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Investigations into the Physicochemical Properties of Jharkhand Winter Honey from the Palamu District

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Abstract

The purpose of this study was to evaluate the quality of Palamu honeys by analyzing their physicochemical parameters, color, total phenols and flavonoids content, and antioxidant capabilities. This evaluation was carried out in order to determine the Palamu honeys' overall quality. Twenty-two specimens of *Apis dorsata* and *Apis florea* were collected from a variety of places within the Palamu District of Jharkhand throughout the winter months, which lasted from November to February. The evaluations of these species' physicochemical properties were carried out in accordance with the parameters that are considered to be Indian standards. These species coexist alongside *Apis cerana* and *Apis mellifera*. A wide range of physicochemical characteristics of the samples were investigated in this study. These characteristics included the amount of sugar present, the ratio of laevulose to dextrose or fructose to glucose, surface tension, viscosity, and acidity % on the samples. During the course of the collection of honey samples, the glucose content ranged from 23.61% to 38.2%, while the fructose level fluctuated between 22.30% and 38.16%. Based on the results of the physicochemical examination, it was determined that the properties of the samples did not undergo any significant changes. It can be concluded that the samples, in their entirety, possess a high level of commercial quality.

Categories: Biotechnology and Engineering, Environmental and Sustainable Engineering, Environmental Engineering
Keywords: acidity, glucose-to-fructose ratio, honey, honey quality, and physical characteristics

Introduction

Honey is a prominent, esteemed, and commercially significant food product with advantageous medicinal properties. The principal sources of honey products in the Palamu District of Jharkhand, India [1], are the colonies of honey bees, *Apis florea* and *Apis dorsata*. Honey bees collect nectar from flowering plants and produce honey, a naturally sweet substance [2]. Bee honey is a rapidly absorbed anti-allergenic food [3]. Honey has many nutrients and consists of 80-85% carbohydrates, serving as an energy source. The sugars in honey are easily metabolized, akin to the sugars present in different fruits. Honey comprises around 22 varieties of sugars. Glucose and fructose are both simple sugars. There exist 10 disaccharides, including sucrose and maltose. Two monosaccharides exist: glucose and fructose [4-6]. Additionally, there are 10 disaccharides: sucrose, maltose, isomaltose, maltulose, nigerose, turanose, kojibiose, laminaribose, trehalose, and gentiobiose. Ten trisaccharides have been identified: melezitose, isomaltosylglucose, maltotriose, kestose, panose, isomaltotriose, erlose, thean-derose, centose, and isopanose. Honey comprises two more intricate sugars, isomaltotetraose and isomaltopentaose; still, glucose and fructose are the primary sugar components. The geographical floral origin [7], seasonal factors, environmental variables, and beekeeper interventions all affect the composition and attributes of honey [8]. The sugar composition of honey may vary, with fructose concentrations surpassing those of glucose in nectar honey [9]. In addition to sugar, the ratios of glucose to water and fructose to glucose (F/G) are critical factors influencing honey quality. The purity of honey is primarily evaluated through physicochemical criteria, particularly the F/G ratio, which indicates its crystallization potential. Honey comprises more than 180 unique constituents, encompassing proteins, amino acids [10], vitamins, enzymes [11], ash, minerals, phenolic compounds, and organic acids [12,13]. The moisture concentration of bee honey substantially affects its stability against granulation and fermentation [14]. Safeguarding honey from moisture is crucial, as increased moisture levels promote bacterial activity, leading to degradation. Melissopalynology is the primary method for determining the botanical and geographical sources of honey [15]. The melissopalynological method is the only methodology that enables direct classification of botanical origin, while physicochemical properties provide quantitative data and allow for approximate evaluations of honey mixtures. Diverse honey types crystallize and precipitate their sugars at distinct rates. The propensity for granulation and precipitation is intricately linked to 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). Honey often crystallizes swiftly when its glucose content exceeds 28% to 30% and the D/W ratio is 2.1 or higher [16].

