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Studies on the Physicochemical Characteristics of Winter Honey From the Region of Gadchiroli District, State of Maharashtra, India

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Abstract

Fifty-six samples from *Apis dorsata* and *Apis florea* were collected during winter (November to February) from different regions of Gadchiroli district in Maharashtra, India, and their physicochemical analyses were carried out according to Indian standard specifications. Different physicochemical parameters of the samples such as sugar content, the ratio of laevulose to dextrose or fructose to glucose, surface tension, viscosity and acidity percentage were analysed in this study. It was observed that glucose content ranged from 26.04% to 39.89% and fructose content ranged from 23.34% to 39.04%. The surface tension changed from 0.129 to 0.151 Nm^{-1}. The physicochemical analysis shows that no substantial dissimilarity was observed in the properties of all the samples. This scientific study of honey from the region helps to understand its quality and purity. This study also provides a better understanding of the nature and properties of winter honey compared to summer honey.

Categories: Food and Pharmaceutical Engineering, Quality and Process Improvement, Data Science and Analytics for Engineering
Keywords: physicochemical properties, honey, total reducing sugar, quality of honey, glucose to fructose ratio, acidity

Introduction

Honey is an important, well-known and economically valuable food product, which has good medicinal properties. The colonies of honey bees, *Apis florea* and *Apis dorsata*, are the main sources of honey products in the Gadchiroli region of Maharashtra, India [1]. Honey bees collect nectar from flowering plants and produce honey, a naturally sweet material [2]. Bee honey is an anti-allergy food that body readily assimilates [3]. There are numerous nutrients in honey, and it contains 80-85% of carbohydrates, which serve as an energy booster. Sugars in honey are easily digestible like sugars in many fruits. There are more than 22 sugars in honey. Two are monosaccharides: glucose and fructose. Ten are disaccharides, including sucrose, malto i.e. Two are monosaccharides, glucose and fructose, Ten are disaccharides i.e. sucrose, maltose , isomaltose, maltulose, nigerose, turanose, kojibiose, laminaribose, trehalose, and gentiobiose. Ten trisaccharides are present: melezitose, isomaltosylglucose, maltotriose, kestose, panose, isomaltotriose, erlose, thean-derose, centose and isopanose. Two more complex sugars, isomaltotetraose and isomaltopentaose, are also present in honey; however, glucose and fructose are the main sugar components [4-6]. The geographical floral origin [7], season, environmental variables and beekeeper treatments all affect the composition and properties of honey [8]. The sugar content of honey can also vary in different cases [9], with fructose content being higher than glucose in nectar honey. In addition to sugar, the ratios of glucose to water and fructose to glucose (F/G) are crucial factors in determining honey quality. Honey purity is mainly quantified using physicochemical properties such as the F/G ratio, which indicates the crystallisation potential of honey. More than 180 different components are present in honey, including proteins, amino acids [10], vitamins, enzymes [11], ash, minerals, phenolic compounds and organic acids [12-13]. The moisture content of bee honey has a significant role in its stability against granulation and fermentation [14]. It is necessary to protect honey from moisture, as high moisture content increases microbial activity, leading to spoilage. Melissopalynology is the most popular method for determining the botanical and geographical origins of honey [15]. The melissopalynological method remains the only one that permits direct classification of botanical origin, while physicochemical factors provide quantitative data and enable approximate calculations of honey blends. Not all types of honey granulate and precipitate their sugars at the same rate. The granulation and precipitation tendency is directly related to some factors such as the amount of glucose (D) and the ratios of glucose to water (D/W), glucose-water to fructose (D-W/L) and fructose to glucose (L/D). In particular, honey typically crystallises quickly when it contains more than 28% to 30% glucose and a D/W ratio of 2.1 or higher [16].

Gadchiroli district in Maharashtra, India, is known for its dense forests and the biodiversity covering 76% of the area of the district [17]. The clean and green forestry environment of this district has a source of

different natural foods with high purity. The main population of Gadchiroli district resides in the forests and collects honey for various purposes, including as a healing agent and natural sweetener, since ancient times [3,18]. The aim of this study was to identify the physicochemical characteristics and properties of winter honey samples collected from the diverse regions of Gadchiroli district and provide tools for assessing honey's suitability as food and medicine.

