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Chemical Analysis of Honey and Major Honey Production Challenges in and Around Gondar, Ethiopia

Addis Getu and Malede Birhan

Department of Animal Production and Extension,
Faculty of Veterinary Medicine, University of Gondar, Ethiopia

Abstract: The study was carried out in North Western parts of Amhara region to characterize honey production systems, major challenges, opportunities and honey quality in the study area. Six randomly selected districts 120 (a total of 720) respondents were employed using semi-structured questionnaires. A total of 42 table honey samples each weighing 0.5 kg (21kg of honey) from different beekeepers and 40 kg honey was collected from local markets on randomly for physicochemical evaluation like (moisture content, pH, free acidity, ash content, electrical conductivity, water insoluble solids, diastase activity and hydroxymethyl furfural (HMF) and organoleptic attributes (taste and color). Honey yield/ production/ households were 77.55kg, 81.84kg and 186.18kg for traditional, transitional and frame hive respectively. The three honey production systems were had varied honey yield capacity. Traditional beekeeping systems with an average honey yield of (7.20 ±0.23kg/year), Transitional beekeeping systems (MCTB) with an average yield of (14.70 ±0.62kg/year) and frame hive with average production of 23.38±0.73kg per year. Almost all samples of honey examined (moisture =18.52%, Ash= 0.23%, sugar reducing = 67.83%, SU=7.55%, Free acidity=28.24milli.equiv.acid/kg, HMF= 6.32mg/kg pH= 3.81 and Water insoluble material = 3.2) were within the acceptable range of world and national standard, except for water insoluble material which is poor mainly due to lack of appropriate handling during harvesting and storage of the product. Due to this high honey production potential of the study area for apiculture and good quality standard of honey, it is advised to exploit the potential for export market with better intervention. More study is also required to characterize the honeybees of the area and major pests and diseases of economic importance.

Key words: Chemical Evaluation · Honey Quality · Challenges

INTRODUCTION

Africa is blessed with numerous types of wild honeybee [1]. Ethiopia is one of the countries of the continent which own big honey production potential. Owing to its varied ecological and climatic conditions, Ethiopia is home to some of the most diverse flora and fauna in Africa. Its forests and woodlands contain diverse plant species that provide surplus nectar and pollen to foraging bees [2]. Beekeeping is an inherited tradition in Ethiopia and estimated 1 farmer in 10 smallholders keep bees [3]. Currently traditional beekeeping accounts 95.57 % of the honey production and almost all the beeswax produced in the country. The remaining 1.63 and 2.8 % includes transitional and modern beekeeping, respectively [4].

According to CSA, [4], the total annual honey and beeswax production is more than 53,680 tons and 4,700 tons, respectively. This makes Ethiopia the 4th largest beeswax and 10th largest honey producing country in the world. Ethiopian honey production accounts for approximately 2.5 % of world production and 21.7 % of African honey production [3]. Despite the country's immense potential for honey and beeswax production, the national annual honey and beeswax yield is very low as compared to the potential of the country [5].

Composition and quality of honey are greatly influenced by geographical and environmental factors [6-8]. According to CSA, [4], Amhara National Regional state was produced 86,843.93 quintals of honey from 965,293 numbers of hives which accounts about 25 % of the total honey production of the country. Therefore;

Corresponding Author: Malede Birhan, University of Gondar, Faculty of Veterinary Medicine, Department of Animal Production and Extension, Ethiopia.

production system study is important to identify problems and come up with appropriate development plan for an area [9]. Hence, the specific objectives of this research;

- To evaluate the chemical composition of honey produced from the three beekeeping systems in the country
- To identify the major challenges and constraints of honey production and quality in North west area of Ethiopia

MATERIALS AND METHODS

Description of the Study Area: The study was conducted in six districts of Amhara National Regional State, in the Northwestern parts of the country. The districts get a uni-modal annual rainfall of which, the rain fall extends between June and August. The dry season extends from December to March and annual average temperature of the study area is about 20.4°C.

Shallow and sandy soils are the two dominate soils types of the district which are characterized by low organic matter and soil fertility. Whereas, the district agricultural office reported that the average land is about 37,654.825 hectares which is suitable for ploughing, 13,601.36 hectares of land used for grazing, 4,429.5 hectare is for forest land and 39,459.561 hectares are for other uses [10]. However, the vegetation coverage in the area has been greatly destroyed by both in natural and anthropogenic factors.