Jharkhand, known as the "Land of Forests," possesses extensive forest cover, particularly the Saranda Forest, the largest Sal forest in Asia. Palamu, Jharkhand, India, is distinguished for its verdant forests and

abundant fauna [17]. Natural forests comprise 14% of the land area in Palamu District, whereas non-natural tree cover represented an additional 0.70%. There are 61.8 thousand hectares (kha) of natural forests and 3.11 kha of artificial tree cover. The total land area of Palamu District is 8,657 square kilometers. The unspoiled forest ecosystem of this region offers a diverse array of natural foods with exceptional purity. This study sought to investigate the physicochemical attributes and qualities of winter honey samples sourced from several regions of Palamu District, Jharkhand, to assess honey's suitability for culinary and medicinal purposes. This study investigates the properties of winter honey obtained from the Palamu District of Jharkhand and collects honey for various purposes, including as a healing agent and natural sweetener, since ancient times [3,18]. The rationale for selecting this region is that the local tribal communities significantly rely on honey for their daily needs. This study aims to define winter honey.

Materials And Methods

Collection of honey samples

Between November and February, 22 specimens of *A. dorsata* and *A. florea* were gathered from various forested areas in the Palamu District of Jharkhand. The *A. dorsa* and *A. florea* are separate species of honey bees that differ in size, coloration, and habitat, as can be seen in Table *1*. A team of skilled individuals managed the honeycomb extraction operation.

Labeling of honey samples

The labels were utilized to ascertain the authentic characteristics of the samples. Samples were labeled in a specific sequence: the initial letter denotes the district name, the second capital letter indicates the forest range from which the sample was obtained, the third capital letter represents the village area where the sample was observed and collected, and the fourth capital letter signifies the type of honeybee hive, specifically *A. dorsata* or *A. florea*. The figure in the label indicates the sample number. The sample number PPJD4 indicates that the sample was obtained from Palamu District (G), within the Palamu Tiger Reserve (P), and specifically from Jaigir (J) village. The letters "D" and "F" denote the samples obtained from *A. dorsata* and *A. florea*, respectively. A total of 22 samples were collected and categorized, as illustrated in Table *1*.

Sample No.	Sample Code	Forest Range	Village	Species
1	PPJD	Palamu Tiger Reserve	Jaigir	*Apis dorsata*
2	PPJD	Palamu Tiger Reserve	Jaigir	*Apis dorsata*
3	PPJD	Palamu Tiger Reserve	Jaigir	*Apis dorsata*
4	PPJD	Palamu Tiger Reserve	Jaigir	*Apis dorsata*
5	PPJF	Palamu Tiger Reserve	Jaigir	*Apis florea*
6	PPJF	Palamu Tiger Reserve	Jaigir	*Apis florea*
7	PPMF	Palamu Tiger Reserve	Jaigir	*Apis florea*
8	PPMD	Palamu Tiger Reserve	Meral	*Apis florea*
9	PPMD	Palamu Tiger Reserve	Meral	*Apis dorsata*
10	PPMD	Palamu Tiger Reserve	Meral	*Apis dorsata*
11	PPMF	Palamu Tiger Reserve	Meral	*Apis florea*
12	PPMF	Palamu Tiger Reserve	Meral	*Apis florea*
13	PPMF	Palamu Tiger Reserve	Meral	*Apis florea*
14	PMCD	Mahuar Forest Range	Chhatarpur	*Apis dorsata*
15	PMCD	Mahuar Forest Range	Chhatarpur	*Apis dorsata*
16	PMCF	Mahuar Forest Range	Chhatarpur	*Apis florea*
17	PMCD	Mahuar Forest Range	Chhatarpur	*Apis dorsata*
18	PMCD	Mahuar Forest Range	Chhatarpur	*Apis dorsata*
19	PMCF	Mahuar Forest Range	Chhatarpur	*Apis florea*
20	PMCD	Mahuar Forest Range	Chhatarpur	*Apis dorsata*
21	PMCF	Mahuar Forest Range	Chhatarpur	*Apis florea*
22	PMCF	Mahuar Forest Range	Chhatarpur	*Apis florea*

TABLE 1: A total of 22 samples were collected and categorized, as illustrated

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, were estimated, as mentioned in Table *1*.

