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QUALITY OF AUTMUN HARVESTED HONEY IN DANGILLA WEREDA

[a]Tadele Andargie, [b]Gebrehana Ashine
[a] Faculty of Chemical and Food Engineering, Bahir Dar Institute of Technology, Ethiopia.

A B S T R A C T

The study was initiated to evaluate the physico-chemical quality of autumn harvested honey of Ethiopia particularly in Dangilla district, North West Gojjam. Twenty seven honey samples were collected from three different altitudes throughout the chain of honey handlers. The mean value of moisture content, pH, ash, titratable acidity, hydroxyl methyl furfural (HMF) and diastase activity was found to be 18.44, 4.18, 0.265, 3.88, 3.61 and 10.39 respectively. All physico-chemical quality of honey exhibit a significant ($P<0.05$) difference between samples collected from different altitude and across the chain. The majority of the samples were found to be in acceptable range of international honey commission standard and Ethiopian honey quality standard for all of the tested parameters. Among the tested honey samples, only 14.8% (moisture content) and 11.1% (titratable acidity) were above the standard limit. Overall, the outcome of this study shows, Dangilla district has the great potential to provide honey for local consumption as well as for exporting honey to foreign market.

Keywords: physico-chemical, quality, honey, altitude, chain.

INTRODUCTION

Africa is blessed with numerous types of wild honeybee (Adjare, 1990). 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. There is an ancient tradition for beekeeping in Ethiopia which stretches back into the millennia of the country's early history (Deffar, 1998). Of all countries in the world probably no country has a longer tradition of beekeeping than Ethiopia (Hartmann, 2004). It has been practiced traditionally. Moreover, beekeeping is an appropriate and well-accepted farming technology and it is best suited to extensive range of ecosystems of tropical Africa. To date, over 10 million of bee colonies are existing, which include both feral, and hived ones (Kassaye, 2001).

However, the products obtained from this sub sector are still low as compared to the potential of the country. Although thousands of tons of honey are produced every year it is usually poorly managed and unattractive in appearance. Faulty handling, from the time of its harvest until it reaches to market is responsible for its inferior quality. The type of hives used the methods of removing and storage of honey play a vital role in the quality of honey (Edessa, 2005) Careless handling of honey can reduce its quality.

Amongst the factors that most influence honey quality is high temperature, length of storage and moisture content greater than 21%. They lead to PH decrease, increasing in titratable acidity, increasing in Hydroxymethylfurfural (HMF), loss of enzymatic activity (Diastase activity) , changes in flavor, darkening and microbial growth (Moguel, *et al.,* 2005).

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 (IHC, 2009). The decrease in PH indicates the honey is fermented as a result, the titrable acidity increase and the honey shows an inferior quality. Increasing in Hydroxymethylfurfural (HMF) shows the fructose is breakdown as a result of long storage time and heat treatment. The value of this parameter indicates the storage condition and the amount of heating. The higher the HMF value, the lower the quality of honey. A decrease in diastase activity indicates overheating of the honey and

* Corresponding Author:
Email ID: tadeleandargie@yahoo.com

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its storage at higher temperature, subsequently reduces the enzyme activity (invertase, glucose oxidase, amylase, etc.). A low enzyme level mean poor quality of honey.

Honey is almost exclusively used for local consumption, mainly for the brewing of mead, also called Tej. Even though the national honey production satisfies the local demand, it is so crude that it could not compete in the international market. National systems for meeting international standards, monitoring the entire value chain, and furnishing required proof have become a prerequisite for exporting honey to developed countries (Hartmann, 2004).

The main global standards that apply to the import and export of honey are the Codex Alimentarius, which define what honey is, set maximum levels for moisture content, sugars, and water soluble solids, list contaminants, and define hygiene and other standards. But, Codex Alimentarius standard is under revision as most of the analysis methods are outdated. As a consequence an International Honey Commission (IHC) was formed in the early 1990th to revise the methods and standards for honey (Bogdanov, 2006).

The physico-chemical analysis of honey is therefore very important to get knowledge on chemical composition of particular honey types and to check the genuineness, adulteration or heat and storage damage of honey. However, little information is known about the physico-chemical quality of autumn harvested honey in Ethiopia in general and Dangilla district in particular. Therefore this research was initiated to analyze the quality of autumn harvested honey produced in Dangilla district, Northwestern Ethiopia.