This study focuses on the characterisation of winter honey collected from Gadchiroli district. While numerous reports on summer and winter honey samples from this region have been published, this research emphasises areas with dense forests and significant tribal populations. The rationale for selecting this area lies in the fact that the local tribal communities extensively use honey for their daily needs. This study aims to characterise the winter honey and compare its properties with honey samples collected during the summer.

Materials And Methods

Honey sample collection

Between November and February, 56 samples of *A. dorsata* (23 samples) and *A. florea* (33 samples) were gathered from various woodland areas in Gadchiroli district. *A. dorsata* and *A. florea* are two different species of honey bees that differ in size, colour and habitat. A team of skilled professionals assisted in the personal supervision of the honeycomb squeezing.

Honey sample labelling

The samples were identified by labelling. To label the samples, a specific order was considered, i.e. the first letter of the sample represents the name of the district, the second capital alphabet represents the forest range from which the sample was collected, the third capital alphabet represents village area where the sample was observed and collected and the fourth capital alphabet from the sample code represents the type of honeybee hive (i.e. either *A. dorsata* or *A. florea*). The number in labelling represents the sample number. The sample code GPYD4 indicates that the sample was taken from Gadchiroli district (G), Permili forest range (P) and Yemili (Y) village. Letters "D" and "F" stand for the samples taken from *A. dorsata* and *A. florea*, respectively. A total of 56 samples were collected and labelled, as shown in Table *1*.

Physicochemical analysis

Indian standards were used for the physicochemical analysis of the honey samples [19-20]. The amounts of dextrose and sucrose, as well as the ratio of all the sugars and the percentage of all reducing sugars, were estimated. The specific gravity or density was determined using a pycnometer (W/V) (density bottle) at room temperature. To determine the surface tension (N m^{-1}), a stalagmometer was used. For this, 1 ml sample of honey was dissolved in distilled water (25 ml). The viscosity (kg m^{-1} s^{-1}) of the honey sample was determined using a viscometer, using a similar dilution parameter [3,21].

Sample No.	Sample Code	Forest Range (Abbreviation)	Sample Collected From Village	Species
1	**GPYD**	**Permili (P)**	**Yemili (Y)**	***Apis dorsata***
2	GEGoF	Etapalli (E)	Goadsur (Go)	*Apis florea*
3	GGhSD	Ghot (Gh)	Saknapur (S)	*Apis dorsata*
4	GPPF	Permile (P)	Permilli (P)	*Apis florea*
5	GGhSF	Ghot (Gh)	Saknapur (S)	*Apis florea*
6	GGhSD	Ghot (Gh)	Saknapur (S)	*Apis dorsata*
7	GMaAsF	Markhanda (Ma)	Ashti (As)	*Apis florea*
8	GPYD	Permili (P)	Yemili (Y)	*Apis dorsata*
9	GEGoD	Etapalli (E)	Goadsur (Go)	*Apis dorsata*
10	GEGoD	Etapalli (E)	Goadsur (Go)	*Apis dorsata*
11	GEGoF	Etapalli (E)	Goadsur (Go)	*Apis florea*
12	GEED	Etapalli (E)	Etapalli (E)	*Apis dorsata*
13	GEED	Etapalli (E)	Etapalli (E)	*Apis dorsata*
14	GEED	Etapalli (E)	Etapalli (E)	*Apis dorsata*

