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Honey bee production practices, constraints and honey qualities in Sigmo District, Jimma zone, Southwestern Ethiopia

By: Zinetu Sado

Advisors;

Main advisor: Eba Alemayehu(PhD)

Co advisor: Gadisa Natea (MSc)

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Abstract

The study was carried out on Honey bee production practices, constraints and honey qualities in Sigmo District, Jimma zone, Southwestern Ethiopia, in four selected kebeles of Sigmo district. Beekeeping is the practice of rearing bees with the aim of exploiting its products. The objective of this study was to asses honey bee production system, its constraints and honey quality produced in the study area. From each districts 120 beekeepers and 25 traders of honey were randomly selected and 8 key informant and 2 experts from office were purposively selected and interviewed. In general, a total of 155 respondents participated in this study. The selected beekeepers were interviewed using structured questioners, discussion and formal survey method. Quality of honey produced in the study area was analyzed in the laboratory. The result of the study showed that majority of the respondents in the study area followed traditional production system but only few beekeepers started transitional and modern beekeeping production system. Based on the result of this study, the existence of pests and predators were a major challenge to the honeybees and beekeepers in the study area. In all surveyed areas, the beekeepers reported the presence of ants, wax moth, honey badger, mites, spider, lizard and bee-eating birds in order of their decreasing importance. Traditionally, the beekeepers used their own methods of pests and predators control like application of ash under the stand of the hive, hanging hives on long trees, cleaning around the apiary site, using dog for large predators like honey badger, fencing their apiary site and etc. Laboratory analysis revealed that the quality of honey within the range of moisture content of highland honey was 17.1 while the midland honey was 18.99., Ash contents of highland honey was 1.9 while the midland was 1.70., pH of highland honey was 3.67 while mid land was 3.7. Almost all samples of honey examined were within the acceptable range of world and national standard. To sustain the beekeeping activity introducing affordable and appropriate beekeeping technologies with all accessories, strengthening the appropriate beekeeping management practices, and creating awareness specially to women is important

Key words: Sigimo, honey quality, production practices, constraints, Agro-ecology, bee colonies.

List of Acronyms

AFB	American Foul Brood
BC	Before Christ
CAC	Codex Alimentherius Commission
CACC	Central agricultural census commission
CSA	Central Statistical Authority
DA	Development Agents
EFB	European Foul Brood
ETB	Ethiopian Birr
EU	European Union
FAO	Food and Agricultural Organization
HBRC	Holeta Bee Research Center
KTBH	Kenya Top Bar Hives
LFRA	Livestock and Fishery Resource Agency
MBH	Mud Block Hives
MOARD	Ministry of Agricultural and Rural development
NGO	Non-Governmental Organization
QSAE	Quality and Standard Authority of Ethiopia
TTBH	Tanzania Top Bar Hives

1. Introduction

1.1. Background

The domestic honey bee (*Apis mellifera* L.) is an insect, (Hymenoptera, Apoidea*).* At present, Honey bees are considered to constitute one of the most complex societies among invertebrates, with a strict caste division and a highly developed communication capacities. Caste and sexual dimorphism are well pronounced, so that within the colony we can easily distinguish the queen bee, the drones and the worker bees. The queen bee, characterized by a well-developed abdomen, is the only fertile female of the colony, mating once in life with different drones. The female progeny will origin from fecundated eggs, whereas non fecundated eggs will give origin to males. All the other females in the colony are worker bees. They accomplish different tasks through their life, depending on age and colony necessity (Michener, 1975). Beekeeping or apiculture entails the rearing or keeping of bees with the aim of exploiting its products (such as honey, pollen, wax, propolis and brood) (Onwumere, *et al*., 2012).

The practice of beekeeping is believed to be evolved in ancient Egypt as one of the oldest practices next to the evolution of agriculture dating back to about 5,000 years (kritsky, 2015). Until the beginning of 19^{th} century people simply rear honeybee and finally kill the entire colony at the time of honey harvest. This trend was changed some 200 years back when Thomas Wildman the English man (Writer and beekeeper) introduced new beehive with multi frame which is closely similar to the modern beehive being used at present (Baessler, 2017).

World honey production is estimated to 1.4 million tons, in the year 2006 (CBI, 2008), and the leading producers according to their production shares are China (22%), the USA (6%), Argentina (6%) and Turkey (5%). According to FAO (2005) estimate, Ethiopia ranked 10^{th} in honey production in the world. According to MoARD (2003), Ethiopia accounts for about 23.58% of the total African and 2.13% of the world honey production.

Africa has been fortunate as it contains a large endemic wild population of honeybees (Allsopp *et al.*, 2009; Dietemann *et al*., 2009). Ethiopia is one of the countries in the continent, which own huge 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. (Agonafir Johannes, 2005 and Tessega Belie, 2009)

Beekeeping in Ethiopia is a long-standing agricultural practice. It has been exercised as sideline activity by many of the rural farming communities for its honey and beeswax production that contributes to income generation (MoARD, 2010). It also provides job opportunity in the sector.

