

Research Article

Effect of Storage Time on Honey Quality in Selected Districts of West Hararghe Zone, Oromia Regional State

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Abstract

This study was conducted to identify the effect of storage time on honey quality in West Hararghe zone. A structured questionnaire interview and checklist were the main tools used to gather primary data from the households. The household data were collected from 96 beekeepers in three districts of west hararghe zone. For the physicochemical analysis, honey was harvested from frame beehive of a single farmer and stored in a glass jar for 3, 6 and 9 months and analyzed for moisture, pH, free acidity, glucose, fructose, sucrose and HMF. Majority of the beekeepers owned traditional beehives. The average beekeeping experience of the sample beekeepers was 10.25 years with the range varying from 1 to 40 years of continued engagement in beekeeping. From the total number of respondents 79.2 were store honey for different purposes up to one year. Beekeepers store their honey in different sizes and types of materials available in the area with the most common being Plastic bucket (46.4%), followed by Plastic bucket and “qil” (29.8%), Plastic bucket,”qil” and “Tanika” (11.9%) and “Tanika” and plastic bucket (6%). From the respondents 97.9% were smoke the hive during honey harvesting and 53.1 said it has no effect on honey quality. Beekeepers identified Olea spp, Vernonia spp, cow dung, Juniperus procera and Carissa spinarum as major smoking material in the study area. The results of the physicochemical analysis indicated all the samples are within the acceptable range of world and Ethiopian honey quality standards with moisture (20.6%), free acidity (34.4 meq/kg), pH (4.6), glucose (30.8%), fructose (33.4%), sucrose (3%) and HMF (8.5 mg/kg). From this study it was revealed that the quality of honey produced in the area was good during the nine month storage time.

Keywords

Honey, Quality, Storage Time, West Hararghe

1. Introduction

Honey, a natural product gathered by honey bees from two different sources: nectar or honeydew. Nectar is the most common source of honey worldwide, while honeydew is only common in European countries such as Greece and Austria. Bees collecting nectar for use as sugars consumed to support metabolism of muscle activity during foraging or to be stored as a long-term food supply. Honey is a sweet, viscous food

substance made by bees and some related insects. It is one of nature's wonders as well as the simplest and often the best way to soothe a sore throat and it can be taken at any time [22]. The variety of honey produced by honey bees (the genus *Apis*) is the best-known, due to its worldwide commercial production and human consumption. Honey is collected from wild bee colonies, or from hives of domesticated bees, a practice

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known as beekeeping or apiculture.

Honey makes complex chemical composition, because it contains a mixture of other carbohydrates, amino and organic acids, minerals, aromatic substances, pigments, waxes as well as pollen grains [26]. Honey is generally evaluated by a physicochemical analysis of its own constituents. These constituents include the storage quality, granulation, texture; flavor and the nutritional quality of the honey are of great importance to the honey industry, which are also responsible for the medicinal quality of honey. The International Honey Commission (IHC) has therefore proposed certain constituents as quality criteria for honey. These constituents include PH, moisture content, electrical conductivity, reducing sugars, sucrose content, minerals, free acidity and hydroxymethylfurfural [6].

PH is an important parameter during the extraction and storage of honey. It influences honey texture, stability and shelf life [29]. In general, a low pH of honey inhibits the growth and proliferation of microorganisms. According to [11] standards, the normal range of pH in honey is 3.4 to 6.1. If the pH is increases or decreases above or below the normal range, then several undesirable changes occurs in honey and therefore the honey is not suitable for human consumption.

In honey, several harmful and toxic compounds such as HMF may be present and they possibly showed their effect when consumed by humans. Several studies have been shown that the compound has adverse effects of causing mutation, toxic genetically and carcinogenic to mice [28] and it also has adverse effects on blood cells. It was also reported that, it induced tumors and colon cancer also [23]. Due to potential toxic effects, HMF is essential for assessing the conformity of honey [23]. Honey quality is significantly influenced by storage time and heating. HMF content increase in a way that beyond the set limits indicate to the adulteration of honey whether by selling the old honey as a new replacement of honey class with another cheaper one or by adding cheap materials such as syrup corn, starch glucose rich and fructose-rich syrup to honey. Other types of honey falsification are feeding bees with sucrose syrup [12]. The increasing concentration of the HMF compound on the limit refers to the increasing age of the honey [30]. HMF content in honey is an important parameter for determining the quality of honey, its age, antioxidant activity as well as its nutritional value.