Sample No.	Sample Code	Forest Range (Abbreviation)	Sample Collected From Village	Species
15	GEED	Etapalli (E)	Etapalli (E)	*Apis dorsata*
16	GMuRF	Mulchera (Mu)	Rengewai (R)	*Apis florea*
17	GMuRF	Mulchera (Mu)	Rengewai (R)	*Apis florea*
18	GMuRF	Mulchera (Mu)	Rengewai (R)	*Apis florea*
19	GMuGaF	Mulchera (Mu)	Gandhinagar (Ga)	*Apis florea*
20	GMuGaD	Mulchera (Mu)	Gandhinagar (Ga)	*Apis dorsata*
21	GPYD	Permili (P)	Yemili (Y)	*Apis dorsata*
22	GPVD	Allapali (A)	Velgur (V)	*Apis dorsata*
23	GAVF	Allapali (A)	Velgur (V)	*Apis florea*
24	GAVF	Allapali (A)	Velgur (V)	*Apis florea*
25	GMaJaF	Markhanda (Ma)	Jayrampur (Ja)	*Apis florea*
26	GMaAsF	Markhanda (Ma)	Ashti (As)	*Apis florea*
27	GMaKaF	Markhanda (Ma)	Konsari (Ko)	*Apis florea*
28	GEGoD	Etapalli (E)	Goadsur (Go)	*Apis dorsata*
29	GEGoD	Etapalli (E)	Goadsur (Go)	*Apis dorsata*
30	GChaChaF	Chatgaon (Cha)	Chatgaon (Cha)	*Apis florea*
31	GChaChaF	Chatgaon (Cha)	Chatgaon (Cha)	*Apis florea*
32	GMaUF	Markhanda (Ma)	Umari (U)	*Apis florea*
33	GMaKaF	Markhanda (Ma)	Kadoli (Ka)	*Apis florea*
34	GMaAsF	Markhanda (Ma)	Ashti (As)	*Apis florea*
35	GMaAsD	Markhanda (Ma)	Ashti (As)	*Apis dorsata*
36	GMaAnF	Markhanda (Ma)	Ankhoda (An)	*Apis florea*
37	GMaAsD	Markhanda (Ma)	Ashti (As)	*Apis dorsata*
38	GMaChanF	Markhanda (Ma)	Chandankhedi (Chan)	*Apis florea*
39	GMaUF	Markhanda (Ma)	Umari (U)	*Apis florea*
40	GMaChanF	Markhanda (Ma)	Chandankhedi (Chan)	*Apis florea*
41	GMaChanF	Markhanda (Ma)	Chandankhedi (Chan)	*Apis florea*
42	GMaKaF	Markhanda (Ma)	Kadoli (Ka)	*Apis florea*
43	GMaAsF	Markhanda (Ma)	Ashti (As)	*Apis florea*
44	GChaGiD	Chatgaon (Cha)	Gilgaon (Gi)	*Apis dorsata*
45	GChaGiF	Chatgaon (Cha)	Gilgaon (Gi)	*Apis florea*
46	GChaGiD	Chatgaon (Cha)	Gilgaon (Gi)	*Apis dorsata*
47	GMaKoF	Markhanda (Ma)	Konsari (Ko)	*Apis florea*
48	GMaKoF	Markhanda (Ma)	Konsari (Ko)	*Apis florea*
49	GMaAnD	Markhanda (Ma)	Ankhoda (An)	*Apis dorsata*
50	GMaUF	Markhanda (Ma)	Umari (U)	*Apis florea*
51	GMaUD	Markhanda (Ma)	Umari (U)	*Apis dorsata*
52	GEEF	Etapalli (E)	Etappalli (E)	*Apis florea*
53	GJiJiF	Jimalgata (Ji)	Jimalgata (Ji)	*Apis florea*
54	GJiJiD	Jimalgata (Ji)	Jimalgata (Ji)	*Apis dorsata*

Sample No.	Sample Code	Forest Range (Abbreviation)	Sample Collected From Village	Species
55	GEED	Etapalli (E)	Etapalli (E)	*Apis dorsata*
56	GEEF	Etapalli (E)	Etapalli (E)	*Apis florea*

TABLE 1: Data represent sample code/number, range and village of sample collection and species.

G: Gadchiroli; D: *Apis dorsata*; F: *Apis florea*

Results

Appearance

The winter honey samples appeared transparent, barely turbid and turbid. This may be because of the honey's chemical composition and pollen content.

