$\text{Ash (\%)} = \frac{(C - A)}{(B - A)} \text{ X } 100$$

Where

A = Weight of the dish/crucible
B = Weight of dish and sample
C = Weight of dish and sample after ashing.

5. Color

The color of the honey samples was determined by using spectrophotometer (Double Beam Spectrophotometer 2203 Systronics) to read their absorbance at a wavelength of 660nm against distilled water.

6. Determination of specific gravity

The specific gravity (SG) of the honey samples were obtained as the ratio of the weight of sample to that of equal volume of water applying following formula.

$$SG = \frac{Wsb - Wb}{Wwb - Wb}$$

Where

Wb = Weight of the bottle
Wsb = Weight of sample + bottle
Wwb = Weight of water + bottle

7. Determination of Viscosity

For determination of viscosity of honey, the method described by A.O.A.C. (1990) was applied using a viscosimeter.

8. Determination of Hydroxymethylfurfural (HMF)

Hydroxymethylfurfural (HMF) was determined by using the standard method AOAC (1990) [5] Official Method 980.23. Five grams of honey sample was dissolved in 25 ml of distilled water into a 50 ml volumetric flask, treated with a clarifying agent (0.5 ml of Carrez I and 0.5 ml of Carrez II solutions) and volume made up to 50 ml. The solution was filtered through paper, and the first 10 ml discarded. Aliquots of 5 ml were put in two test tubes; to one tube was added 5 ml of distilled water (sample solution); to the second was added 5 ml sodium bisulphate ($NaHSO_3$) solution 0.2% (reference solution). The absorbance of the solutions at 284 nm and 336 nm were measured against an aliquot of the filtered solution treated with $NaHSO_3$ by Double Beam Spectrophotometer 2203 Systronics. HMF was determined as per following formula:

$$\text{HMF (mg/100g) of honey} = \frac{(Abs_{284} - Abs_{336}) \text{ x } F}{W}$$

Where

W = wt. of sample in grams

$$\text{Factor (F)} = \frac{126 \times 100 \times 1000 \times 100}{16830 \times 1000} = 74.87$$

126 = the molecular weight of honey
16830 = the molar absorptivity of HMF at 284 nm

9. Determination of Sugars as total reducing sugar, glucose fructose and sucrose in honey

Determination of Reducing Sugar

The estimation of reducing sugars was done by using the Layne-Enyon method as described in AOAC. About 25 g of honey was weighed and transferred to a 250 ml volumetric flask. Added 10 ml neutral lead acetate solution and diluted to volume with water and filtered. Transfer an aliquot of 25 ml of the clarified filtrate to 500 ml volume flask containing about 100 ml water. Added potassium oxalate in small amount until there is no further precipitation. Make up to volume. Mixed the solution well and filter through Whatman No. 1 filter paper. Transfer the filtrate to a 50 ml burette having an off-set tip.

Preliminary Titration

Pipette 5 ml each of Fehling A and B into 250 ml conical flask. Mix and add about 10 ml water and a few boiling chips of glass beads. Dispense solution. Heat the flask to boiling. Add 3 drops of methylene blue indicator. Continue the addition of solution drop wise until the blue color disappears to a brick-red end point.

Final Titration

Pipette 5 ml each of Fehling A and B. Add sample solution about 2 ml less than titer value of the preliminary titration. Heat the flask to boiling within 3 minutes and complete the titration. Perform the titration duplicate and take the average. Calculate the reducing sugars % as shown below.

$$\text{Reducing Sugars \% (as Invert Sugar)} = \frac{\text{Dilution x Factor of Fehling (in gm) x 100}}{\text{Weight of sample x titre}}$$

Determination of Total Reducing Sugar

Pipette an aliquot of 50 ml of the clarified, de-leaded filtrate to a 100 ml volumetric flask. Add 5 ml of concentrated HCL and allow to stand at room temperature for 24 hrs. Neutralise with concentrated NaOH solution followed by 0.1 N NaOH. Make up to volume and transfer to 50 ml burette having an offset tip and perform the titration on Fehlings solution similar to the procedure described in the determination of reducing sugars.