Sampling Techniques and Frame-Works: Reconsensus survey and informal data collection from districts of agricultural office and key informants discussion were employed before the actual data collection work was started. Agro ecological zones of the districts were purposively selected based on honey bee colonies potential followed by 6 districts (2 from high land, 2 from mid-highland and 2 from lowland) were identified. For semi-structured questionnaire was used on 120 beekeepers per district a total of 720 respondents on randomly selected districts.

Types of Data Collection Methods: Performance data like productivity, honeybee colony manage the activities, socio-economic characteristics, such as family size and land holding size of the respondents were documented through semi-structured questionnaires. Ranking trial was used to prioritize the major constraints of honey production systems.

Ranking Trials: Beekeepers were asked to rank their major problems like 1st, 2nd, 3rd and 4th constraints of agro-chemical and production systems related with current honey bee consequences.

Focus Group Discussion: One focus group discussion one per district was inhaled to generate information. The focus group members were communally known to have deep rooted knowledge about a socio-economic status of the district and well known, story teller and community leaders. From the focus group discussion the PA's of agricultural office experts were participated. This multiple approaches were used to generate data like trends of beekeeping activities in the district, potential area in beekeeping, major constraints and opportunities of honey production systems.

Laboratory Data Types: During primary data collection a total of 42 honey samples were considered from purposively selected six potential beekeeping districts. Honey samples were collected at farm gates from the three hive types (12 local, 12 top bar and 12 frame hives) and 6 samples from local market. Fresh honey samples were collected during the peak honey harvesting season (November to December).

Physicochemical Procedures: Physicochemical compositions (moisture content, water-insoluble solids, pH, acidity, diastase activity, electrical conductivity, HMF and mineral content) of honey samples were determined according to the (HMIHC) Harmonized Methods of the International Honey Commission [11]. The physicochemical properties of the collected honey samples were analyzed at Bahir Dar University, School of Chemical and Food Engineering in Food Chemistry and Analysis laboratory.

Moisture Content: The moisture content of honey sample was estimated by determining the refractive index of the sample with the use of digital refractometer (Abe refractometer) that can be thermostated at 20°C, regularly calibrated with distilled water from the refractive index of the honey by reference to a standard table. The sample was directly smeared on the surface of the prism evenly; after two minutes the reading of refractive index were recorded. Each sample was measured triplicate and averages of three readings were recorded and corresponding value for moisture content was recorded.

PH: The pH of honey was determined by using digital pH meter (Inolab, Germany). Ten grams of honey sample was dissolved in 75 ml of distilled water in 250 ml beaker. The solution was stirred and pH electrode was immersed in the solution and pH was recorded.

Free Acidity: Ten grams of honey was weighed with the help of electronic balance and poured in conical flask and 75 ml of distilled water was added by rinsing the utensil. The solution is titrated against 0.1M NaOH solutions in burette using phenolphthalein as indicator. The titration was carried out till the solution turns to pink from colorless. Free acidity is expressed as mill equivalents or mill moles of acid/kg honey = ml of 0.1M NaOH x 10 and the result was expressed to one place of decimals.

Mineral (ash): Ash content was determined after the sample was burnt in an electric muffle furnace (Lenton Thermal Designs, England). First the ash dish was heated in the electrical furnace at ashing temperature, subsequently cool in a desiccator to room temperature and weigh to 0.001g (M_2). Then, 10 grams of honey sample was weighed to the nearest 0. 001g (M_0) and put in the prepared ash dish and two drops of olive oil was added to prevent frothing. Then water was removed and commence ashing without loss (by foaming and overflowing) at a low heat rising to 350 - 400° C by using electrical device. Hot plate was used to char the sample before inserting into the furnace. After the preliminary ashing with hot plate, the dish was placed in the preheated muffle furnace (at a 550° C) and heated for 1 hour. The ash dish was cooled in the desiccator and weighted. The ashing procedure was continued until constant weight is reached (M_1). Percent ash in g/100g honey is calculated using the following formula.

$$\text{Ash \%} = \frac{M_1 - M_2}{M_0} \times 100$$

Where M_0 = weight of honey taken, M_1 = weight of dish + ash and M_2 = weight of dish.