The Study area, West Hararghe zone is known by high potential of honey production. And again there is different type of bee forages that are locally known by people. This different type of bee forage makes bee to produce honey with different component, color and flavor. By saying this, when honey analyzed at laboratory after storage of certain time interval; the physiochemical properties of honey may differ from each other. And the farmer store honey for a lot of month in order to expect the time when honey is more expensive and to use as medicine when it is needed. Therefore, the time of storage has its own impact. Thus, the objectives this study was:-

1) To identify the effect of storage time on honey quality;

- 2) To know the relationship between storage time and physiochemical properties of honey at study area;
- 3) To assess the storage material, method of storage and time of storage for honey in the study area.

2. Materials and Methods

2.1. Description of Study Area and Data Collection

The study was conducted in three districts (Gemachis, Oda Bultum and Daro Labu) of West Hararghe Zone of Oromia National Regional State, Eastern Ethiopia. Gemachis district has mean annual temperature of 17 degree Celsius. The area has also 1280 mm annual rainfall. Oda Bultum district is characterized by 28 and 13 degree Celsius maximum and minimum daily temperature and 1053 mm mean annual rainfall. Daro Lebu district has 21.5 mean daily temperature and 1120 mm mean annual rain rainfall [31].

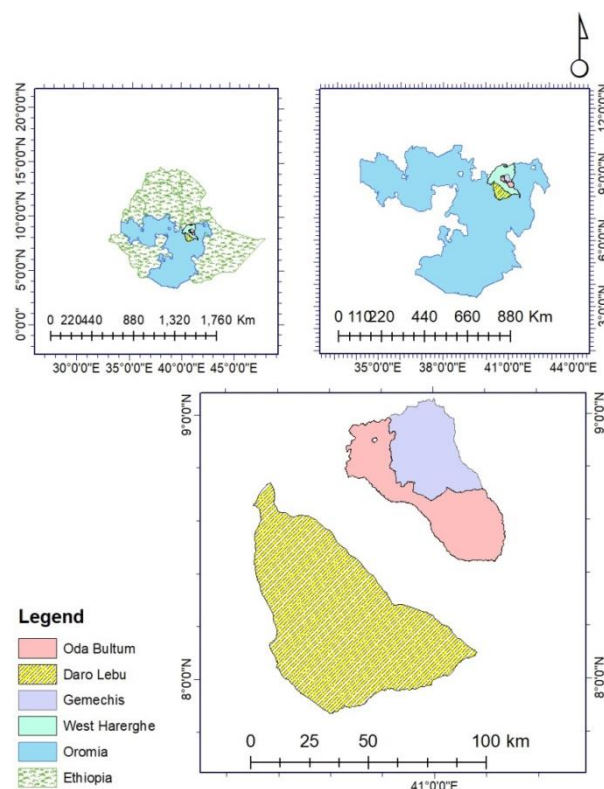


Figure 1. Map of the study area and sampling district.

2.2. Data Collection Method

Phase I: Survey Parts

Primary and secondary data was collected by using well-structured questionnaire and checklist. And again data like market price of honey, honey harvesting Method, honey handling, Storage material that farmer's use, for how many

month or year that farmers are store honey and constrainer of storage were collected. Additional data was collected through focused group discussion from experts, community groups, development agents and farmers. All necessary information like socio-economic description of the household, honey production potential, honey flow season was also collected.

Phase II: Laboratory Parts

Honey samples were collected from three agro ecologies (high land, mid land and Low land) of West Hararghe zone for laboratory analysis. All the samples was collected freshly in sterile containers of glass jars (labeled with numbers, place and date of collection) and was stored under room temperature (25-29 °C) in the laboratory until analysis. Then the sample was analyzed by three month interval from harvesting time, for physicochemical in order to know whether the component that exist in the honey like, Ash content, PH, HMF, glucose content, fructose content, sucrose content, moisture content, acidity and so on are increase or decrease.