$$\text{Total Reducing Sugars \% (as Invert Sugar)} = \frac{\text{Dilutions x Fehling factor x 100}}{\text{Weight of sample x titre}}$$

Determination of Factor (for Invert Sugar) of Fehling Solution

Accurately weigh around 4.75 gms of analar grade sucrose. Transfer to 500 ml volumetric flask with 50 ml distilled water. Add 5 ml concentrated HCL and allow to stand for 24 hours. Neutralize with NaOH solution and make up to volume. Mix well and transfer 50 ml to a 100 ml volumetric flask and makeup to volume. Transfer to a burette having an offset tip.

Perform the titration of Fehling solution following the similar procedure as above:

$$\text{Fehling Factor (for Invert Sugar)} = \frac{\text{Titre x Weight of sucrose in gm}}{500}$$

Non-reducing sugars = (Total reducing sugars - Reducing sugars)

Sucrose % = (Total reducing sugar / invert sugar 5% - reducing sugars %) x 0.95

Determination of glucose and fructose

The estimation of glucose and fructose in honey was performed by using UV/Vis Spectrophotometer. For the determination of glucose and fructose content in honey, 2 standard solutions was used i.e. glucose and fructose. They were prepared with concentration of 5000 ppm respectively in distilled water and diluted to 1000, 2000, 3000 and 4000 ppm as standards. Diluted honey solutions were prepared by dissolving 0.1 g of honey in, 12 mL and 10 mL for glucose and fructose analysis, respectively. By taking glucose as example, 2 mL of each standard solution and samples were pipetted into different test tubes. Same amount of deionized (DI) water was used as blank. Next, 8 mL of 2.5 M sodium hydroxide (NaOH) solution and 2 mL of 3, 5-Dinitrosalicylic acid (DNSA) solution were introduced before the tubes were covered by parafilm and shook to mix. The mixtures were then placed in warm water for another 5 minutes followed by 10 minutes in ice water. The absorbance of standards, blank and samples were measured at 540nm and the concentrations were obtained from the standard calibration curve. Similarly, the absorbance of fructose was measured at 490nm.

Statistical analysis of data

Data of all physical characteristics were 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

The results and basic statistics obtained for various physico-chemical parameters of the fourteen (14) honey samples collected from different villages of northern hill zone of Chhattisgarh are summarized in Table (1&2) and Figure (1&2). The result showed that the quality parameters of honey samples were recorded within acceptable ranges of moisture, pH, Total soluble solids (TSS), ash, color, specific gravity, viscosity, Hydroxymethylfurfural (HMF), Total reducing sugars (TRS), non-reducing sugar, glucose, fructose and sucrose with values of 18.27-24.64%, 3.71-5.13%, 76.02-81.72%, 0.18-0.44%, 0.32-3.91mPfund, 1.37-1.47g/cm^3, 2.80-3.30cPoise, 5.52-37.88 mg kg^{-1}, 65.52-70.99%, 2.35-5.59%, 32.67-36.75%, 35.40-38.45% and 2.47-5.88%, respectively. Analysis of variance have shown that differ significantly for the entire honey sample.

Table 1: Physico-chemical characterization of honey collected from different villages in northern hill of Chhattisgarh during 2017

S. No.	Name of honey sample	Moisture (%)	pH	TSS (%)	Ash (%)	Color (mPfond)	S. Gravity (g/cm^3)	Viscosity (cPoise)	HMF (mg kg^{-1})
1	Bhitthikala	22.67	3.92	77.33	0.26	0.32	1.39	2.94	8.79
2	Rampur Lodhima	20.39	5.13	79.60	0.23	0.42	1.39	3.02	5.52