Estimation of Hydroxyl Methyl Furfural (HMF): The reagents enlisted below, required to estimate the HMF content in honey samples were prepared as follows:

Carrez Solution I: 15 g of Potassium Hexacyanoferrate $K_2Fe(CN)_6\ 3H_2O$ was dissolved in distilled water and volume was made to 100 ml.

Carrez Solution II: 30 g of Zinc Acetate, $Zn(CH_3.COO)_2\ 3H_2O$ was dissolved in distilled water and volume was made to 100 ml.

Sodium Bisulphate solution 0.20 g /100 g (0.2 %):-0.20 g of solid Sodium Bisulphate ($NaHSO_3$) was dissolved in distilled water and volume made to 100 ml. Five gram of honey sample was taken approximately and diluted in 25 ml water and then poured in to volumetric flask. Then 0.5 ml of Carrez solution I was mixed with 0.5 ml of Carrez solution II and made up the volume. Then the solution was filtered through the filter paper and the first 10 ml of filtrate was rejected. Five ml of sample was pipette out in two test tubes and 5 ml of water was added to the first test tube and mixed well. Five ml of 0.2 % Sodium Bisulphate solution was added to the second test tube and mixed well for reference solution (Table 1).

The absorbance of the sample was determined against the reference solution with UV Spectrophotometer at wavelength 284 and 336 nm by using 1cm-quartz cells within one hour. Sample and reference solution was diluted with water and sodium bisulphate, if the absorbance exceeds 0.6 at 284 nm.

$$\text{Dilution D} = \frac{\text{Final volume of Sample Solution}}{10}$$

HMF expressed as mg/kg = $(A_{284}-A_{336})$ x 149.7 x 5 x D/W.
A_{284} = Absorbance at 284 nm.
A_{336} = Absorbance at 336 nm.
149.7 = 126 x 1000 x 1000/16830 x 10 x 5.
126 = Molecular weight of HMF.
16830 = Molar absorptive and HMF at 284 nm.
10 = Conversion of g into mg.
1000 = Conversion of g into kg.
5 = Theoretical nominal sample weight.
D = Dilution factor (in case dilution is required).
W = Weight in g of honey sample.

Water Insoluble Solids Content: Twenty grams of honey was weighed to the nearest 0.01g and dissolved in a suitable quantity of distilled water at 80 °C and mixed well. The test sample was filtered through a previously dried

Table 1: Dilution of sample and reference solutions carried for estimation of HMF

Addition to test-tubes	Sample solution (in ml)	Reference solution (in ml)
Initial solution	5.0	5.0
Water solution	5.0	-
Sodium bisulphate (0.3%)	-	5.0

and weighed fine sintered glass crucible and washed thoroughly with hot water (80 °C) until free from sugar. The crucible was dried for one hour at 130 °C, cooled and weighed to the nearest 0.1 mg. Finally the result was expressed as percent water-insoluble solids.

$$\text{Insoluble solids \% by mass} = \frac{(M_1 - M_2)}{W} \times 100$$

Where:-
M_1 = Mass of the residue and the crucible
M_2 = Mass of the crucible
W = Mass of the test portion

Diastase Activity: The reagents enlisted below, required to estimate the Diastase Activity in honey samples were prepared as follows:

Sodium Chloride Solution: 4 g NaCl was dissolved in 100 ml measuring flask with fresh distilled water.

Buffer Solution I (pH = 5.4): 40 g Di-sodium Hydrogen Phosphate and 9.29 g Citric acid was dissolved in 1000 ml measuring flask with fresh distilled water.

Buffer Solution II (pH = 7.0): 58.9 g Di-sodium Hydrogen Phosphate and 3.7 g Citric acid was dissolved in 1000 ml measuring flask with fresh distilled water.

Iodine Solution (0.001 mol/l): 5 ml Iodine-solution (0.05 mol/l) and 10 g Potassium Iodide was dissolved in 250 ml measuring flask with fresh distilled water.

Starch Solution: 0.5 g water free Starch was dissolved with 20 ml distilled water. A mixture of 5 ml buffer solution I and 50 ml hot water was added in to the above solution and brought in to boiling by string frequently. After cooling the solution was poured in to 100 ml volumetric flask.