MATERIALS AND METHODS

The study was conducted from November to April 2013 at Bahir Dar University, Institute of Technology, School of Chemical and Food Engineering under Food chemistry and food analysis laboratory.

Honey samples were collected directly from Dangilla district, located in all low (≤ 1750m) (medium (1750-2000m) and high (2000-2400m) altitude in North western part of Ethiopia. It is one of the administrative regions under West Gojjam zone of Amhara regional State. Twenty-seven samples of locally produced honey (1 kg each) were collected from Dangilla district. Each sample was mixed thoroughly and kept in plastic containers at 4^{o}C till final analysis was carried out.

Moisture Content: The moisture content of honey sample was estimated by determining the refractive index of the sample with the use of refractometer (AR 200 digital refractometer, Reichert, USA Reichert Inc.) at 20^{0}C following (AOAC , 2000) Official method 969.38.

PH: The pH of honey was determined by using calibrated digital pH meter (Inolab PH / Cond. level, D-82362 weilheim, Germany). Ten gram 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.

Ash: Ash of honey samples was determined following the procedure stated in (IHC, 2009) Official method 920.181.

Titratable Acidity: Titratable acidity of honey samples was estimated following (IHC, 2009) Official method 962.19.

Hydroxyl Methyl Furfural (HMF): HMF of honey samples was estimated following the method stated in (IHC, 2009) Official method 980.23. The absorbance of the samples was determined with UV Spectrophotometer (Jenway LTD, Felsted, Dunmow, Essex, M6 3LB, UK) at wavelength 284 and 336nm by using 1cm-quartz cells.

Diastase activity (DN): Diastase activity of honey samples was determined by using UV spectrophotometer at 565nm wavelength using the procedure stated in (IHC, 2009) Official method 958.09.

Experimental Design and Data Analysis: The experiment had Completely Randomized Block Design (CRBD) which considers one independent variable namely altitude blocked under sample chain with three levels of each. Data obtained from the experiment were analyzed using Analysis of Variance (One way ANOVA) method to compare the mean value and standard deviation of each treatments at significant level of $P<0.05$ by JMP statistical analysis software version 5.0.

RESULT AND DISCUSSION

The results of moisture, ash, pH, titratable acidity, Hydroxymethyl furfural (HMF) and diastase activity of autumn harvested honey from Dangilla district are presented in table 1-6 respectively.

Moisture content of autumn harvested honey: The moisture content of autumn harvested honey of Dangilla district was in the range of 15.723 to 24.637%. The international honey commission standard (IHC, 2009) fix the maximum moisture content must not greater than 21%. Except three samples (WD2 and K3 of peasant and WD3 of merchant in Dangilla town), all other honey samples moisture content falls within the standard limits of both Ethiopia and International honey standards.

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Table 1. Moisture content values of honey samples across the chain and altitude.

Honey Sample Location	Peasant	Intermediate retailer	Merchant in Dangilla
D1	17.487^{d}±0.031	17.307^{f}±0.016	17.153^{d}±0.06
D2	16.867^{e}±0.21	22.67^{a}±0.252	18.396^{b}±0.04
D3	16.21^{f}±0.82	18.327^{b}±0.03	18.7^{b}±0.015
K1	18.72^{c}±0.036	18.23^{c}±0.036	16.67^{e}±0.253
K2	16.927^{e}±0.015	18.72^{b}±0.03	18.43^{b}±0.045
K3	23.85^{b}±0.03	15.74^{g}±0.076	17.66^{c}±0.62
WD1	17.77^{d}±0.11	17.813^{e}±0.061	17.76^{c}±0.04
WD2	24.637^{a}±0.045	15.723^{g}±0.045	17.88^{c}±0.04
WD3	16.527^{e}±0.015	18.027^{d}±0.061	23.75^{a}±0.065

Treatments connected by different letter are significantly different at P < 0.05.

According to the results presented in table 1, significant differences (p < 0.05) were observed in moisture content of autumn harvested honey samples in the district along the chain and altitude. The moisture content of honey at peasant level is probably increasing due to harvesting of unripened honey and improper storage conditions which increase the hygroscopic nature of honey (Chala Kinati, Taye Tolemariam and *et al.,* 2011). Harvesting of honey with high humidity, or subsequent addition of water to honey can result in honey fermentation and lower its quality. The moisture content of honey may vary within the chain under the same ecological zone due to improper handling practice between harvesters, retailers & merchants.