3	Ranpur	22.38	4.14	77.62	0.31	0.60	1.38	2.80	25.33
4	Mendrakala	22.60	4.03	77.39	0.34	1.21	1.39	3.01	27.94
5	Mangari	18.35	3.90	81.65	0.18	4.10	1.43	3.26	7.47
6	Sitapur	18.49	4.25	81.51	0.26	2.57	1.44	3.14	13.55
7	Devgarh	18.27	4.27	81.72	0.22	3.91	1.47	3.30	17.07
8	Lamgaon	20.13	4.27	79.87	0.32	2.69	1.42	3.17	14.70
9	Mudesa	20.86	4.08	79.14	0.18	2.16	1.41	3.10	37.88
10	Amgaon	23.16	3.90	76.83	0.19	0.56	1.37	2.87	23.31
11	Sukhari	21.15	4.91	78.85	0.21	2.12	1.47	2.96	20.65
12	Ajirma (KVK)	24.64	3.71	76.02	0.27	1.13	1.42	3.30	21.90
13	Ajirma (RMD -I)	21.87	4.37	78.12	0.44	0.61	1.42	2.89	12.05
14	Ajirma (RMD-II)	20.94	4.24	79.06	0.43	0.57	1.44	2.92	8.91
	Overall mean	21.14	4.24	78.91	0.27	1.64	1.42	3.05	17.86
	SE(m±)	0.632	0.076	0.637	0.016	0.127	0.002	0.032	2.621
	CD	1.8306	0.2199	1.8464	0.0459	0.3690	0.0066	0.0935	7.5913

Significant at *P*< 5% level of significance

Table 2: Sugar characterization of local honey collected from different villages in northern hill of Chhattisgarh during 2017

S. No.	Name of honey sample	Total Reducing Sugar (%)	Glucose (%)	Fructose (%)	Sucrose (%)	Non-reducing Sugar (%)
1	Bhitthikala	66.26	34.41	36.27	4.52	4.29
2	Rampur Lodhima	70.99	32.67	35.40	2.47	2.35
3	Ranpur	67.61	34.15	35.89	5.01	4.76
4	Mendrakala	70.34	35.88	37.69	4.19	3.98
5	Mangari	65.52	34.02	36.20	4.66	4.43
6	Sitapur	68.36	33.94	35.64	4.59	4.36
7	Devgarh	66.87	34.29	36.75	3.02	2.87
8	Lamgaon	68.44	35.22	37.38	3.29	3.13
9	Mudesa	70.72	35.44	37.76	4.18	3.97
10	Amgaon	69.25	35.48	37.58	4.90	4.66
11	Sukhari	68.70	33.81	36.44	4.96	4.71
12	Ajirma (KVK)	70.33	36.75	38.45	5.88	5.59
13	Ajirma (RMD -I)	68.97	35.05	37.20	4.90	4.66
14	Ajirma (RMD-II)	69.60	35.52	38.35	4.57	4.34
	Overall mean	68.71	34.76	36.93	4.37	4.15
	SE(m±)	0.999	0.289	0.241	0.500	0.47
	CD	2.8929	0.8377	0.6982	1.4471	1.37

Discussions

- **Moisture**

Honey moisture content is a critical variable which influence the product quality, granulation and texture. It is widely related to the harvest season and the humidity inside the hive, but also on nectar conditions and treatment of honey during extraction. Higher water content could lead to undesirable honey fermentation during storage. This parameter is highly important for the shelf life of the honey during storage. Moisture percentage of honey was observed between 18.27 to 24.64 per cent. The highest moisture per cent was observed in honey sample collected from the village of northern hill region named Ajirma (KVK) and lowest in Devgarh honey. The average was 21.14%. There was significant differences (*P*<0.05) among the entire honey sample collected from different villages of northern hill zone of Chhattisgarh. These values were observed in the range of earlier reported value (21.9±0.48%) by Manzoor *et al.,* (2013) [19] from Tamil Nadu. The moisture content of the present study similar results was detected by Balasubramanyam (2011) [9] who reported 21.45-23.55% moisture content of honey recorded in Western Ghats of Karnataka, while Olugbemi *et al.,* (2013) [22] found 20.26-22.40% moisture content in Nigerian honey. Generally, the Indian honey has significantly higher moisture content (20 - 25%) in comparison to the Western honeys *i.e.,* 12-15%.