One gram of honey was dissolved in 50 ml volumetric flask with 25 ml buffer solution I and 1.5 ml of sodium chloride solution was added in to the above honey solution and filled the flask to the mark with buffer solution I. From the above honey solution 20 ml was pipette in a 50 ml flat bottom flask and also 20 ml starch solution in to another 50 ml flat bottom flask. Both flat bottom flasks was heated for 15 min. at a temperature of 40ºC and mixed carefully both aliquots. After exactly fixing the time difference (stopwatch) 2, 6, 12, 20, 30 min. 1 ml of the mixed reaction solution was pipette in to 50 ml volumetric flask which already had 30 ml buffer solution II and 5 ml iodine solution. After good mixing the solution of each volumetric flask, the flask was heated in a water bath by 20ºC for some time and measured the absorption by 565 nm in the presence of blank which contains 50 ml volumetric flask (30 ml buffer solution II, 5 ml iodine solution, 0.5 ml honey solution) filled with distilled water. The measured absorption (Abs.) was plotted against the reaction time (t). The Intersection of the line with absorption axis at time (t) = 0 and at time (t) = 30 min. The diastase activity (DN) which is equal to the degraded amount of starch in g/h and 100 g honey was calculated by using the following formula:

$$DN = 1 \frac{500\,(E_0 - E_{30})}{E_0 .30}$$

Where:-
1500 - Factor of 1h and 100g honey
E_0 - Absorption at time = 0
E_{30} - Absorption at time t = 30
30 - Reaction time

Electrical Conductivity (EC): Twenty grams of anhydrous honey was dissolved in distilled water and transferred the solution quantitatively in to a 100 ml volumetric flask. Forty ml of the solution were poured into a beaker and it was placed in the thermostated water bath at 20 °C. Then conductivity cell was rinsed thoroughly with the remaining part of the solution. Immersed the conductivity cell in the sample solution and read the conductance in mS after temperature equilibrium has been reached.

Color and Taste: Determination of color and taste of the honey samples were performed by nine hedonic scales [12], by fifth year Food Technology and Process Engineering students of Bahir Dar University in School of Chemical and Food Engineering, Food Chemistry and Analysis laboratory of Bahir Dar University.

Data Management and Statistical Technique: Data was managed both in hard and softcopies. All collected datum were entered and managed using Microsoft Excel computer progarmme. Data from focus group discussion and personal observations were briefly summarized and simple descriptive statistics on, performances and socio-economic characteristics were analyzed by using SAS Soft ware program [13]. Indexes were used to calculate for fifth ranked data collected from rankings with the formula: Index = sum of (5 for rank 1 + 4 for rank 2 + 3 for rank 3 + 2 for rank 4+ 1 for rank 5) given for an individual reason divided by the sum of (5 for rank 1 + 4 for rank 2 + 3 for rank 3 + 2 for rank 4+ 1 for rank 5) for overall reasons adopted. Data of eight important honey physicochemical parameters and two organoleptic attributes was analyzed and observed variations for each experimental parameter by using SAS Software program [13]. Tukey comparison test was used to compare sub factor means separately that was brought significant difference.

RESULT AND DISCUSSIONS

Socio-Economic Characteristics of Households: From the total 720 sample respondents, only (2.5%) were female beekeepers while the rest 117 (97.5%) were male beekeepers. This is in line with the reports of Hartmann [14], who noted that beekeeping is the man's job in Ethiopia. Similar result also indicated that beekeeping is mainly the activity of male in Bale highlands of southeast Ethiopia [15]. The mean age of the beekeepers in the districts were 47.63 with standard deviation of 11.42 and ranged from 26 to 75 years. The beekeepers had an average experience of 12.47 (ranges from 3 to 37 years) of beekeeping for districts. Based on this study the average family size of the beekeepers were 6.12 persons using average land holding per household of 1.22 ha and this is within the range of the National average household land holding of 1.0 - 1.5 ha.