Results are similar with (Nuru,, 1999) who stated that the mean result of Ethiopian honey moisture content to be 20.5% but higher than those of (Latif, *et al.,* 1956) who have reported the moisture content of Pakistani honey to be within the range of 14.3 and 18.6%. Similarly, different honey samples has been assessed for their moisture content and reported their moisture content to be within the standard limits (Duthil, 1983). The moisture content of honey is related to its degree of fermentation. The control of the water content is an important requirement for honey, which sets an upper limit for moisture of 21 percent for honey in general (Codex Alimentarius Commission Standards, 2001).

Ash content of autumn harvested honey: Ash (Mineral) content is a quality criterion for honey botanical origin; the blossom honeys have lower ash content than honeydew honeys. The ash content of honey can be affected by certain nitrogen compounds, minerals, vitamins, pigments and aromatic substances. As (Chala, *et al.,* 2011) suggested that ash content of honey averages about 0.212% of its weight, but varies widely from 0.02 to over 1.0%.

Table 3. Ash content of honey samples collected from Dangilla district.

Honey Sample Location	Peasant	Intermediate retailer	Merchant in Dangilla
D1	0.262^{bc}±0.042	0.270^{bc}±0.045	0.248^{bcd}±0.075
D2	0.312^{bc}±1.1	0.253^{bcd}±0.67	0.230^{cd}±0.05
D3	0.284^{bc}±0.03	0.208^{cd}±0.21	0.261^{bcd}±0.1
K1	0.294^{bc}±0.1	0.310^{b}±0.076	0.224^{de}±0.23
K2	0.249^{cd}±0.14	0.247^{bcd}±0.15	0.306^{a}±0.02
K3	0.462^{a}±0.079	0.411^{a}±1.36	0.188^{e}±0.14
WD1	0.325^{b}±0.24	0.286^{bc}±0.19	0.267^{abc}±0.61
WD2	0.136^{de}±0.073	0.255^{bcd}±0.25	0.271^{ab}±0.14
WD3	0.183^{e}±0.006	0.177^{d}±0.14	0.223^{de}±0.037

Treatments connected by different letter are significantly different at P < 0.05.

Ash content of normal honey is not more than 0.6% (Codex Alimentarius Commission Standards, 2001, Quality Standard Authority of Ethiopia, *Honey Specification*, 2005). The ash content of autumn harvested honey samples from Dangilla district ranged between 0.136 – 0.462 which is within the standard limits. These results are in-line with those of who reported that ash content of honey samples to be within the range of 0.1-1.0% (Nuru, 1999, Quality Standard Authority of Ethiopia, *Honey Specification*, 2005).

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Based on the results showed in table 2, autumn harvested honey sample location across the chain has a significant ($p < 0.05$) effect on the ash content of honey. This variability in ash contents has been associated with different botanical and geographical origins of honey. Honey samples collected from peasants of lower altitude have higher ash content values.

PH value of autumn harvested honey from Dangilla district: PH influences the texture, stability and shelf life of honey and has a great importance during the extraction and storage of honey. Autumn harvested honey samples collected from Dangilla district have the pH value ranged from 3.89 to 4.49. The lower the pH value of honey inhibits the presence and growth of micro-organisms and makes honey compatible with many food products in terms of pH and acidity.

Table 3. pH value of collected honey samples.

Honey sample Location	Peasant	Intermediate retailer	Merchant in Dangilla
D1	$4.36^{b}\pm0.21$	$4.44^{a}\pm0.1$	$4.11^{c}\pm0.057$
D2	$4.15^{f}\pm0.15$	$4.25^{bc}\pm0.06$	$4.15^{c}\pm0.38$
D3	$4.21^{cd}\pm0.06$	$4.42^{a}\pm0.53$	$4.12^{c}\pm0.49$
K1	$4.20^{de}\pm0.057$	$3.97^{e}\pm0.25$	$3.89^{e}\pm0.17$
K2	$4.10^{f}\pm0.06$	$3.98^{e}\pm0.21$	$4.31^{a}\pm0.01$
K3	$4.09^{f}\pm0.01$	$4.22^{cd}\pm0.1$	4.23 ± 0.12
WD1	$4.27^{c}\pm0.12$	$3.96^{e}\pm0.057$	4.04 ± 0.21
WD2	$4.49^{a}\pm0.11$	$4.20^{d}\pm0.06$	4.03 ± 0.31
WD3	$4.18^{de}\pm1.01$	$4.28^{b}\pm0.23$	$4.21^{b}\pm0.29$

Treatments connected by different letter are significantly different at $P < 0.05$.

