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Honeybee Production and Honey Quality Assessment in Guji Zone, Ethiopia

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Abstract

Assessment of Honeybee production practices and quality were undertaken in Guji district of Ethiopia. Honey samples were collected from farmer's hives and local honey market for chemical analysis to determine its quality. Physicochemical analysis of honey was carried out at Haramaya University Animal Nutrition and Food Science technology. All physicochemical parameters analyzed lie within limits of local and international standard. Honey laboratory analysis was subjected to one way ANOVA of SAS. Above all, improving the low level of technological input and honey quality defects, address the skill gap on post-harvest handling of hive products, processing and packaging need a practical training to local beekeepers. Moreover, facilitating supply of quality apicultural equipment is crucial and further consistent practical training on bee and bee products management for community is recommended.

Keywords: *Honey bee; Physic-chemical property; Honey quality*

Introduction

Honey is a natural substance produced by bees and nutritious food of economic importance worldwide. It is a sweet viscous liquid that is composed of sugars, amino acids, proline, minerals, aromatic substances, pigment waxes and grains [1,2] and contains large amount of glucose but low in sucrose (< 8%) [3]. Honey is easily digestible and a more palatable which supplies substantial energy with 75 to 85% fructose and glucose. The physicochemical composition, flavour and colour of honey vary due to climate, soil, flora, bee species and production methods. The precise composition variation depending on the plant species on which bee forages are the main constituents [4,5,6].

In their own nest either in the wild or any other types of hive bee always store quality honey. The place where they live has no effect upon the quality of honey that bees make. It is only subsequent handling and harvesting by humans that leads to reduction in quality like harvesting when the water content is too high ('unripe') contaminated, over-heated, over-filtered or spoiled in any other way. Storage conditions may also influence final composition, with the proportion of disaccharides increasing overtime [7]. Careless handling of honey can reduce quality like high temperature, length of storage and moisture content which lead to fermentation, high levels of Hydroxymethylfurfural (HMF), loss of enzymatic activity changes in flavor, darkening and microbial growth [8]. Therefore, this study was designed to collect information on production system, productivity, bee flora and post managements of honey and determine it's quality.

Materials and Methods

Sampling Techniques and Sample Size

The study was conducted in beekeeping potential of Guji Zone. A total of 16 honey samples were purposively selected from four of beekeeper peasants of the zone and a sample of honey from market. A half (1/2) kg of honey samples were collected from two types of hives for laboratory analysis.

Collected Data

The study was requiring wide range of information with reference to beekeeping. The chemical compositions of honey samples was determined according to [9] and [10] in the laboratory.

Moisture content

The moisture content of honey was determined by using the refractive index of the honey.

The table is derived from a formula developed by Wedmore, (1955) and calculated by:

$$W = \frac{1.73190 - \log (R.I - 1)}{0.002243}$$

Where W= is the water content in g/100g honey and R.I. is the refractive index.

Mineral (ash) content

Ash content was determined after the sample burnt in an electric muffle furnace. Percent ash g/100g honey was calculated by using:

$$\text{Ash \%} = \frac{M1 - M2}{M0} \times 100$$

Where M0= weight of honey, M1= weight of dish + ash and M2= weight of dish.

pH and Free Acidity

The pH of sample was measured with pH meter and the solution was further titrated with 0.1M sodium hydroxide (NaOH) solution to pH 8.30.

Acidity =10V

Where V = the volume of 0.1N NaOH in 10 g honey.

Reducing Sugar

This method is a modification of the [11] procedure, involving the reduction of Soxhlet's modification of Fehling's solution by titration at boiling point against a solution of reducing sugars in honey using methylene blue as an internal indicator and expression of result:

$$C = \frac{2 \times 1000}{W2\,Y2}$$

Where C = g invert sugar per 100 g honey.

W2 = weight (g) of honey sample.

Y2 = volumes (ml) of diluted honey solution.

Apparent Sucrose

The procedure of determining reducing sugar was

ASC= (invert sugar content after inversion - invert sugar content before inversion) x 0.95

Where ASC= Apparent sucrose content.

The result will be expressed as g apparent sucrose per 100 g honey.

Data Management and Statistical Analysis

Honey quality parameters were analyzed by using one way ANOVA and ± SD.

Results and Discussion

Feeding honey bees and flora condition

Honey bee colonies naturally withstand themselves and produce honey by for aging natural and cultivated crops and store honey for their own feeding during dearth period. But, beekeepers are harvesting honey which honey bees stored for them. The management for honey bees is very minimal in the study area. During the survey period it was observed that some farmers who have modern beehives (33.33%) were manage and 66.67% did not manage it properly. With regard to type of feed they provide, respondent feeding their bees (36.67%) use honey and pea flour (3.33%), pea flour and sugar syrup (6.67%), sugar syrup (10.0%) and pea flour (16.67.8%). 63.33% beekeepers were not give anything to honey bees as food.