3. Honey Storage

Honey is stored in a cool place for longer shelf life. It is stored at very low (-20 °C) and close to ambient (20 °C) temperatures resulted in fine crystals and coarse grains, respectively. While storing in the mild temperature range (4-10 °C) resulted in mixed size crystals. Therefore, the honey can be processed into a number of value added products ranging from intermediate moisture to dried products, to overcome the problems of storing liquid honey and of crystallization during its storage. Honey in the dried form could overcome these problems, and therefore, has good commercial potential in the bakery and confectionary industry. Usage of honey powder in dry mixes for cakes and bread found to improve the sales appeal, as well as flavor, color, aroma, texture, and the keeping quality of the product.

3.1. Effect of Storage

During storage honey becomes crystallized sooner or later. Crystallized honeys are not popular with consumers and can only be marketed when it is liquefied. In order to change to a liquid, heat is needed. Gentle heating (32-40 °C) is mostly used to liquefy crystallized honey and to destroy yeast. Besides long period of storage high temperatures can adversely affect the chemical composition of honeys [8].

3.2. Physiochemical Properties of Honey

3.2.1. Sugar Content

Honey is supersaturating sugar solution, where carbohydrate is the main constituent's accounts for about 95% dry. The most important physiochemical and nutritional properties of honey, such as sweetness, viscosity, granulation specific rotation and energy value depends on sugars composition [9].

3.2.2. Hydroxy-Methylfurfural

HMF is a furanic compound produced by sugar degradation, from dehydration of hexoses in acidic medium and to a lesser extent as an intermediate in the Millard reactions. HMF is the quality index which is a good model to estimate shelf life of honey [5]. Several factors such as temperature, time of heating during processing, storage conditions, aging of honey products and sources of floral were found to influence the HMF content in honey [24]. Hydro material increases during honey processing by heat treatment and also by adulteration with a commercial sugars and thought storage [4].

3.2.3. Free Acidity

Honey could have be difference in its free acidity. This difference in free acidity among different honeys can be attributed to floral origin or to variation in the harvest season. The limit for honey acidity according to EU honey standard [13].

3.2.4. Moisture Content

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). Moisture contents of honey from different locations and hive types are 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 [2, 7].

3.3. Data Analysis

In order to analysis the above data, SPSS. 20 versions Software and excel spreadsheet were used.

4. Results and Discussions

4.1. Household Socio-Economic Characteristics

From the total of 96 sample households interviewed, about 80.2% and 18.8% were male and female headed household, respectively (Table 1). The mean age of the respondents was 41.76 ± 12.117 years that ranged from 20 to 70 years (Table 2). The result showed that beekeeping can be performed by different age groups and in most cases people at younger and older ages are more engaged in beekeeping. The average family size 5.33 persons, with minimum and maximum family size of 1 and 12 persons, respectively (Table 2). The average beekeeping experience of the sample beekeepers was 10.25 years with the range varying from 1 to 40 years of continued engagement in beekeeping. The average landholding during the study year was 0.82703 hectares with minimum and maximum holding of 0.125 and 3.000 hectares, respectively.

From the total beekeepers, 96.9% were married while 1% and 1% were single and divorced, respectively (Table 3). Based on the study result, beekeeping activities could be performed by every social class of the community regardless of their marital status. Among the respondents 31.3%, 27.1% and 34.4% were illiterate, read and write and other, respectively. The survey result showed that all the beekeepers in the area are using all types of beekeeping practices. Majority of the beekeepers own traditional type of beekeeping with having maximum number of 30 colonies.

Table 1. Sex of the household.

Sex of the HH	Frequency	Percent
Male	77	80.2
Female	18	18.8
Total	96	100.0

Table 2. Family size, experience, age, and landholding of household heads (N = 96).

Socio-Economic Characteristics	N	Minimum	Maximum	Mean	Std. Deviation
Age of the respondent (yrs)	91	20	70	41.76	12.117
Family size	95	1	12	5.33	2.482
Landholding (ha)	86	.125	3.000	.82703	.543061
Experience in beekeeping (yrs)	93	1	40	10.25	9.613

Table 3. Educational level and marital status of the respondents.

Socio-Economic Characters	Frequency	Percent
Educational level	7	7.3
Illiterate	30	31.3
Read And Write	26	27.1
Other	33	34.4
Marital Status		
Single	1	1.0
Married	93	96.9
Divorced	1	1.0

Table 4. Honeybee colony ownership.