pH

The pH values of all the samples were significantly different (*P* < 0.05) and varied from 3.71 to 5.13. The highest pH value (5.13) of collected honey was observed in Rampur Lodhima honey, while lowest pH value (3.71) was observed in honey sample of Ajirma (KVK). The average value of 4.24 pH was obtained in various honey samples. The pH value of honey samples was in agreement with the values reported by other authors (Terrab *et al.*, 2004; Zerrouk *et al.* 2011; Nyau *et al.* 2013; Diafat *et al.* 2017; Azonwade *et al.* 2018; Lullah-Deh *et al.* 2018; Sajid *et al.* 2020) [27, 31, 21, 13, 8, 18, 23]. Due to the presence of pyruvic acid, gluconic acid, citric acid and maleic acid, and with lactones or inorganic ions (phosphate, chloride and sulphate) and esters, pH of the honey remains in balance and it is a useful index for growth of the microbes in honey (Silva *et al.*, 2009) [29].

- **TSS**

Among all the group of honey significantly different in the amount of TSS range varied between 76.02 and 81.72% for honey collected villages in northern hill of Chhattisgarh. The TSS value of honey was observed highest ranges of 81.72% from Devgarh and lowest of 76.02% from Ajirma (KVK) honey. The determined TSS ranges between 76.02 to 81.72% indicating that they were within the acceptable ranges. A reduction or absence of total solid in honey samples shows that the honey had been adulterated during processing. The present findings are supported with the work of Kamal *et al.* (2019) [17] who found that TSS value of honey was 79 to 80%, while Nyau *et al.* (2013) [21] reported as 83.6 and 85.7% of TSS.

- **Ash**

Generally less content of ash observed in honey and it depends on nectar composition of predominant plants during their formation. The ash content in the collected honey samples significantly varied between 0.18-0.44 per cent, which is in the acceptable range. The highest ash percent (0.44) was observed in honey sample of Ajirma (RMD-I) whereas lowest (0.18) in honey sample of Mangari and Mudesa. These values showed good agreement with the earlier reported values (0.12 - 0.28%) by various workers from India. Ash content is an important quality characteristic of food because it represents the mineral content in the food and is part of proximate analysis for nutritional evaluation. The percentage ash contents for the honey from all the beehive types were within the guidelines stipulated by the Codex Alimentarius Commission (1998) [11] of less or equal to 0.6% and are in agreement with the findings of Zerrouk *et al.* (2011) [31] who reported the ash content of between 0.075 and 0.330% for honey harvested from central Algeria. Similar values were observed by Attri (2011) [6]; Buba *et al.* (2013) [10] in Nigeria *i.e.* 0.47%, Nyau *et al.* (2013) [21] in Zmbia *i.e.* 0.198 – 0.271%, and Azonwade *et al.* (2018) [8] *i.e* 0.42-0.53%. Honey normally has low ash content and may be different from one sample to another because it depends on the material collected by the bees during foraging.

- **Colour**

Among all the group of honey significantly different in the ranges of colour varied between 0.32 and 3.91 for local honey collected in northern hill of Chhattisgarh. The least colour value (0.32) observed from sample collected from village Bhitthikala whereas the highest colour value (3.91) was observed in honey sample collected from village Devgarh whereas lowest value. Honey colour depends on various factors, being their minerals content an important one. Light-coloured honeys usually have low ash contents, while dark-coloured honeys generally have higher color value (Al *et al.*, 2009). In current findings, the dark colour observed for most of the analyzed honeys corresponded to high color values, except for the honey sample of Bhitthikala, Rampur Lodhima, Ranpur, Amgaon Ajirma (RMD-I) and Ajirma (RMD-II). 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.

- **Specific gravity**

Specific gravity of honey depends on the water content of the honey and is greater than water. In present study the specific gravity values obtained ranged between 1.37 - 1.47g/cm^3 with overall average value of 1.42g/cm^3, which are similar to the values (1.365 - 1.432 g/cm^3) observed by various workers from India including Garhwal Himalayan region (Tiwari *et al.* 2010). There was significant difference in the values of honey samples obtained from the study area. There were little variations in the specific gravity values of the honey samples obtained from localities. The variation in the specific gravity might be due to variation in the chemical composition (Singh and Bath, 1997) [25]. The specific gravity property of honey has not been legislated by Indian Standard and by the European legislation (UEC 2002) [12].