Hive products harvesting and post handling

The frequency and amount of honey harvested varied depending on flowering condition of major bee forage, colony management practices and number of beehive [12]. In the study area, honey harvesting periods were from March to April and July to August where harvesting periods correlate with availability of moisture and peak flowering period. During honey harvested, beekeepers cut and pull the fixed combs one by one and then pollen, brood and honey combs were removed and kept in a container and covered with a lid which affects quality of honey in relation to length of storage. According to [13] plastic container is the ideal one for the quality of honey. Accordingly plastic bucket and plastic sack were highly used and in some case they use nickels to store honey for both short and long period and which result rusting; deteriorates the honey and technically not appropriate for storage facilities.

Honey Bee flora

Beekeeping is more dependable on ecological suitability of an area than any other live stock production [14] and honey bee population and their productivities in general are mainly influenced by the nature of honey bee flora. Vegetation characteristics of the study areas are considered to be an important indicator for the potentialities of the area for beekeeping. Survey conducted showed that, the potential of cultivated and natural honey flora makes it very favorable for beekeeping. The respondents pointed that, even though there are different types of bee plants and flora seasons, there is a shortage of bee feed during the dry seasons where ground and surface water resources are limited. They also indicated that bee forages become declined as compared with the past period due to forest degradation, use of herbicides and expansion of cultivated lands in the area.

Honey quality laboratory result

Physicochemical properties of honey produced in the study area were analyzed compared to Quality and Standards Authority of Ethiopia (QSAE), Codex Alimentarius Commission (CAC) and European Union (EU) were described below.

Moisture

The mean moisture contents of honey samples collected from different locations and hive types are reported below which is depends on the environmental conditions such as temperature, relative humidity of the area and the manipulation of honey during harvesting period by beekeepers and seasonal variation [15,16]. After the carbohydrates, water is the second most important component of honey. Moisture content ranges between 15 and 23% and it substantially affects some physical properties of honey (crystallization, viscosity, specific weight) and influenced by climatic factors, bee species, bee-colony's strength, humidity and air temperature in the hive, processing and storage conditions as well as by the honey plant species. The moisture content of the research finding implies from 15.12 ± 0.74 to 14.28 ± 0.89 which is safe. The higher moisture-in-honey content, the greater is the possibility that the yeasts will ferment and change the flavor. However, there are no substantial differences in water content between individual honey types.

Ash

The minimum, maximum and mean ash contents of the honey samples analyzed in the present study was lower than the maximum limits (0.6%) set for ash content of the honey by EU, CA and QSAE and the average was within the national and international limits for ash content of honey.

Free Acidity

The overall mean free acidity of honey samples analyzed was 24.08% which is within the acceptable limits (≤ 40 m eq/kg) set by QSAE and CAC, whereas the limit for honey acidity according to EU (2002) honey standard is≤ 50 m eq/kg. This result revealed that the freshness of honey samples and absence of unwanted honey fermentation where harvesting time and storage condition are the matter. None of the samples exceeded the limit set, which may be taken as indicative of freshness of all the honey samples of the study area. Variation in free acidity among different honeys can be attributed to floral origin or to variation in the harvest season.

PH

Honey is naturally highly acidic. Its pH is extremely low, ranging between 3 and 4.5, which inhibits the growth of bacteria and other spoil-ready organisms. There was no significant difference (p> 0.05) in pH between honey samples obtained from traditional (3.45) and modern hives (4.03) (Table 1), similarly, no significant difference in acidity. Honey pH has great importance during storage of honey, as they influence the texture, stability and shelf life of honey [17]. pH of honey samples in the current study ranged from 4.13 to 5.02, with an average value of 4.45 (Table 2) which reveal honey is quality enough for long time storage. The low pH of honey inhibits the presence and growth of micro-organisms and makes honey compatible with many food products in terms of pH and acidity.

Temperature (^{0}C)	Variety		Average temp
	Dongola	Berbar	
Reducing sugars (%)			
25^{0}C	31.27 ± 4.93^c	27.51 ± 5.52^d	29.39^B
40^{0}C	38.99 ± 14.08^a	34.46 ± 9.24^b	36.73^A
Average variety	35.13^A	30.99^B	
Non-reducing sugars (%)			
25^{0}C	8.41 ± 4.19^d	10.30 ± 4.54^b	9.29^B
40^{0}C	11.11 ± 0.21^a	9.94 ± 5.55^c	10.53^A
Average variety	9.70^B	10.12^A	
Total sugars (%)			
25^{0}C	38.84 ± 5.09^c	38.30 ± 4.19^d	38.57^B
40^{0}C	50.74 ± 11.08^a	44.93 ± 9.06^b	47.84^A
Average variety	44.79^A	41.62^B	

*Means in the same columns and rows bearing same superscript small letters are not significantly different (P≥ 0.05).

Values are mean ± SD.