Regarding to level of education, 38.3 % of those interviewed beekeepers had not received any formal or informal education. The rest were at different stages of literacy ranging from reading and writing skills to completion of secondary school. The role of education is obvious in affecting household income, adopting new technologies, demography, health and as a whole the socio-economic status of the family as well [16]. Sources of honeybee colonies to start beekeeping: Based on the beekeepers experiences and exposure in beekeeping activities the indigenous knowledge of beekeeping differs from area to area and from farmer to farmer as well. When the beekeepers were asked to explain how they started beekeeping, it is nearly half of them (49.2 %) replied that they have started beekeeping by catching swarms. Similar study by Tessega, [17], shows in Burie district of Amhara region 34.2 % of the beekeepers establishing colonies by catching swarms, 25.0 % buying, 22.5 % gift, 10 % training and Agricultural office (8.3 %). From this result, one can concluded that catching swarm is the main sources of honeybee colonies in the study areas. The price of one established colony in Libo Kemkem district ranges from 30 to 600 ETB (the average being 371 ETB), but there is no as much extended bee colony marketing in the study area (Table 2). The beekeeper who wants to sell his bee colony broadcast information to the others during coffee or funeral ceremony, *Equb and Senebetie.* The other beekeeper who wants to strengthen his beekeeping activities or the one who wants to establish the new beekeeping activity approaches him and ask the price of the colony and purchase it after a long time bargaining and transport it during night time in order to reduce the biting behavior of the bees.

Honey Quality of the Libo Kemkem District: the present investigation the quality variables analyzed (moisture content, HMF, diastase activity, electrical conductivity, pH, ash/mineral content, free acidity and water insoluble solids) are well summarized. The moisture content of the Libo Kemkem district honey samples ranged from 15.60 - 21.20%, (n = 72). Based on the results of this study none of the honey samples exceeding the limit allowed by the Codex and Council of the European Union (EU) of < 21%. Moisture content is the criterion that determines the capability of honey to remain stable and resist spoilage by yeast fermentation. High moisture content increases the probability/risk that the honey will ferment upon storage. The final water content of a honey sample depends on a number of environmental factors during production such as weather, humidity amounts

Table 2: Socio-economic indicators of the respondents (n = 120) in the study area

Socio-economic Indicators of Respondents	Minimum	Maximum	Average	SD
Age of households head	26	75	47.63	11.4
Beekeeping Experience (yrs)	3	37	12.47	3.54
Household Family size (person)	1	10	6.12	1.83
Land holding (hectare)	0.25	4	1.22	0.59
Honeybee colony holding size	1	60	7.58	8.75

n = number of respondent SD = Standard deviation

Table 3: Physicochemical component values of honey samples by hive types

	Hive Type						
	Traditional (n=12)		Transitional (n=12)		Modern (n=12)		
	Highland (n=6)	Mid highland (n=6)	Highland (n=6)	Mid highland (6)	Highland (n=6)	Mid highland (n=6)	Overall mean (36)
Para meters	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ± SE	Mean ±SE	Mean ± SE
EC	0.41±0.02^{b}	0.61±0.04^{a}	0.65±0.03^{a}	0.65±0.03^{a}	0.72±0.05^{a}	0.67±0.03^{a}	0.62±0.20
ASH	0.15±0.01^{b}	0.27± 0.02^{a}	0.30±0.02^{a}	0.30±0.02^{a}	0.33±0.02^{a}	0.31±0.02^{a}	0.28±0.01
pH	4.20±0.07^{a}	4.20±0.07^{a}	4.16±0.04^{a}	4.16±0.04^{a}	4.27±0.02^{a}	4.27±0.02^{a}	4.21±0.02
MC	14.70±0.32^{a}	14.70±0.32^{a}	14.40±0.34^{a}	14.40±0.34^{a}	14.13±0.38^{a}	14.13±0.38^{a}	14.41±0.13
TA	38.8±2.54^{ab}	38.16±2.35^{ab}	43.33±1.80^{a}	43.16±1.79^{a}	35.0±1.18^{b}	35.0±1.18^{b}	38.91±0.91
WIS	1.33±0.14^{b}	1.85±0.08^{a}	0.60±0.05^{c}	0.78±0.04^{c}	0.25±0.04^{d}	0.60±0.03c	0.90±0.09
HMF	28.89±0.63^{a}	23.10±0.44^{b}	24.15±0.70^{b}	19.55±0.45^{c}	23.50±1.05^{b}	20.43±0.45^{c}	23.27±0.56
DA	7.00±0.65^{e}	9.78±0.50^{d}	11.66±0.52^{c}	14.01±0.71^{b}	15.76±0.58^{a}	17.15±0.51^{a}	12.56±0.62

N = Number of cases, SE = Standard error of mean, meq = Mill equivalent, S = Significant, NS = Non significant ($p > 0.05$)
Within column means followed by the different letter(s) differ significantly ($p < 0.05$)

inside the hive, nectar conditions and treatment of honey during storage and extraction. All the honey samples of the 42 analyzed for moisture had higher moisture content than the acceptable minimum limit, an indication that most farmers harvest ripened capped honey and that generally honey is stored under suitable conditions.