Hive type	Minimum	Maximum	Mean	Std. Deviation
Frame hive	0	7	2.42	1.816
Transitional hive	2	4	3.00	1.414
Traditional hive	1	30	5.02	5.444

From the respondents 97.9% were smoke the hive during honey harvesting and 53.1 said it has no effect on honey

quality. *Olea*, *Vernonia spp*, cow dung, *Juniperus procera* and *Carissa spinarum* were the major smoking material in the study area.

4.2. Honey Storage

From the total number of respondents 79.2 were store honey for different purposes. Among them for medicine, to expect when market value is high and home consumption. Majority of the respondents store their honey for only one year (Table 5).

Table 5. Honey storage.

Respondent	Frequency	Percent
Yes	100.0	79.2
No	18	18.8
Total	96	100.0

4.3. Storage Material

Beekeepers store their honey in different sizes and type of materials available in the area with the most common being Plastic bucket (46.4%), followed by Plastic bucket and “qil” (29.8%), Plastic bucket,”qil” and “Tanika” (11.9%) and “Tanika” and plastic bucket (6%) for maximum of one year period.

Table 6. Storage Material.

Storage Material	Frequency	Percent
Plastic bucket,”qil” and “Tanika”	10	11.9
Plastic bucket	39	46.4
Qil and “Tanika”	2	2.4
“Tanika” and plastic bucket	5	6.0
Plastic bucket and qil	25	29.8
Stainless steel	3	3.6
Total	84	100.0

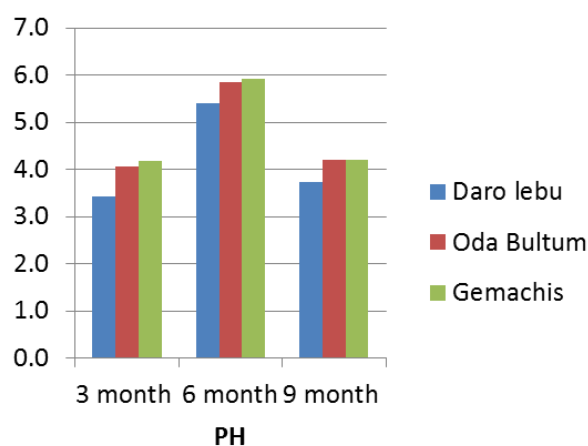
4.4. Physicochemical Property of Honey Samples

Table 7. Mean value of physicochemical property of honey.

Time (months)	PH value	Moisture (%)	HMF (mg/kg)	Free Acidity (mequiv/kg)	Glucose (%)	Fructose (%)	Sucrose (%)
3	3.9	20.2	7.1	36.0	27.0	37.5	0.5
6	5.7	21.9	9.7	25.2	26.4	34.4	2.6
9	4.0	20.8	8.6	42.0	38.9	28.3	5.8
Over all mean	4.6	20.6	8.5	34.4	30.8	33.4	3.0
Ethiopian standard	3.2-4.5	<20	<40	<40	-	-	<5

4.4.1. The pH

Gemechis district showed significant increase in the pH, from 4.1-5.8 in the last six months of the storage and the pH declined to 4.2 during nine month storage. After six months of the storage, honey samples of the all sites experienced increased in the pH, whereas each sample of the honey from tall site showed decrease in pH after nine months of storage. On the whole, Gemachis honey samples showed fluctuation in the pH during storage. The pH increased to 5.8 during the initial six months and decreased to 4.2 during the subsequent three month of storage (Figure 2). The pH increased during the initial three months of storage which was 3.4-5.4 in Daro Lebu sample of the honey. Instead of further increase, pH of Daro Lebu honey samples showed a decrease, becoming lower than the one recorded at six month storage. The pH increased from 4.2 to 5.9 in oda bultum's honey during the initial six months. Instead of further increase, pH of the honey samples decreased to 4.2 at the end of nine months of storage. The pH of honeys samples from West hararghe zone showed significant difference ($p=0.002$) among the sample districts.

**Figure 2.** The effect of storage time on pH of honey samples.

4.4.2. Moisture Content

The moisture content is an important criterion for evaluating the grade of ripeness of the honey and its shelf-life. In general high amount of water causes the honey to ferment, to

spoil and to lose flavor, with ensuing honey quality loss. Honey moisture content depends on the environmental conditions and the manipulation from beekeepers at the harvest period, and it can vary from year to year. High moisture content could accelerate crystallization in certain types of honey and increase its water activity to values where certain yeasts could grow. During storage of honey, the undesirable fermentation is caused by the action of osmotolerant yeasts resulting in formation of ethyl alcohol and carbon dioxide. The alcohol can be further oxidized to acetic acid and water resulting in a sour taste. The moisture content of honey increased significantly with the increase of storage period.