Results And Discussion

Appearance

The winter honey samples exhibited transparency, with minimal turbidity and varying degrees of turbidity. This may be attributed to the chemical composition and pollen content of the honey.

Color

The color of honey often varies from pale yellow to amber, dark amber, and, in rare instances, black, with occasional hues of green or red [11]. The colors of the honey examined in the present study were dark brown, brown, and yellowish brown. Figure *1* shows the photograph of a honey hive, and Figure *2* shows the photograph of test tubes containing honey samples.

FIGURE 1: Bee hives

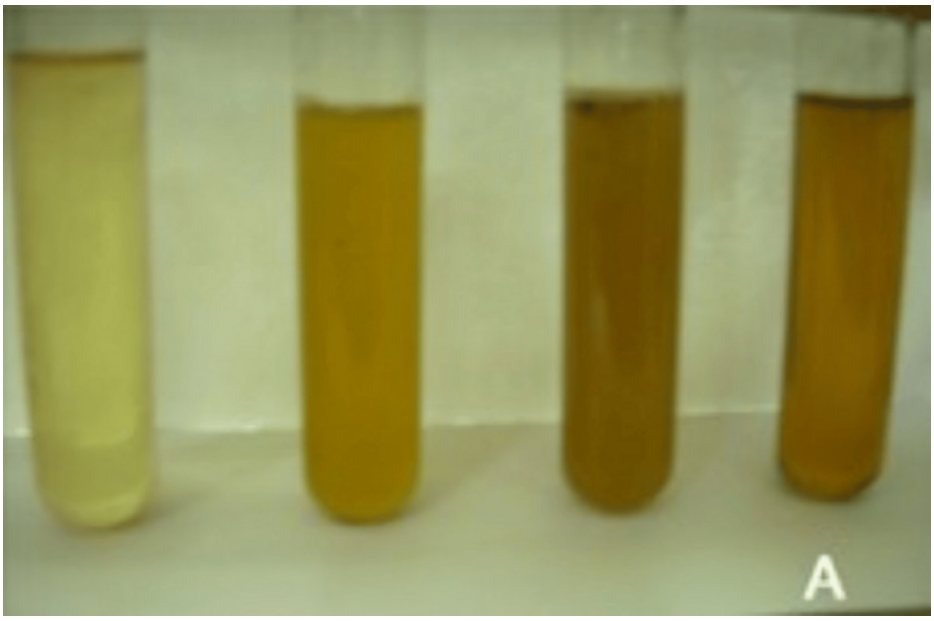

FIGURE 2: Test tube containing honey

Sugars

Glucose and fructose constitute the principal sugars found in honey. The sugar content in the collected samples was analyzed according to the Indian standard technique for honey quality assessment. The glucose concentration in the analyzed honey samples ranged from 23.61% to 38.2%, with an average glucose percentage of 32.78%. The fructose content varied from 22.30% to 38.16%, with a mean of 33.60%, suggesting that fructose predominates over glucose.

F/G ratio or levulose/dextrose ratio

The crystallization propensity of honey is contingent upon the F/G ratio as mentioned in Table *3*, since fructose exhibits more solubility in water than glucose. Furthermore, abbreviations are used in Table *2*. If the ratio exceeds 1, honey crystallizes at a reduced rate; conversely, it exhibits increased crystallization. Of the 22 samples collected, 9 exhibited F/G ratios below 1.0, while 13 displayed F/G ratios beyond 1.0. The honey from the Palamu District of Jharkhand is regarded as having low crystallization

capabilities.

pH levels

The analyzed winter honey samples exhibit acidic characteristics, with a pH range of 2.4 to 4.2 and an average pH of 3.00. The elevated acidity result from the fermentation of honey sugars into organic acids, which imparts flavor to honey and enhances its stability against microbial degradation.