Moisture Content: The minimum, maximum and average moisture contents of the honey on different hive type and honey source analyzed in the present study are indicated in (Table 3). Honey moisture is the quality criterion that determines the capability of honey to remain stable and to resist spoilage by yeast fermentation: the higher the moisture, the higher the probability that honey will ferment upon storage. Lower moisture limits (e.g. 19%), ensuring a better shelf-life of honey which would be met by a large majority of the commercial honeys, have been proposed by some countries for the revision of the Codex Alimentations. The overall mean moisture content of the study area's honey was lower than the country's average (20.6%) for moisture content of honey reported by Adgaba [18]. According to honey standards set by the Ethiopian Quality and Standards Authority, the moisture content of the study area's honey falls under the Grade 'A' category [19]. The maximum acceptable limit for moisture content of Ethiopian honey is 23% [18], while the maximum acceptable moisture content of honey reported by the International Honey Commission is 20% [11]. The low moisture content of the examined honey samples is important and affects quality. Moulds and yeasts cause deterioration of the quality of honey when the moisture content is high, especially if it is > 19%. The moisture content of honey depends on various factors such as the harvesting season, the degree of maturity that honey reached in the hive, type of hive used and environmental temperature. The moisture content of honey samples obtained from modern hives was significantly ($p<0.001$) higher than honey collected from traditional hives. The variation observed in moisture content among honey samples obtained from the two hive types may be due to the difference in bee-hive handling practiced by the beekeepers. The low moisture content of honey obtained from traditional hives may be associated with a hive type that allowed loss of moisture from honey by evaporation. No significant moisture content differences ($p>0.05$) were observed between honey samples obtained from the different locations (Table 3).

Ash (Mineral) Content: The ash content of the honey samples obtained from the study area ranged from 0.014-0.31g with a mean value of 0.17. The mineral content of blossom honey ranges from 0.1 to 0.3% [11]. The average ash content of honey collected from traditional hives was numerically lower than the average ash content of honey samples collected from modern hives (Table 2); however, no significant difference ($p>0.05$) in ash content was observed between honey samples obtained from the two type of hives or among honey samples obtained from the different locations. The ash content of all the analyzed honey samples fell within the 0.01-1.2% range reported by the Ethiopian Quality and Standards Authority [19] and 0.6% maximum limit reported by the International Honey Commission [11], for mineral content of honey. The mineral content of

Table 4: Physicochemical component values of honey samples by honey sources

	Honey source		
Parameters	Overall mean Mean ± SE	Beekeepers (n=36) Mean ± SE	Retailers (n=6) Mean ± SE
EC	0.29±0.02[b]	0.62±0.03[a]	0.57±0.03
ASH	0.22±0.01[a]	0.27±0.03[a]	0.27±0.01
pH	4.22±0.02[a]	4.21±0.04[a]	4.21 0. 02
MC	14.2±0.14[a]	14.41±0.41[a]	14.38±0.13
TA	39.6±0.91[a]	38.91±1.8[a]	39.02±0. 82
WIS	9.30±0.09[a]	0.90±1.5[b]	2.10±0.51
HMF	25.33±0.57[a]	23.27±6.9[a]	23.56±1.0
DA	7.33±0.63[a]	12.56±1.8[b]	11.81±0.65

honey is related to the geographical and botanical origin of the honey. The suggestion stated that ash content of honey depends on the material contained in the pollen collected by the bees during foraging on the flora. The ash percentage found in honey expresses its richness in mineral content and constitutes a quality parameter was seen that honey from all the studied regions showed mean ashes percentages below the allowable maximum and thus conform to the international regulatory standards for quality honey [11]. The ash content is a quality criterion for honey origin, the blossom honeys having lower ash content than the honeydew ones. The RSDR values of one ring trial varied from 4 to 11% over the whole determination range.