However, the values of moisture content of honey after 3, 6, and 9 months, of storage varied critically and were found to be non-significant. The mean value of honey at nine month storage was 20.6%. The results of the present study of moisture content are in agreement with the findings of [16] who reported that the moisture content in ranges of 17.5-18.4%. Also supports the findings of [10, 14] who reported increase in moisture content from 20.13 to 21.06% and 24.25 to 26.30 respectively with storage. Results clearly indicate that moisture content increased with increasing storage period of honey and decreased.

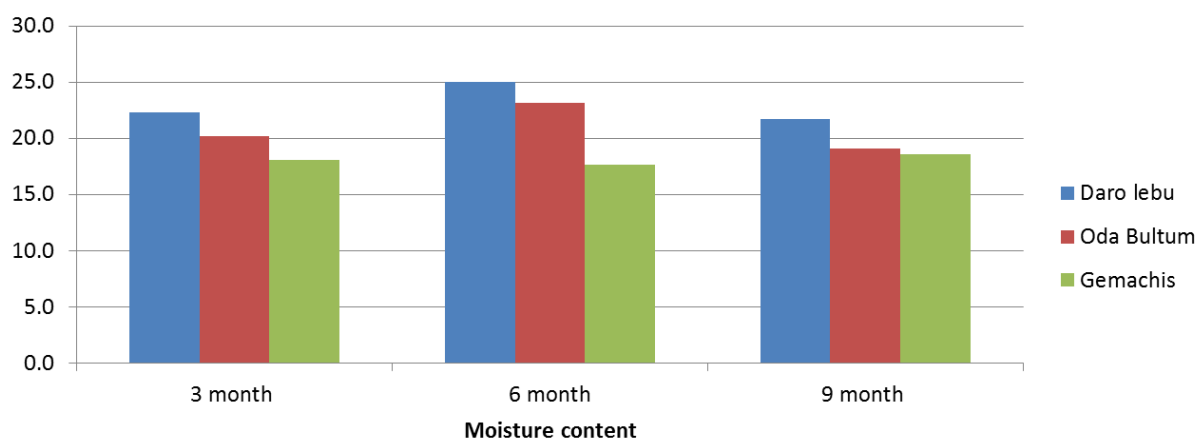


Figure 3. The effect of storage time on moisture content of honey.

4.4.3. Acidity

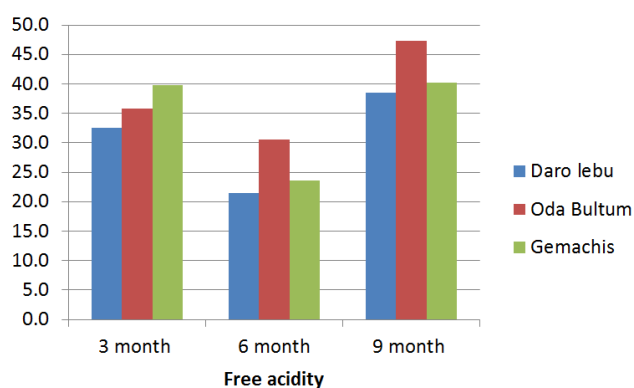


Figure 4. The effect of storage time on free acidity of sampled honey.

On the whole, at the end of nine months of storage, the free acidity value in all Gemechis, Daro Lebu and Oda Bultum honey samples showed 37.84 meq/kg, 30.84 meq/kg, 34.5 meq/kg, value respectively. When stored, Gemechis honey samples had high free acidity values, which according to the international standards was close to the upper permissible,

limit (50 meq/kg). These samples showed (35.8- 30.5 meq/kg) decrease in the free acidity during initial six months of storage time and in the later three months free acidity of the honey increased to 47.3 meq/kg (Figure 4). Ageing increased the free acidity value of every independent sample during nine months storage. The free acidity of all honey samples from West Hararghe zone were less than 50 meq/kg, a maximum limit for acidity prescribed by International Honey commission [19].