Published reports indicate that pH should be between 3.2 and 4.5 (Chala, *et al.,* 2011). The result presented in table 3 is within the standard value mentioned in the European Standard (IHC, 2009) which is given in the range 3.4-6.1.

Titratable acidity of honey: The free acidity values of autumn harvested honey of Dangilla district were ranged from 26.7±1.31 to 70.3±2.20. Variation in free acidity among different honeys can be attributed to floral origin or to variation because of the harvest season (Chala, *et al.,* 2011). When the acidity becomes high, the honey becomes sour.

Table 4. Titratable acidity (TA) of honey.

Honey sample Location	Peasant	Intermediate retailer	Merchant in Dangilla
D1	$26.7^{d}\pm1.31$	$36.0^{bcde}\pm0.1$	$44.0^{abc}\pm1.23$
D2	$27.3^{d}\pm0.30$	$40.3^{abc}\pm0.80$	$53.3^{a}\pm0.58$
D3	$36.0^{bcd}\pm0.17$	$32.0^{cde}\pm0.57$	$50.3^{ab}\pm1.05$
K1	$51.0^{b}\pm0.7$	$46.0^{a}\pm0.36$	$32.3^{de}\pm0.32$
K2	$42.3^{bcd}\pm0.38$	$28.7^{e}\pm0.23$	$29.7^{e}\pm0.45$
K3	$70.3^{a}\pm2.20$	$42.3^{ab}\pm0.49$	$34.6^{cde}\pm0.32$
WD1	$44.3^{bc}\pm0.49$	$37.3^{bcd}\pm0.42$	$34.7^{cde}\pm0.21$
WD2	$33.7^{cd}\pm0.06$	$38.7^{abc}\pm0.35$	$26.7^{e}\pm0.42$
WD3	$37.3^{bcd}\pm0.61$	$29.3^{de}\pm0.56$	$41.0^{bcd}\pm0.1$

Treatments connected by different letter are significantly different at $P < 0.05$.

It is stated that free acidity of honey may be explained by taking into account the presence of organic acids in equilibrium with their corresponding lactones, or internal esters, and some inorganic ions, such as phosphate (Chala, *et al.,* 2011). This may be due to the origin of the flora from which the honey is made. The majority of the results are endorsed as Ethiopian honey titratable acidity mean test result is 39.9 meq kg^{-1} (Nuru, 1999). As reported in (Latif, *et al.,* 1956) work, formic acid content of Pakistani honey to be within the permissible limits of international standards. The International honey commission stated that the titratable acidity of honey ranges from 40-50 meq/kg of honey (IHC, 2009). The research results were under the standard limit except that of three sample values (51.0, 70.3 & 53.3 meq/kg). This deviation may be due to the origin of the flora from which the honey is made and its storage time & condition.

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HMF value of autumn harvested Honey: Hydroxyl methyl furfural (HMF) is formed by the decomposition of fructose in the presence of acid. This major honey quality factor is an indicator of honey freshness and overheating. In fresh honeys, practically there is no HMF, but it increases upon storage depending on the pH of honey and on the storage temperature (Bogdanov, 2006).

Table 5. HMF value of honey samples.

Honey Sample Location	Peasant	Sc retailer	D Merchant
D1	$4.64^{b}\pm0.01$	$1.047^{g}\pm0.042$	$8.528^{b}\pm0.045$
D2	$1.645^{f}\pm0.03$	$0.746^{h}\pm0.046$	$8.378^{c}\pm0.04$
D3	$1.195^{g}\pm0.036$	$2.84^{e}\pm0.03$	$10.324^{a}\pm0.07$
K1	$3.741^{d}\pm0.025$	$5.539^{c}\pm0.025$	$4.042^{d}\pm0.03$
K2	$4.777^{a}\pm0.032$	$6.436^{b}\pm0.04$	$0.151^{i}\pm0.06$
K3	$4.14^{c}\pm0.049$	$8.23^{a}\pm0.03$	$1.492^{h}\pm0.046$
WD1	$1.195^{g}\pm0.03$	$0.749^{h}\pm0.026$	$3.74^{e}\pm0.016$
WD2	$1.794^{e}\pm0.025$	$2.544^{f}\pm0.04$	$2.69^{f}\pm0.053$
WD3	$4.490^{h}\pm0.006$	$3.889^{d}\pm0.032$	$2.54^{g}\pm0.032$

Treatments connected by different letter are significantly different at $P < 0.05$.