In Ethiopia over 10 million honeybee colonies and has been considered the heart of honey and bees wax production in Africa (MoARD, 2010 and Tessega Belie, 2009).Due to its wide climatic and edaphic variability, Ethiopia is a home to some of the most diverse flora and fauna in Africa that provide surplus nectar and pollen source to foraging bee colonies Tessega Belie, (2009). Despite the favorable agro ecology for honey production and the number of bee colonies the country is endowed with, the level of honey production and productivity in the country is remain low. One of the prominent factors for this low honey and productivity is traditional hives. During the years of 2014-2016, it was increased to 5458.3 tons. The currents annual beeswax production is estimated at 5700 tons. This makes Ethiopia the fourth largest beeswax producing country in the world after China, Mexico and Turkey (Negash, 2018).

The knowledge and skill of honey and beeswax production of Ethiopian farmers is still very traditional and 95% of beekeepers follow traditional method of beekeeping practice with no improved techniques or technology (Oxfam, 2008). The most important honey producing regions are Oromia (38%), Amhara (26%), SNNPR (18%) and Tigray (7%) AAU (2015). However the country is suffering from the ecological degradation of its natural resources and this means the basis for any honey production is threatened and affected in many regions of the country, beekeeping is considered as one of the income generating activities for resource poor farmers including women, youth and the unemployed sectors of the community (CSA, 2015).

Ethiopian honey differs in color, taste and quality, not only this also it differs in the quantity produced and the timing of harvesting seasons that vary by region and type of honey (Oxfam, 2008). In Ethiopia, honey was harvested once or twice and in some cases even three times (Beyene and Phillips, 2007). There are two major honey harvesting periods, November to December in the lowlands and midlands and from April to May in the highlands. However, in addition to these major harvesting periods, there are many small harvesting periods which depend on the availability of bee forage and rainfall patterns in different agro – ecologies as

reported by Nuru (2007) and Beyene and Phillips (2007) and Haftu and Gezu ,(2014) in Hadiya Zone of southern Ethiopia; (Tessega,2009) in Western Amhara region), which experienced beekeepers and local people easily associate the harvesting season with the botanical origin of honey in their locality Tesfa *et al.*, (2013).

Moreover, beekeepers in Ethiopia are facing a range of challenges including bee disease such as Nosema, wax moth, fungal, viral and bacterial disease, bee pests, predators, indiscriminate use of pesticides and herbicides, pathogens and poor extension services, absence of coordination between research extension and farmers, and inadequate research institutions to address the problems pesticide impacts that stifle the beekeeping sector. Moreover, indiscriminate use of pesticides and herbicides has negative effects on the environment and the life of all pollinating insects (Amsalu Bezabeh *et al*., 2012). Therefore, in this study the practices and constraints of honeybee production and honey quality in apiculture sub-sector in Sigmo district were assessed.

1.2. Statement of the problem

Beekeeping is a traditionally well-established household activity in almost all parts of the country. But, the benefit from the sub sector to the nation as well as to the beekeepers, traders, processors and exporter is not satisfactory (Beyene and David, 2007).

In Ethiopia there are many constraints in the beekeeping sub sector. Those include the behaviors of bees, lack of skilled manpower and training institutions, low level of technology used, high price of improved beekeeping technologies, drought and deforestation of natural vegetation, poor postharvest management of beehive products and marketing constraints, indiscriminate application of agrochemicals, honeybee disease, pest and predators, poor extension services, absence of coordination between research extension and farmers, shortage of records and up to date information, and inadequate research institutions to address the problems. Nevertheless, all these problems may not be constraints to all parts of the country and may not be equally pressing to every place. (HBRC, 1997; Ayalew, 2001; Edessa, 2005).

Due existence of those constraints, the honey sub sector production and productivity is low and it is now contributing much lower than its potential to the regional and national economy. Even if the intervention of the government to minimize the sub sector constraints is taken as a good practice, the beekeepers are not still producing the amount what they are supposed to produce

(Gidey and Mekonen, 2010). In most cases, beekeeping has remained traditional and never rewarding. Because of this, the yield of honey and other hive products have been constantly the same over the past years. It did not exceed 45 kg per modern hive per year and not more than 7 kg from traditional hive per year (REST, 2004).