4.4.4. Hydroxyl-Methyl-Furfural (HMF)

The HMF content in the samples of honey from Gemechis district decreased from 12.1 to 9.3 during three month to six month storage time. After six months of storage HMF content was less than permissible limit of 40 mg/kg in the samples. Daro Lebu honey samples showed significant increase in HMF content 2.8-9.2 mg/kg during the first six months and decreased to 6.8 by the end of nine months (Figure 5). The HMF content at Oda Bultum showed continuous increase during the six month storage time 6.2-10.7 mg/kg and decreased to 6.2 mg/kg after nine month of storage. The results are in line with [27] who reported that the HMF content in honey increased with increase in the storage duration.

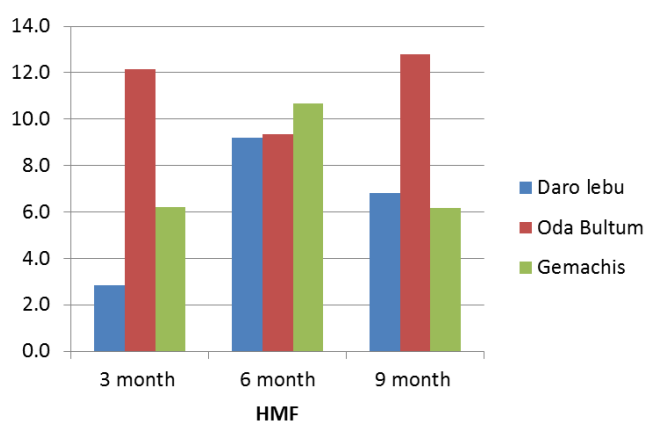


Figure 5. The effect of storage time on HMF.

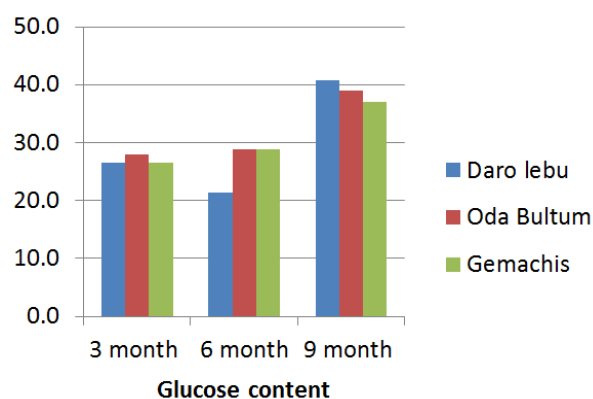


Figure 7. The effect of storage time on glucose content.

4.4.5. Fructose

The fructose content of honey sample of the study area was 33.4 g/100g. A significant difference was declared between districts ($p=0.000$) in terms of fructose content of the honey. The current finding is in line with [3] who reported the mean fructose content of 38.64 ± 0.61 g/100g from the Godere district.

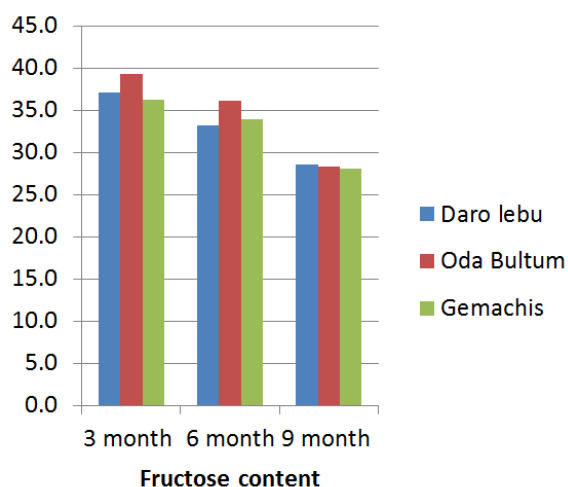


Figure 6. The effect of storage time on fructose content.

4.4.6. Glucose Content

The glucose content of the evaluated honey samples of the study area was 30.8 g/100g. There was a significant difference between districts ($p=0.001$) in terms of the honeys glucose content. The difference in the glucose content between the sources of the honey collection might be due to the difference in the flora of honeybee and Agro ecology. Aregay [3] reported similar finding of 36.37 ± 2.14 g/100g glucose content from Godere district. The sugars of honey are responsible for several of the physicochemical properties such as viscosity, hygroscopic and granulation characteristics of honey.