International honey commission has proposed HMF value between 40-60 mg kg^{-1} Honey which contains more than 60 mg kg^{-1}(IHC, 2009). HMF value indicates that the honey is heated or adulterated with invert sugar or syrups. The HMF contents of autumn harvested honey samples collected from Dangilla district ranged between 0.151 and 10.324 mg kg^{-1}. Thus, all of the samples meet the HMF standard for honey quality. The HMF data shown in table 5 exhibits a significant ($p < 0.05$) difference between honey sample locations under each sample chain.

Previously, (Nuru, 1999) observed that Ethiopian honey mean test result of HMF was 32.4 mg $kg^{-1}$and (Crane, 1976) analyzed the HMF content of honey samples and the mean values were ranged from 0.9 to 22.8 mg kg^{-1}. Similarly, (Duthil, 1983) have also reported that mean HMF content of different honey samples ranged from 5.47 to 5.95 mg kg^{-1}.

Diastase number of autumn harvested Dangilla district honey: Diastase Number (DN) in Schade scale, which corresponds to the Gothe scale number, is defined as a gram of starch hydrolyzed in 1 h at 40^{0}C per 100 g honey.

According to the Honey Quality and International Regulatory Standards, from the International Honey Commission, the diastase activity must not be less than or equal to 8, expressed as diastase number (DN) (IHC, 2009). The Codex Alimentarius standard has established the minimum diastase activity value of 3, similarly to Ethiopian honey quality standard for honeys with natural low enzyme content. In honeys with a DN less than 8 and higher than or equal to 3, the HMF must not be higher than 15 mg/kg (Codex Alimentarius Commission Standards, 2001).

Table. Diastase number of honey samples.

Honey sample Location	Peasant	Intermediate retailer	Merchant in Dangilla
D1	$9.23^{c}\pm0.056$	$5.26^{e}\pm0.03$	$22.46^{b}\pm0.055$
D2	$8.54^{d}\pm0.046$	$2.87^{g}\pm0.036$	$3.22^{h}\pm0.051$
D3	$3.62^{f}\pm0.025$	$4.65^{f}\pm0.0351$	$10.18^{f}\pm0.082$
K1	$27.29^{a}\pm0.03$	$19.58^{a}\pm0.031$	$20.93^{c}\pm0.0252$
K2	$2.93^{g}\pm0.031$	$11.13^{d}\pm0.03$	$6.48^{g}\pm0.045$
K3	$3.73^{e}\pm0.046$	$12.30^{b}\pm0.006$	$38.41^{a}\pm0.21$
WD1	$2.08^{h}\pm0.035$	$4.65^{f}\pm0.0351$	$10.85^{e}\pm0.04$
WD2	$20.15^{b}\pm0.03$	$11.42^{c}\pm0.0251$	$14.70^{d}\pm0.098$
WD3	$0.78^{i}\pm0.03$	$2.06^{h}\pm0.04$	$0.95^{i}\pm0.07$

Treatments connected by different letter are significantly different at $P < 0.05$.

Overall the diastase activity (table 6) for autumn harvested honey samples collected from dangilla district was ranged from 0.78 to 38.41 DN. When comparing the DN values of samples, it clearly exhibits the significant

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difference (P<0.05) between honey sample location and the chain. The lowest value was found for sample collected from peasants. This may happen due to heat intensity during harvesting and storage conditions that the honey handler practiced.

CONCLUSION

The majority of the samples were found to be in acceptable range of international honey commission standard and Ethiopian honey quality standard for all of the tested parameters. All physico-chemical quality of honey exhibit a significant (P<0.05) difference between samples collected from different altitude within the chain. Among the tested honey samples, only 14.8% and 11.1% were above the standard limit for moisture content and titratable acidity respectively. The deviation of samples of honey moisture and titratable acidity could easily be brought to standard range by harvesting the honey at the right ripening time through trained harvesters. Handlers can also trained to use proper packaging materials.

The value of physico-chemical quality indices of autumn harvested honey samples collected from Dangilla district were under the limit of both International Honey Commission and Ethiopian Honey Quality Standards. Overall, the outcome of this research shows, Dangilla district has the great potential to provide honey for local consumption as well as for exporting honey to foreign market.

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