- **Viscosity**

The viscosity was observed between 2.80 and 3.30 cPoise. The lowest viscous honey was observed in honey collected from village Ranpur whereas highest from villages Devgarh and Ajirma (KVK). Honey of high quality is usually thick and viscous. The various ranges of viscosity in honey has described by different authors but the current findings coincided with the work of Manzoor *et al.* (2013) [19] who reported as 2.945 to 3.017 cPoise viscosity of honey. The viscosity depends on a large variety of substances and therefore varies with its composition and particularly with its water content. The percentage of fructose content in honey has also been found to affect its viscosity and rheological properties. Honeys become less viscous with increase in fructose content.

- **Hydroxymethyl furfural (HMF)**

HMF content is quality parameters that have been associated with honey freshness. This is a by-product of fructose decay and formed during storage or during heating. Thus, its presence is considered the main indicator of honey deterioration. The excessive value of HMF indicates overheating during processing, prolonged storage or adulteration with invert sugars. Besides, honeys from subtropical countries have naturally high content of HMF due to the high temperature. Statistical analysis revealed significant difference ($P < 0.05$) in HMF content of all the collected honey samples from various sources (Table 1). Mudesa honey had the highest (37.88 mg kg^{-1}) HMF content, while lowest HMF (5.52 mg kg^{-1}) was recorded in honey sample of Rampur Lodhima. All the honey samples have HMF content well within the current Codex Standards for HMF (<40 mg/kg) and Indian Standard for HMF (<50 mg/kg), and thus confirms the relative freshness of the samples. Similar HMF values were also described by Finola *et al.* (2007) [14] in Argentina honey and Nafea *et al.* (2014) [20] in Egyptian honeys.

Sugar analysis of honey

The results of sugar analysis as total reducing sugar, glucose, fructose, sucrose and non-reducing sugar in different honeys collected from different villages at northern hill of Chhattisgarh region were described bellows which are presented in Table (2) & Figure (2).