Colour

Honey's colour often ranges from pale yellow to amber, dark amber and even black in rare circumstances, with occasional green or red colour [11]. The hues of the honey used in the current investigation included dark brown, brown and yellowish brown. Figure *1* shows the photographs of test tubes containing honey samples and honey hives.

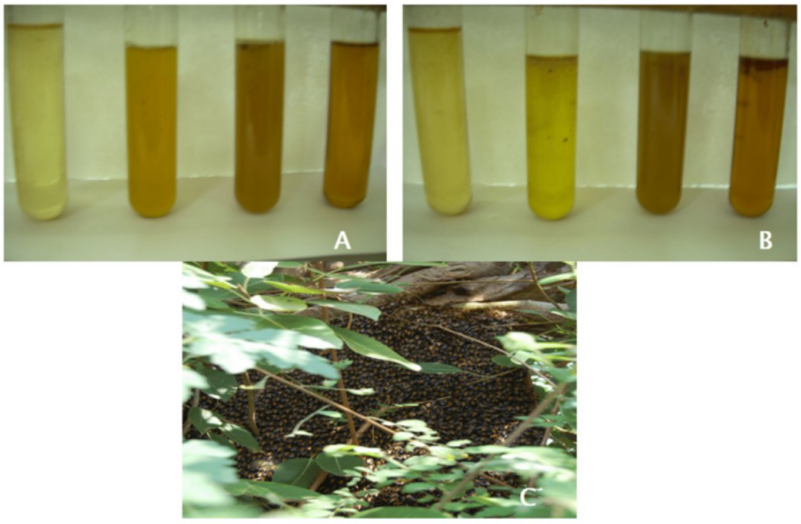

FIGURE 1: (A and B) Honey samples after collection. (C) Bee hive.

Sugars

Glucose and fructose are the primary sugars present in honey. The percentage of sugar in the collected samples was analysed using the Indian standard protocol for honey quality determination [22]. The glucose content in the collected honey samples was in the range of 26.4% to 39.89%, and an average glucose percentage was found to be 31.43%. The percentage of fructose ranged from 23.34% to 39.05%, with an average value of 32.69%, indicating that glucose predominates over fructose. It was discovered that the proportion of all reducing sugars (glucose and fructose) ranged from 52.12% to 73.73% and had an average value of 64.43%.

F/G ratio or laevulose/dextrose ratio

The crystallisation ability of honey depends on the F/G ratio as fructose has more solubility in water compared to glucose [23]. If the ratio is greater than 1, honey crystallises in a lesser rate; otherwise, it shows greater crystallisation [24]. From the collected 56 samples, it was observed that 19 samples had the F/G ratios less than 1.0, and 37 samples had the F/G ratios greater than 1.0. The average value of the F/G ratios from the whole analysis was found to be 1.04, with a range of 0.71-1.29, and it is considered that honey found in the region of Gadchiroli had a low crystallisation ability. The F/G ratio is found to be same for unifloral and multifloral honey from Argentina [25].

pH Values

The collected winter honey samples show acidic behaviour as their pH range was found to be between 2.5 and 4.05, and an average pH was found to be 3.062. The high acidity is due to the fermentation of honey sugar into organic acid, which gives honey its flavour and keeps it stable against microbial spoilage [26].

Surface tension and specific gravity

The surface tension of honey is a crucial component in the processing of honey. The surface tension of the collected honey samples was analysed and found to be 1.3-1.55 Nm^{-1}. A low value could cause a buildup of scum and excessive foaming. The average specific gravity for the collected honey samples was found to be 1.45.

Sucrose and acidity

The percentage of sucrose and acidity in the collected samples was analysed. The percentage of sucrose in all the collected samples was in the range of 1.08-3.59%, and the average value was found to be 2.29%. The acidity percentage was in the range of 0.04-0.19%, and the average value was found to be 0.061. The antimicrobial activities of honey depend on the acidity and pH [27]. The acidity intensity of honey depends on three factors: the type of acid present, overall amount and the impact of other substances, such as minerals, that are present in honey [27].