Sucrose and acidity

The sugar percentage and acidity in the collected samples were analyzed. The sucrose content in the collected samples ranged from 0.90% to 3.55%, with an average of 2.16%. The acidity percentage ranged from 0.02% to 0.12%, with an average value of 0.056%. The antibacterial properties of honey are contingent upon its acidity and pH levels . The strength of honey's acidity is contingent upon three factors: the type of acid present, the total quantity, and the influence of other compounds, such as minerals, found in honey.

Viscosity

The viscosity of the gathered honey samples was measured with an Ostwald viscometer. The viscosity of all samples varied from 1.60 to 2.10 (10^{-1} kg m^{-1} s^{-1}), with a mean of 1.73 (10^{-1} kg m^{-1} s^{-1}). All metrics were observed to be within the standard norms set by the Bureau of Indian Standards. The physicochemical properties of the gathered honey samples were analyzed, and the results are displayed in Table *2*.

Sample No.	Sample Code	Color	VA	%G	%F	L/D Ratio	V (10^{-1} kg m^{-1} s^{-1})	%S	%A	pH
1	PPJD	Dark brown	Turbid	35.50	38.16	1.074	1.71	2.80	0.06	2.6
2	PPJD	Dark brown	Turbid	32.80	35.10	1.070	1.737	2.05	0.06	2.4
3	PPJD	Dark brown	Turbid	35.65	36.7	1.02	1.778	3.00	0.05	3.0
4	PPJD	Dark brown	Turbid	30.76	22.30	0.724	1.610	2.25	0.05	3.1
5	PPJF	Yellow brown	Transparent	32.2	34.14	1.060	1.676	2.05	0.05	3.2
6	PPJF	Yellow brown	Transparent	34.88	35.66	01.022	1.755	3.5	0.04	2.4
7	PPMF	Yellow brown	Transparent	23.61	28.71	1.216	1.640	2.34	0.05	2.8
8	PPMD	Dark brown	Turbid	30.53	35.22	1.153	1.60	1.65	0.06	2.8
9	PPMD	Dark brown	Turbid	32.20	30.10	0.934	1.70	1.05	0.09	3.2
10	PPMD	Dark brown	Turbid	35.26	36.14	1.024	1.665	1.55	0.10	3.7
11	PPMF	Yellow brown	Transparent	31.96	32.56	1.018	1.664	3.55	0.02	4.2
12	PPMF	Yellow brown	Transparent	34.28	36.35	1.060	1.70	0.90	0.10	3.0
13	PPMF	Yellow brown	Transparent	27.59	36.80	1.333	1.75	1.29	0.11	3.4
14	PMCD	Yellowish	Turbid	32.36	36.85	1.138	1.615	1.55	0.12	2.9
15	PMCD	Yellowish	Turbid	31.03	30.02	0.967	1.758	1.063	0.08	2.8
16	PMCF	Yellowish	Turbid	35.55	37.2	1.046	1.741	2.35	0.04	3.3
17	PMCD	Dark brown	Turbid	36.29	35.8	0.986	1.614	2.02	0.01	3.2
18	PMCD	Yellowish	Turbid	25.72	25.30	0.983	1.644	2.27	0.04	2.6
19	PMCF	Yellowish	Turbid	34.14	32.16	0.942	1.70	2.82	0.02	3.2
20	PMCD	Dark brown	Turbid	38.2	36.93	0.966	1.980	2.07	0.03	2.6
21	PMCF	Brown	Turbid	35.51	34.7	0.977	2.016	3.00	0.05	2.7
22	PMCF	Brown	Turbid	35.15	32.45	0.923	2.100	2.54	0.06	3.0

TABLE 2: The physicochemical properties of the gathered honey samples were analyzed, and the results are displayed

Abbreviation	Parameters	Abbreviation	Parameters
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 3: Abbreviations used in the tables and manuscript

The physicochemical analysis indicates that the honey from the Palamu District in Jharkhand possesses a substantial sugar content, is unlikely to crystallize, and has a prolonged shelf life. This honey is safe for ingestion and serves multiple functions.