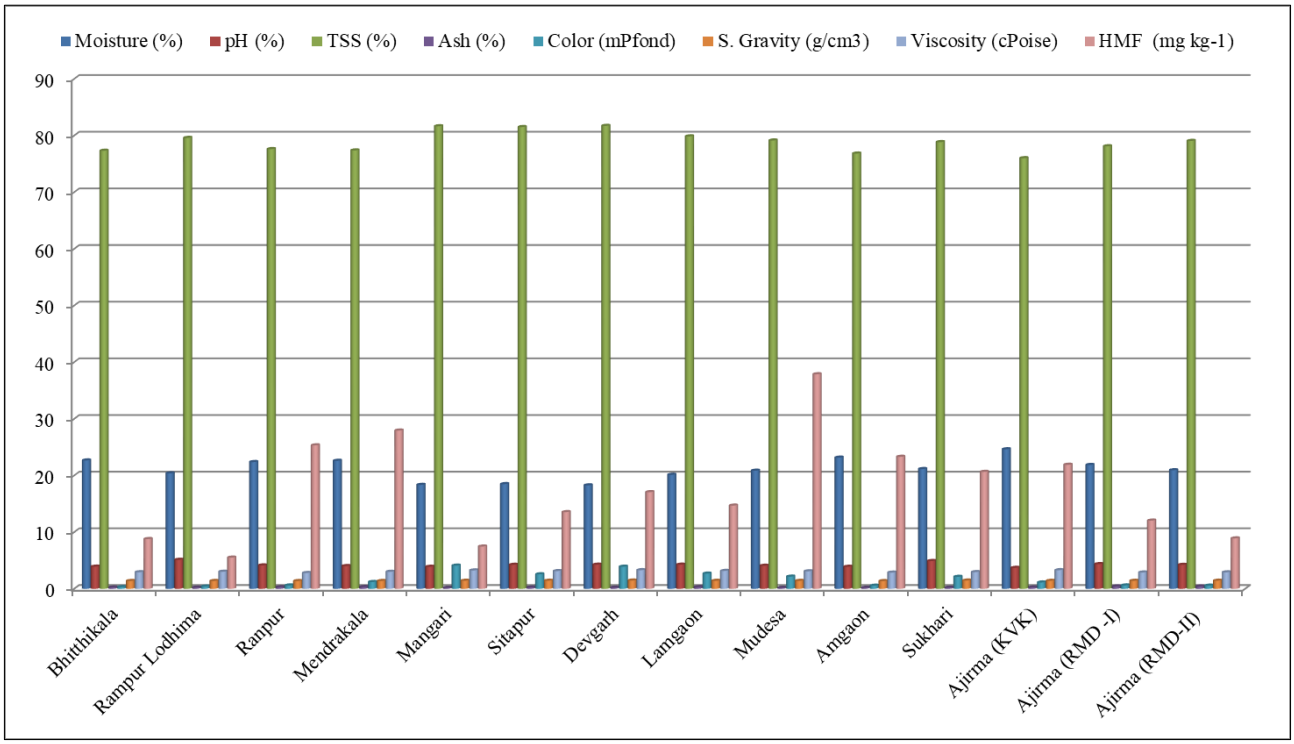

Fig 1: Physico-chemical characterization of honey collected from different villages in northern hill of Chhattisgarh during 2017