Viscosity

The viscosity of the collected honey samples was determined using an Ostwald's viscometer. The viscosity ranged across all samples from 1.61 to 2.10 (10^{-1} kg m^{-1} s^{-1}) with an average of 1.76 (10^{-1} kg m^{-1} s^{-1}) [24].

It was also noted that all of the parameters were found to be within the standard norms established by the Bureau of Indian Standards.

The physicochemical parameters of the collected honey samples were analysed, and the data are presented in Table *2*. Table *3* shows the honey samples' physicochemical characteristics, including the mean, standard deviation and variance. Table *4* provides the abbreviations used in the tables and manuscript.

Sample No.	Sample Code	Colour	VA	%TRS	%G	%F	L/D ratio	V (10^{-1} kg m^{-1} s^{-1})	SG (g/cm^3)	ST (Nm^{-1})	%S	%A	pH
1	GPYD	Dark brown	Turbid	73.73	35.55	38.18	1.07	1.73	1.43	0.137	2.83	0.07	2.7
2	GEGoF	Dark brown	Turbid	73	34.88	38.12	1.09	1.758	1.52	0.146	2.09	0.06	2.8
3	GGhSD	Dark brown	Turbid	71.15	34.45	36.7	1.06	1.788	1.51	0.150	3.04	0.05	3.1
4	GPPF	Yellow brown	Transparent	56.12	32.78	23.34	0.71	1.612	1.3	0.129	2.27	0.06	3.2
5	GGhSF	Yellow brown	Slightly turbid	69.44	34.3	35.14	1.02	1.671	1.51	0.122	2.06	0.05	3.2
6	GGhSD	Yellowish	Turbid	60.5	33.89	26.61	0.78	1.759	1.5	0.150	3.7	0.05	2.5
7	GMaAsF	Yellow brown	Slightly turbid	54.35	26.61	27.69	1.03	1.642	1.28	0.129	2.37	0.06	2.8
8	GPYD	Yellow brown	Transparent	69.86	32.63	37.23	1.14	1.642	1.28	0.129	1.68	0.07	2.9
9	GEGoD	Yellow brown	Slightly turbid	64.33	32.24	32.09	0.99	1.73	1.33	0.137	1.08	0.10	3.1
10	GEGoD	Yellow brown	Transparent	63.44	32.26	31.18	0.96	1.671	1.29	0.133	1.58	0.11	3.9
11	GEGoF	Yellow brown	Slightly turbid	66.46	32.91	33.55	1.01	1.671	1.27	0.133	3.59	0.04	4.1
12	GEED	Brown	Turbid	60.63	32.29	28.34	0.87	1.73	1.32	0.137	0.95	0.11	3.2
13	GEED	Yellowish brown	Slightly turbid	62.47	26.58	35.89	1.35	1.73	1.32	0.137	1.26	0.10	3.8
14	GEED	Yellowish brown	Slightly turbid	61.52	31.37	30.15	0.96	1.612	1.298	0.133	1.52	0.10	2.7