Free Acidity: The free acidity level of honey samples analyzed in the present study, ranged from 18.01 to 36.54 meq/kg with a mean value of 23.9 meq/kg) (Table 1). The acidity of honey samples obtained from the two hive types and from the different locations (Table 3) did not show significant differences ($p>0.05$). None of the samples exceeded the honey acidity limit suggested by national (40 meq/kg) [18] and international standards (50 meq/kg) [11]. Such results indicate the freshness of the honey samples and absence of unwanted fermentation in the analyzed honey samples. The acidity of honey is important for taste [11]. The main organic acid found in honey is gluconic acid. Honey also contains minor components such as formic, acetic, citric, lactic, maleic, malic, oxalic, pyroglutamic and succinic acids [11].

pH: Most honeys are acidic and have low pH values. The pH values of honey samples analyzed in the current study ranged from 3.52 to 4.46 with a mean value of 4.02. The mean pH value of the honey from the study area is in line with pH values reported earlier. The pH of honey should be between 3.2 and 4.5 according to Bogdanov [11], there is no significant differences ($p>0.05$) in pH were observed between honey samples obtained from traditional and modern hives and also between honey samples obtained from the different locations.

HMF: The hydroxymethylfurfural (HMF) content of the honey samples analyzed in this study ranged from 0.5 to 3.2 mg/kg with a mean value of 1.8 mg/kg. The average HMF content of honey collected from traditional hives was significantly higher ($p<0.05$) than that from modern hives (Table 2). The amount of HMF in honey is one of the important indicators of honey quality. In fresh honey, HMF is present only in trace amounts and its concentration increases with storage and prolonged heating of honey [11]. Nonetheless, no significant difference in HMF content was observed between honey samples obtained from different locations (Table 3). The overall mean HMF content of honey from the study area is by far lower than the national average (32.4 mg/kg) [18]. The low HMF content of honey produced in the study area indicates its freshness and the good honey handling practice of the area.

Water-Insoluble Solids: The water-insoluble solids content of honey samples analyzed in the present study ranged from 0.01 to 0.46 g/kg with a mean value of 0.09. The mean water insoluble solids content of honey obtained from traditional hives was significantly higher ($p<0.05$) than that obtained from modern hives. This variation may be due to difference in harvesting practices and the storage condition of honey from the two types of hives. The amount of water insoluble solids content of honey samples obtained from different locations did not show significant differences ($p>0.05$). Honey's water-insoluble matter (solids) includes wax, pollen, honey-comb and particles of debris. Water-insoluble matter of honey is used as a criterion of honey's cleanliness. The maximum acceptable amount of water-insoluble matter in honey is 0.1% as reported by [19]. According to Bogdanov [20], even 0.1% of water-insoluble matter in honey is considered high. The high water-insoluble solids content of honey obtained from traditional hives suggests the poor hygienic and harvesting conditions of honey from traditional hives in the study area.

Electrical Conductivity: The conductivity is a good criterion of the botanical origin of honey and thus is very often used in routine honey control. A lower limit has been proposed for blossom than for honeydew honeys. Exceptions have to be made for some blossom honeys, e.g., Tilia, Erica, Calluna, Arbutus, Gossipium, Lavender and Eucalyptus, in which the conductivity shows considerable natural variation.

Diastase Activity: Diastase activity is a quality factor influenced by honey storage and heating. Although there is a large natural variation of this parameter in honey, a standard of a minimum value of 8 on the Gothe scale, has proven to be useful [11]. From this point of view the analyzed samples were fresh with a mean value of 13.50 Gothe units. Thirty-eight percent of the samples from the region of senguerr. River presented diastase activity lower than 6 but greater than 3 Gothe units, with very low or no detectable values of HMF, so the honey samples were in line with international standards. Further studies could be necessary to determine whether the differences in diastase activity of these honeys were mainly due to the botanical origin.

Comparison: Whereas the physicochemical component values of the honey quality in the different sources were obtained significant variations.

CONCLUSIONS AND RECOMMENDATIONS

The production system in the area is mostly characterized by Traditional beekeeping systems with an average honey, Transitional beekeeping systems and frame beekeeping systems. Almost all samples of honey examined in Moisture, Ash, Sugar reducing, free acidity, HMF, pH and water insoluble material were within the acceptable range of world and national standard, except for water insoluble material which is poor mainly due to lack of appropriate handling during harvesting and storage of the product. Due to high potential of the study area for apiculture and good quality standard of the honey, it is advised to exploit the potential for export market with better intervention. More study is also required to characterize the honeybees of the area and major pests and diseases of economic importance.