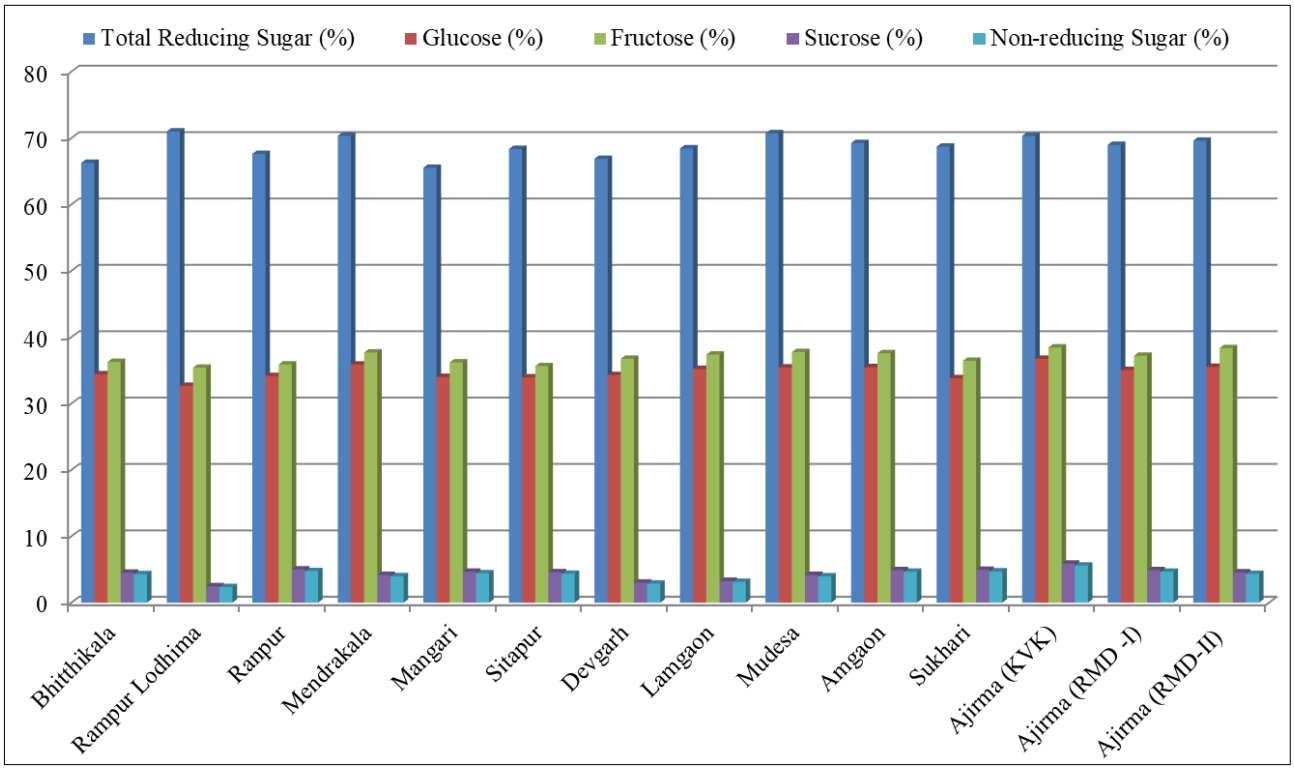

Fig 2: Sugar characterization of local honey collected from different villages in northern hill of Chhattisgarh during 2017

- **Total Reducing Sugar**

The results of the total reducing sugar (TRS) was recorded highest (70.99%) in honey collected from village Rampur Lodhima of northern hill region of Chhattisgarh whereas lowest value (65.52%) was observed in honey collected from village Mangari. Statistical analysis revealed significant difference ($P < 0.05$) in TRS of all the collected honey samples from various sources with an average value of 68.71%. These values were in agreement with values earlier reported by various researchers in floral honey (Azonwade *et al.* 2018; Teshome *et al.* 2020) [8, 28]. According to Indian Standard (1994) [16] the TRS percentage of all 14 honey samples were found in the acceptable standard (≤65%) for "A" grade honey.

- **Non-reducing sugar**

The non-reducing sugar values of entire samples were significantly different ($P < 0.05$) and varied from 2.35 to 5.59% with an average of 4.15%. The highest non-reducing sugar value (5.59%) was observed in honey sample collected

from Ajirma (KVK) village whereas lowest value (2.35%) observed from collected honey sample of Rampur Lodhima village. High sucrose or non-reducing sugar content in the honey sample may be due to early harvesting as sucrose is not converted to glucose and fructose by Azeredo (2003) [7].

- **Glucose**

The glucose percentage of the honey samples investigated ranged from 32.67 – 36.75% with mean value of 34.74% where, highest level of Glucose content (36.75) was observed in honey of village Ajirma (KVK) whereas lower value (32.67) observed in honey sample of village Rampur Lodhima. There was a significant difference ($p < 0.05$) in the values obtained from the study area. These values were in agreement with values earlier reported by various researchers in bee-honey (Gairola *et al.* 2013) [15]. In other study, Sulieman *et al.* (2013) [26] reported that the value of 25.9 – 40.5% glucose in honey while, 31.65% glucose in honey reported by Buba *et al.* (2013) [10] and Amabye and Mekonen (2016) [3].

- **Fructose**

The fructose values of all the samples were significantly different ($P < 0.05$) and varied from 35.40 to 38.45%. The hhighest fructose value (38.45) was observed in honey sample of Ajirma (KVK) whereas lowest value (35.40) observed from sample of Rampur Lodhima. Similar fructose values were also described by Buba *et al.* (2013) [10] in Nigerian honey, Amabye and Mekonen (2016) [3] in Ethiopian honey and Gairola *et al.* (2013) [15] in Indian honey.

- **Sucrose**

The sucrose values of all the samples were significantly different ($P < 0.05$) and varied from 2.47 to 5.88% with an average of 4.37%. Among all, one honey sample collected from Rampur Lodhima was observed lower ranges of (2.47) sucrose in honey whereas the highest ranges of 5.88% sucrose observed from sample collected villages of Ajirma (KVK), followed by honey sample of Ranpur (5.01%). According to Indian Standard (1994) [16] among the entire collected honey samples accepted except one honey samples collected from Ajirma (KVK) village, which were recorded higher percentage of sucrose (5.88). The level of sucrose differs according to the maturity degree and origin of the nectar compound of the honey. Our findings showed approximately similarity with the results of Kamal *et al.* (2019) [17]. But slightly lower ranges of 1.84% sucrose in honey reported by Buba *et al.* (2013) [10].

Conclusion

The aim of present study was to determine and compare the quality characteristics of some local honey samples from northern hill zone of Chhattisgarh. The results showed that all the samples have good quality. This study would be helpful to understand local honey properties and very important towards the commercialization of regional honey.

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