**Means in the same row with the same superscript capital letters are not significantly different (P≤ 0.05).

***Means in the same column bearing different superscript capital letters are significantly different (P≤ 0.01).

Table 1: *Effect of Garlic Variety and Storage Temperature on Sugars Content of Garlic Paste.*

Reducing Sugars

The overall mean reducing sugar content of the analyzed honey samples was 76% which is within quality requirement limits (≥ 65%) of (QSEA; CAC; EU) and a minimum reducing sugar content of 65% is required [19]. There were no significant differences (P> 0.05) in reducing sugars content between honey samples obtained from the two hive types and locations (Tables 1 and 2). Similarly, the average reducing sugars content of honey obtained from market location (80.2%) was significantly higher (p< 0.05) than the average moisture

content of honey obtained from the two agro ecologies (collected directly from beekeepers). This implies that, the product meet the quality standard and honey was harvested early before sucrose has not been converted to fructose and glucose [18].

Treatments	Storage period (months)			Average Treatment
	2	4	6	
Reducing sugars (%)				
T_0	20.27 ± 4.13^{m}	37.64 ± 5.08^{f}	38.43 ± 11.45^{d}	32.11^{D}
T_1	23.10 ± 1.67^{j}	37.50 ± 4.12^{f}	37.24 ± 7.12^{g}	32.61^{C}
T_2	21.65 ± 3.48^{l}	39.21 ± 4.72^{c}	40.91 ± 0.75^{b}	33.92^{B}
T_3	24.84 ± 2.03^{i}	38.14 ± 0.75^{e}	41.52 ± 9.58^{a}	34.83^{A}
T_4	22.01 ± 2.27^{k}	34.80 ± 6.35^{h}	38.59 ± 11.50^{d}	31.80^{E}
Average storage	22.37^{C}	37.46^{B}	39.34^{A}	
Non-reducing sugars (%)				
T_0	13.51 ± 3.18^{a}	9.48 ± 2.34^{f}	7.11 ± 4.69^{g}	10.03^{D}
T_1	13.61 ± 4.38^{a}	12.70 ± 2.23^{b}	9.74 ± 2.96^{f}	12.02^{A}
T_2	10.61 ± 4.79^{de}	10.30 ± 6.14^{e}	6.52 ± 3.66^{h}	8.98^{E}
T_3	10.90 ± 6.85^{d}	11.33 ± 2.67^{c}	10.81 ± 2.07^{i}	11.01^{B}
T_4	12.66 ± 5.88^{b}	11.46 ± 2.10^{c}	7.36 ± 2.82^{g}	10.49^{C}
Average storage	12.16^{A}	11.05^{B}	8.31^{C}	
Total sugars (%)				
T_0	37.35 ± 1.73^{h}	46.11 ± 5.51^{e}	44.64 ± 11.64^{f}	42.70^{D}
T_1	32.80 ± 0.87^{l}	49.35 ± 5.90^{a}	47.78 ± 8.67^{c}	43.31^{E}
T_2	36.43 ± 5.25^{i}	48.86 ± 9.46^{b}	43.40 ± 11.43^{g}	42.23^{F}
T_3	34.55 ± 2.06^{k}	49.56 ± 4.96^{a}	48.81 ± 11.84^{b}	44.31^{A}
T_4	35.33 ± 4.64^{j}	46.69 ± 5.46^{d}	46.36 ± 9.92^{e}	42.79^{C}
Average storage	34.89^{C}	48.11^{A}	46.20^{B}	

Values are mean ± SD.

*Means in the same columns and rows bearing same superscript small letters are not significantly different (P≥ 0.05).

**Means in the same row with the same superscript capital letters are not significantly different (P≤ 0.05).

***Means in the same column bearing different superscript capital letters are significantly different (P≤ 0.01).

T_0 = Control.

T_1 = Ascorbic acid (0.5mg/g).

T_2 = Citric acid (2mg/g).

T_3 = Ascorbic acid (0.25mg/g) and Citric acid (1mg/g).

T_4 = Ascorbic acid (0.5mg/g) and Citric acid (2mg/g).

Table 2: *Effect of Chemical Treatments and Storage Periods on Sugars Content of Garlic Paste.*

Apparent Sucrose

Apparent sucrose are set to be 5g/100g for the majority of honeys, which have higher limits (10g/100g), as well as lavender honeys (15g/100g) (EC Directive 2001/110). Higher sucrose contents could be the result of an early harvest of honey i.e., the sucrose has not

been converted to fructose and glucose [18]. The amount of sucrose in honey differs according to the degree of maturity and nectar compound of the honey.

Summary and Recommendation

Laboratory evaluation showed that the mean moisture, reducing sugars, sucrose, acidity, ash and pH contents of the honey samples collected from the study area revealed that, all the physicochemical parameters lie with-in limits of local and international standards set by Quality and Standards Authority of Ethiopia, Codex Alimentarius Commission and EU Council. There were significant differences for acidity and water insoluble solids ($p< 0.01$) between hive types. But, there were no significant differences ($p< 0.05$) between hive types and among locations for moisture, reducing sugar, sucrose, ash and pH contents of honey samples tested.

Therefore, to improve the low level of technological input utilization, it needs to be facilitate the supply improved bee-hives, honey processing materials and other beekeeping equipment, address the skill gap on bee colony management and post harvest handling of hive products, further consistent practical training on bee and bee products management for community is recommended.

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