REFERENCES

1. Adjare, S.O., 1990. Beekeeping in Africa. Agricultural Services Bulletin 68/6 Food and Agriculture Organisation of the United Nations Rome1990http://www.fao.org/docrep/t0104e/t0104e00.htm.
2. Girma Deffar, 1998. Non-Wood Forest Production in Ethiopia. Addis Ababa, Ethiopia http://www.fao.org/DOCREP/003/X6690E/X6690E00.htm.
3. MoARD, 2007. Livestock Development Master Plan Study. Phase I Report-Data Collection and Analysis, Volume N-Apiculture. Addis Ababa, Ethiopia: Ministry of Agriculture and Rural Development.
4. CSA., 2012. Central Statistical Authority, Agricultural Sample Survey: Report on Livestock, Poultry and Beehives Population, Vol. II, No 132, CSA, Addis Ababa, Ethiopia, pp: 28.
5. Tarekegn Garomsa, Lenesil Asfaw and Fekadu Adugna, 2012. Researching Women's Collective Action (RWCA) Qualitative research phase-III Synthetic report-Ethiopia, Submitted to: Oxfam Great Britain (Oxfam GB).
6. Jones, S.L., H.R. Jones and A. Thrasyvoulou, 2011. Disseminating research about bee products. A review of articles published in the Journal of Apicultural Research over the past fifty years. Journal of Api Product and Api Medical Science, 3(3): 105-116.
7. Persano, O.L. and R. Piro, 2004. Main European unifloral honeys: descriptive sheets. Apidologie, 35: 38-81.
8. Szczêsna, T., H. Rybak-Chmielewska, E. Waœ, K. Kachaniuk and D. Teper, 2011. Characteristics of Polish unifloral honeys. I. Rape honey (Brassica napus L. var. Oleifera Metzger). J. Apic. Sci., 55(1): 111-119.
9. Edessa Negera, 2002. Survey on honey production system in West Shoa Zone (unpublished). Holeta Bee Research Center (HBRC), Ethiopia, pp: 15.
10. LKDAO., 2012. Libo Kemkem District Agricultural Office, Types of lands and their Coverage in Libo Kemkem District, Addis Zemen, Ethiopia.

11. Bogdanov, S., 2009. Harmonised Methods of the International Honey Commission [online] http://www.bee-hexagon.net/en/network.htm.
12. David, R.P., 1998. The Nine-point Hedonic scales, Peryam and Kroll Research Corporation; Chicago, Illinois.
13. Adgaba, N., 2007. Atlas of Polen Grains of major honeybee flora of Ethiopia. Holleta, Ethiopa: Hollota Bee Research Centre.
14. SAS., 2002. Statistical Analysis System (SAS), SAS Users? Guide, Version 9.1, (SAS Institute Inc, North Carolina).
15. Hartmann, I., 2004. The management of resources and marginalization in beekeeping Societies of South West Ethiopia. Paper submitted to the conference: Bridge Scales and Epistemologies. Alexandria.
16. Solomon Bogale, 2009. Indigenous knowledge and its relevance for sustainable beekeeping development: a case study in the Highlands of Southeast Ethiopia.
17. Kerealem Ejigu, 2005. Honeybee Production Systems, Opportunities And Challenges In Enebse Sar Midir Wereda (Amhara Region) And Amaro Special Wereda (Southern Nations, Nationalities And Peoples Region), A Thesis Submitted to the Department of Animal Science, School of Graduate Studies Alemaya University, Ethiopia.
18. Tessega Belie, 2009. Honeybee Production and Marketing Systems, Constraints and Opportunities in Burie District of Amahara Region, A Thesis Submitted to the Department of Animal Science and Technology, School of Graduate Studies Bahir Dar University, Ethiopia.
19. Adgaba, N. and A. Admasu, 2002. Effect of honeybee pollination on seed yield and oil content of Niger (Guizotia abyssinica): Proceedings of the first National Conference of Ethiopian Beekeepers Association, June 7-8, 1999, Addis Ababa, Ethiopia, pp: 67-73.
20. QSAE., 2005. Quality and Standards Authority of Ethiopia (QSAE), Honey specification: Ethiopian standard, ES 1202: 2005. Addis Ababa, Ethiopia, pp: 1-17.
21. Bogdanov, S., 2004. Determination of honey botanical origin: problems and issues, Apidologie, 35: 2-3.