For their valorization in terms of biological activities, the darker honey samples presented a good antioxidant activity with a high phenolic content, while the lighter ones, in spite of their lower content of antioxidant compounds, could be a good sugar substitute for diabetics because they contribute to

slowing down the degradation of the starch in honey by the supposed effect of enzymatic inhibition, especially if it presents a low glycemic index, which is imperative to measure especially after the elimination of a high percentage in the concerned samples and then a study confirmation by clinical trials is still necessary [21]. Abbreviations used in manuscript are summarized in Table *3*. On the other hand, it is strongly confirmed that the botanical origin influences the composition and the biological activity of honey.

Conclusions

Fundamental characteristics for honey characterization are beneficial when combined with pollen analysis for its classification based on floral and geographical origin. Notable differences were seen among certain samples, with pH, humidity, electrical conductivity, and color being the primary factors that distinguished them. In light of the fact that honey is utilized extensively in both the medical and culinary fields, it is necessary to evaluate both its composition and its quality. Through the use of physicochemical analysis, one is able to determine both the composition and the quality of honey. According to the findings of this study, honey samples obtained from the Palamu region of the Jharkhand forest range were found to be of good quality since they achieved compliance with the requirements established by the Indian Standard Protocol. The concentration of glucose experienced fluctuations ranging from 26.4% to 39.89%, whereas the concentration of fructose experienced variations ranging from 23.34% to 39.05%. The honey from this region has a low tendency to crystallize, as indicated by the F/G ratio values, which ranged from 0.71 to 1.29. The mean value was 1.04, and the range was between 0.71 and 1.29. Variations in surface tension readings ranged from 1.3 to 1.55 N/m, while the specific gravity was found to be 1.45 on average. The concentration of sucrose in each of the samples ranged from 1.08% to 3.59%, while the acidity was found to be anywhere between 0.04% and 0.19%. Upon analysis, it has been established that the average viscosity value is 1.76×10^{-1} kg m^{-1} s^{-1}. A comparison was made between the physicochemical properties of winter honey and those of summer honey, as well as with the literature that was already available. Honey produced throughout the summer months has higher values than honey produced during the winter months; the values that have been reported are from previously published research. This study lays the groundwork for diagnosing honey adulteration, which has significant implications for the preservation of the natural ecosystem as well as for the populations that are involved in honey extraction and commerce in the surrounding area. Any modification in the qualities of the honey referenced or assessed in this study, as well as others, might affect its organoleptic properties and differentiate it from others, as evidenced by distinct sensory profiles for each honey type. The labeling and declaration of honey's monoflorality without the process of melissopalynology is a prevalent error frequently committed by beekeepers. This stage, regarded as foundational in the study of honey, is inadequate unless corroborated by an additional set of analyses. In contemporary science, the chemical detection systems for molecules have significantly advanced researchers' ability to trace their products. Honey is a product whose composition is particularly complex, necessitating thorough analysis of all manufacturing conditions.

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.

Concept and design: Nilu Kumari

Acquisition, analysis, or interpretation of data: Nilu Kumari

Drafting of the manuscript: Nilu Kumari

Critical review of the manuscript for important intellectual content: Nilu Kumari

Supervision: Nilu Kumari

Disclosures

Human subjects: All authors have confirmed that this study did not involve human participants or tissue. **Animal subjects:** All authors have confirmed that this study did not involve animal subjects or tissue. **Conflicts of interest:** In compliance with the ICMJE uniform disclosure form, all authors declare the following: **Payment/services info:** All authors have declared that no financial support was received from any organization for the submitted work. **Financial relationships:** All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. **Other relationships:** All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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