15	GEED	Yellowish brown	Transparent	63.75	32.03	31.72	0.99	1.759	1.5	0.133	1.064	0.10	2.9
16	GMuRF	Yellowish brown	Slightly turbid	66.53	36.56	38.2	1.04	1.743	1.42	0.137	2.37	0.05	3.2
17	GMuRF	Yellowish brown	Transparent	68.2	30.29	35.8	1.18	1.612	4.31	0.129	2.06	0.05	3.2
18	GMuRF	Brown	Transparent	67.5	26.73	25.39	0.95	1.643	1.28	0.129	2.27	0.06	2.5
19	GMuGaF	Yellow	Slightly turbid	71.25	35.14	32.18	0.92	1.75	1.4	0.148	2.83	0.03	3.1
20	GMuGaD	Dark brown	Turbid	72.2	32.2	30.93	0.96	1.983	1.5	0.150	2.09	0.06	2.7
21	GPYD	Dark brown	Turbid	70.15	36.51	35.7	0.98	2.015	1.52	0.150	3.04	0.05	2.8
22	GPVD	Dark brown	Turbid	69.8	30.15	32.44	1.08	2.102	1.53	0.151	2.59	0.07	3.1
23	GAVF	Brown	Slightly turbid	55.53	30.28	30.18	1.00	1.745	1.43	0.149	2.65	0.78	2.6
24	GAVF	Brown	Slightly turbid	59.32	28.16	27.89	0.99	1.783	1.45	0.149	2.8	0.07	2.8
25	GMaJaF	Greenish yellow	Transparent	59.61	29.85	30.45	1.02	1.672	1.3	0.129	1.43	0.06	3.1
26	GMaAsF	Yellowish brown	Transparent	60.79	34.35	38.1	1.11	1.67	1.28	0.121	1.58	0.04	3.5
27	GMaKaF	Greenish yellow	Transparent	62.89	32.42	35.25	1.09	1.673	1.32	0.121	2.3	0.04	3.1
28	GEGoD	Dark brown	Turbid	63.44	30.87	31.18	1.01	1.985	1.55	0.151	3.15	0.08	3.8
29	GEGoD	Dark brown	Turbid	61.79	30.97	29.7	0.96	1.992	1.5	0.151	3.42	0.07	2.9
30	GChaChaF	Brown	Slightly turbid	62.78	32.54	34.59	1.06	1.749	1.49	0.139	2.89	0.06	2.7
31	GChaChaF	Brown	Slightly turbid	60.59	32.59	33.25	1.02	1.748	1.49	0.139	2.87	0.06	2.5
32	GMaUF	Light Yellow	Slightly turbid	68.32	25.48	33.09	1.29	1.759	1.32	0.138	2.5	0.06	2.75
33	GMaKaF	Light Brown	Slightly turbid	65.5	26.4	33.5	1.26	1.75	1.43	0.133	1.9	0.15	2.5
34	GMaAsF	Light Brown	Turbid	70.15	35.5	39.05	1.1	1.95	1.52	0.150	3.02	0.04	3.5
35	GMaAsD	Brown	Slightly turbid	65.5	30.41	38.12	1.25	1.68	1.39	0.149	2.51	0.06	3.8
36	GMaAnF	Yellowish brown	Turbid	69.43	32.26	30.26	0.93	2.17	1.48	0.134	2.85	0.08	2.9
37	GMaAsF	Brown	Slightly turbid	65.33	31.89	31.2	0.97	1.67	1.38	0.151	3.1	0.05	2.7
38	GMaChanF	Yellowish brown	Turbid	67.41	34.88	35.55	1.01	2.14	1.46	0.141	2.05	0.06	3.1
39	GMaUF	Yellowish brown	Transparent	59.05	27.05	26.87	0.99	1.639	1.38	0.129	2.09	0.07	2.5
40	GMaChanF	Yellowish brown	Transparent	56.35	26.65	28.05	1.05	1.631	1.35	0.129	2.03	0.05	2.6
41	GMaChanF	Yellowish brown	Transparent	52.12	34.5	30.26	0.87	1.641	1.36	0.129	2.05	0.05	3.5
42	GMaKaF	Brown	Turbid	67.8	33.48	36.15	1.07	1.982	1.42	0.145	2.65	0.08	2.89