4.4.7. Sucrose

The mean sucrose content of the sampled study area honey was 3 g/100g. The result revealed that the samples were within the standard range of [25]. A significant difference was not noticed between districts ($P=0.044$) in sucrose content of honey. The higher sucrose content of honey from shop as opposed to the farm-gate source of honey might be due to the adulteration of honey by the addition of commercial sugar in honey to increase the volume of honey. Additionally, it might be due to the early harvest of honey before sucrose is converted into fructose and glucose (shop traders might purchase unripen honey from their customers). In line with this result, [15] reported the mean sucrose content of 2.60 ± 0.51 g/100g from the Adaberga district of West Shewa zone. Nevertheless, higher than the current finding [20, 21, 17, 18, 1] reported the mean of 4.1 ± 1.2 g/100g, 7.55 ± 4.03 g/100g, 4.46 ± 2.59 g/100g, 7.55 g/100g, and 4.04 g/100g sucrose content, respectively, from the different locations of the country. The variation in sucrose content from different parts might be due to harvesting, handling practices and flora sources. The low sucrose content of the studied honey samples indicated that honey produced from the study areas (farm gate) was natural and free of any adulteration. International Regulatory Standards restricted sucrose content not to be greater than 5 g/100g of honey.

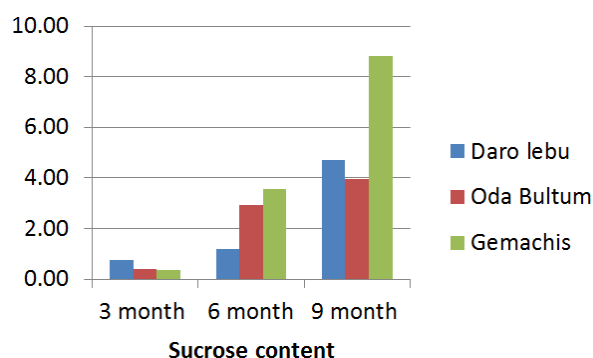


Figure 8. The of storage time on sucrose content.

4.5. Correlation

As shown in Table 8 below, pH is strongly positively cor-

related with moisture and HMF; moisture content and HMF are also positively correlated. Sucrose and glucose are also highly positively correlated.

Table 8. Correlation between physicochemical properties of honey.

Time	pH	Free Acidity	Moisture	HMF	Fructose	Glucose	Sucrose
pH	1						
Free acidity	-0.97	1					
Moisture	1.00	-0.99	1				
HMF	1.00	-0.94	0.99	1			
Fructose	0.18	-0.44	0.27	0.11	1		
Glucose	-0.39	0.61	-0.47	-0.32	-0.98	1	
Sucrose	-0.12	0.37	-0.21	-0.04	-1.00	0.96	1

5. Conclusion and Recommendation

Beekeeping is practiced as an integral part of other agricultural activities mainly livestock and crop production. The majority (95.5%) of the beekeepers own traditional hive.

From the total number of respondents 79.2% were store honey for different purposes. Majority of the respondents store their honey for only one year in different sizes and types of materials available in the area with the most common being Plastic bucket (46.4%), followed by Plastic bucket and “qil” (29.8%), Plastic bucket,”qil” and “Tanika” (11.9%) and “Tanika” and plastic bucket (6%). The results of the physico-chemical analysis indicated that except the pH all the samples are within the acceptable range of world and Ethiopian honey quality standards with moisture (20.6%), free acidity (34.4 meq/kg), pH (4.6), glucose (30.8%), fructose (33.4%), sucrose (3%) and HMF (8.5 mg/kg). Honey collected from the study area is in good quality standard during storage, but further analysis is important to determine the effect storage time on honey quality in relation to different storage materials that farmers use and temperature.

Abbreviations

PH	Power of Hydrogen
HMF	Hydroxyl-Methyl-Furfural
QSAE	Quality and Standard Authority of Ethiopia
IHC	The International Honey Commission
HH	House Hold
meq/kg	Milliequivalents per Kilogram
mg/kg	Milligram per Kilogram
°C	Degree Celsius

Author Contributions

Dema Dugda: Data curation, Formal Analysis, Software, Visualization, Writing – original draft, Writing – review & editing

Segni Giza: Conceptualization, Investigation, Methodology, Supervision

Sudi Dawud: Supervision, Validation, Visualization

Conflicts of Interest

The authors declare no conflicts of interest.

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