43	GMaAsF	Yellow	Transparent	55.4	30.2	35.26	1.16	1.671	1.4	0.137	1.68	0.08	2.7
44	GChaGiD	Yellowish brown	Slightly turbid	72.31	34.05	38.05	1.11	2.011	1.52	0.151	1.7	0.05	4.05
45	GChaGiF	Yellow	Slightly turbid	60.7	26.9	34.25	1.27	1.61	1.41	0.129	1.81	0.05	4.1
46	GChaGiD	Brown	Slightly turbid	68.3	30.01	31.15	0.96	1.731	1.43	0.139	2.15	0.07	3.8
47	GMaKoF	Yellowish brown	Slightly turbid	67.5	30.25	32.05	1.05	1.738	1.4	0.137	3.05	0.06	3.5
48	GMaKoF	Yellowish brown	Slightly turbid	65.3	29.8	32.56	1.09	1.75	1.39	0.137	3.37	0.06	3.7
49	GMaAnD	Light Brown	Slightly turbid	62.89	39.89	34.14	1.14	1.748	1.39	0.133	2.8	0.06	2.9
50	GMaUF	Light Brown	Slightly turbid	60.33	31.57	33.86	1.07	1.739	1.4	0.134	2.7	0.07	2.5
51	GMaUD	Light Brown	Slightly turbid	65.44	30.5	35.05	1.14	1.74	1.3	0.134	1.26	0.06	2.6
52	GEEF	Light Brown	Slightly turbid	62.5	31.25	36.12	1.15	1.751	1.32	0.133	1.95	0.06	3.1
53	GJiJiF	Brown	Slightly turbid	69.05	30.15	28.15	0.93	1.753	1.4	0.139	1.3	0.99	3.2
54	GJiJiD	Brown	Slightly turbid	68.84	28.1	29.86	1.06	1.738	1.41	0.137	1.52	0.19	2.7
55	GEED	Light Brown	Transparent	60.44	27.26	30.5	1.11	1.621	1.28	0.133	2.39	0.06	2.6
56	GEEF	Light Brown	Transparent	59.3	27.56	30.86	1.11	1.632	1.29	0.133	2.38	0.06	2.8

TABLE 2: The physicochemical parameters of winter honey.

Physicochemical constraints	Honey				
Colour	Yellow brown, dark brown, light brown, yellowish brown, greenish yellow				
Visual appearance	Transparent, slightly turbid, turbid				
	Lowest	Highest	Mean	±SD	Variance
Total reducing sugar	52.12	73.73	64.43	±5.18004	26.83285
Glucose	25.48	39.89	31.43	±3.08924	9.5434
Fructose	23.34	39.05	32.69	±3.67111	13.47701
Laevulose to dextrose ratio	0.71	1.35	1.04	±0.11693	0.01367
Specific gravity	1.27	1.55	1.45	±0.398	0.15841
pH	2.5	4.1	3.06	±0.45884	0.21054
Surface tension Nm^{-1}	0.121	0.151	0.138	±0.00821	0.00007
Viscosity 10^{-1} kg m^{-1} s^{-1}	1.612	2.17	1.76	±0.14055	0.01975
%Sucrose	0.95	3.7	2.29	±0.67857	0.46045
%Acidity	0.03	0.99	0.097	±0.1942	0.00038

TABLE 3: Winter honey sample's physicochemical constraints with mean, standard deviation and variance.

Abbreviation	Parameters	Abbreviation	Parameters
TRS	Total reducing sugar %	ST	Surface tension (N m^{-1})
G	Glucose %	V	Viscosity (10^{-1} kg m^{-1} s^{-1})
F	Fructose %	A	Acidity %
L/D	Laevulose to dextrose ratio	S	Sucrose %
SG	Specific gravity	VA	Visual Appearance

TABLE 4: Abbreviations used in the tables and manuscript.

According to the results of the physicochemical investigation, the honey produced in Gadchiroli district has a good amount of sugars, has no chance of crystallising, and can be stored for a long time. This honey is safe for consumption and useful for various purposes.

Discussion

A total of 56 samples of honey were collected and analysed. As observed in Tables *2* and 3, the honey collected from the forest range of Gadchiroli district resembles the findings reported in honey literature.

The range of fructose, glucose and sucrose present in the honey samples was determined and is displayed in Table *5* in accordance with the worldwide Honey Commission and Indian standard specification.

Sr. No.	Parameters	Value in Literature	Value in This Study	Values Specified by International Honey Commission	Reference
1	Specific Gravity	1.37	1.45		
2	%Total Reducing Sugar	65	64.43	Not less than 60%	
3	%Sucrose	5	2.29	Not more than 5%	
4	Fructose to Glucose Ratio	0.95	1.04	Not less than 0.95	[28-29]
5	%Acidity (max.)	0.2	0.097		
6	%Fructose		32.69	27-44%	
7	%Glucose		31.43	22-40%	

TABLE 5: Comparison of physicochemical property of honey samples with literature values.

After making an observation from Tables *2* and 5, as well as comparing the values from the current study with those from the International Honey Commission, it was found that Samples 4, 7, 23, 24, 25, 37, 41, 43 and 56 had less total reducing sugar than the other samples, all of which produced results that were within the required range. Similar results were seen when comparing the F/G ratio of samples 4, 6, 12, 19, 36, 41 and 53, which indicate lower values than specified, while other samples have values within the specified range.

Sr. No.	Parameters	Value for Summer Honey	Value in This Study for Winter Honey	Reference
1	Specific Gravity	--	1.45	
2	Total Reducing Sugar	69.95	64.43	
3	Sucrose	2.31	2.29	
4	Fructose to Glucose ratio	1.21	1.04	[30]
5	Acidity (max.)	0.51	0.097	
6	Fructose	36.42	32.69	
7	Glucose	33.48	31.43	

TABLE 6: Comparing the parameters of summer and winter honey.

The nature of honey and its value as a food are affected by its lower and higher physicochemical values, although there are certain reasons for this, such as the fact that honey has a low sugar content because its invertase enzyme breaks down sugar. The source of the nectar affects the fructose and glucose percentages, which also affect the F/G ratio [31].

To compare the data with existing reports, we also attempted to correlate the findings of the current study with values available for summer honey in literature. As shown in Table *6*, the comparative analysis of summer and winter honey, based on physicochemical parameters, reveals notable differences. The specific gravity of winter honey was recorded at 1.45, with no corresponding data for summer honey. The total reducing sugar content was higher in summer honey (69.95%) compared to winter honey (64.43%). Sucrose levels were fairly similar in both samples, with 2.31% for summer honey and 2.29% for winter honey. The F/G ratio was greater in summer honey (1.21) than in winter honey (1.04), indicating a higher proportion of fructose in the summer samples. Acidity was significantly higher in summer honey, with a maximum value of 0.51%, compared to 0.097% in winter honey. Similarly, the fructose and glucose contents were higher in summer honey, at 36.42% and 33.48%, respectively, compared to 32.69% and 31.43% in winter honey. These variations suggest that the warmer temperatures in summer may have contributed to the increased values of certain physicochemical properties in honey.

Table *5* shows that every sample of honey was tested and determined to be within the parameters specified by the International Honey Commission and the literature study. The information was consistent in every way, and it shows that the honey samples found in the Gadchiroli woodland area are of high impact and have a potential for global and worldwide market value.

Conclusions

Honey is widely used in medicine and food, making it essential to evaluate its composition and quality. The composition and quality of honey can be assessed through physicochemical analysis. In this study, honey samples collected from the Gadchiroli forest range were found to meet the parameters specified by the Indian Standard Protocol, indicating good quality. The glucose content ranged from 26.4% to 39.89%, while the fructose content ranged from 23.34% to 39.05%. The average F/G ratio was 1.04, with a range of 0.71 to 1.29, suggesting that the honey from this region has a low crystallisation tendency. Surface tension values ranged from 1.3 to 1.55 N/m, and the average specific gravity was found to be 1.45. The sucrose content in all samples ranged from 1.08% to 3.59%, while acidity was between 0.04% and 0.19%. The average viscosity value is found to be 1.76×10^{-1} kg m^{-1} s^{-1}. The physicochemical characteristics of winter honey were compared with summer honey and the literature report. It is observed that summer honey exhibits higher values compared to winter honey, and the values available in the report were attributed to literature report. This study also provides a basis for detecting honey adulteration, which has significant implications for the preservation of the natural ecosystem and the local communities involved in honey extraction and trade. Overall, these findings contribute to a comprehensive assessment of honey quality.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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Disclosures

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