There are different studies conducted by researchers in different area of Ethiopia. Temesgen Terefe (2018) in Chiro District of West Hararghe Zone on practices and challenges of honey production; (Yirga, Koru, Kidane, and Mebrahatu, 2012) conducted on honey production in Gamo Gofa zone; (Yemane, and Taye, 2013), in Illubabor zones of Oromia Regional State; Haftu and Gezu, 2014 in Hadiya Zone of southern Ethiopia; Nuru (2002) honey production in Amahra and Tigray Regions; Tessega (2009) in Amhara region, Chala *et al,*. (2012) in Gomma district of Jimma zone, South-west Ethiopia, Nebiyu and Messele (2013) in Gamo Gofa zone of southern Ethiopia, Tariku and Mechthild (2013) in Sidama Zone, Southern Ethiopia and Tesfaw (2012) in Ada'a district of east Shoa Oromia region, Ethiopia. However, there is no any research conducted regard honey bee production and related issues in Sigmo district.

Sigmo district is believed to have diversified type of vegetation and cultivated crops and expected to have good potential for beekeeping activities. In Sigmo district in addition to different agricultural activities, the practices of honey production exercised by large number of households. Even though in Sigimo district there are different types of honey production activities and the district is known by providing large amount of honey production for local and national markets, but, there is no any research done on the honey production in the district. So, this research was done to fulfill the research gap of honey production practices in the district based on the following research questions.

1. What mechanisms used in honey bee production practices in Sigimo district?
2. What are the major constraints of bee production in the area?
3. How we explore beekeepers understanding on existing honeybee major constraints?
4. What is the quality of honey produced in the study area?

1.3. Objectives of the study

1.3.1. General objective

The general objectives of this study were to assess the practices and constraints of honeybee production, their potential risk factors and honey quality in Sigmo district.

1.3.2. Specific Objectives

The specific objectives of this study were:

- ✓ To assess honey bee production practices in Sigmo district.
- ✓ To identify major constraints of honey bee production in the area.
- ✓ To explore beekeepers understanding on existing honeybee major constraints.
- ✓ To determine the quality of honey produced in the study area.

1.4. Significance of the study

This study is believed to be significant in the following ways:

- ❖ The findings of this study will provide base line information to the concerned bodies like government officials, non-governmental organizations, DA and farmers to give due attention for the solutions of the existing constraints related with the honey productivity and beekeeping.
- ❖ The results of the study will motivate other researchers to carry out further studies.

1.5. Scope of the study

This study was conducted in South Western part of Ethiopia, Oromia regional State, Jimma zone, Sigmo district which is found at a distance of 128km from capital of Jimma town and 464km from Addis Ababa, Capital of Oromia Regional state. This study focuses on major constraints within beekeeping and honey quality. Moreover this study was done focusing on the honey production related data obtained from beekeeping cooperative members and non-members. It was done by dividing the district into two; Moist Dega and Moist woina Dega by selecting 2 kebeles (Yadeso and Aterkeda) from moist Dega and 2 kebeles (Seriti and Onja) from moist Woina Dega.

2. Literature Review

2.1. Races and Species of Honeybees

About 20,000 bee species collect nectar, convert into honey and store as a food source. Only honey bees that live together in large colonies store appreciable quantities of honey; these include bees of the genera *Apis* (honeybees), *Trigona* and *Melipona* (stingless bees) that people have recognized throughout the ages as sources of honey (Bradbear, 2003).

Since the late 1700s about 9 species of honeybees have been recognized (Roubik, 1989). These are: *Apis and reniformis, Apis cerana, Apis cerana indica, Apis dorsata, Apis dorsatabinghami, Apis florea, Apis laboriosa, Apis mellifera and Apis vechti*. Among these the following are the major honeybee species: *Apis cerana/indica, Apis dorsata, Apis florea* and *Apis mellifera.* Among the four commonly recognized species of Apis, only *Apis cerana* and *Apis mellifera* are kept commercially by man.

The most widely used honeybees are European races of *Apis mellifera*, a species of honeybee also indigenous to Africa and the Middle East. *Apis mellifera* is not indigenous to the Americas, Australia, New Zealand or the Pacific islands, but during the last four centuries European races of bees have been introduced to these regions (Bradbear, 2003).

There are five distinct races of honeybees in Ethiopia namely, *Apis millifera jementica, A. m. scutellata, A. m. bondasii, A. m. monticola and A. m. woyi-gambella* (Amsalu *et al.,* 2004). African bees are much more active in collecting nectar than temperate-zone bees. They produce wax readily, possibly in response to their need to build new combs frequently. They are very adapted and can live in tropical climates ranging from semi desert to tropical rain forests.

2.2. History of honey bee production

2.2.1. World Honey bee Production and honey Marketing Overview

Honeybees are essential organisms that contribute to global nutrition and food security and provide large ecosystem services. However, dramatic increase in abnormal honeybee colony decline in contemporary beekeeping has brought about extensive research and glowed public

interest in honeybee health (Neuman, 2009; Genersch *et al.*, 2010; Rohr *et a*l., 2013). The decline in honeybee numbers is alarming given their important role in ecosystem services and diversification of income (Neumann and Carreck 2010; Vanbergen *et al*., 2013).
Starting in late 2006, commercial migratory beekeepers along the East Coast of the United States began reporting sharp declines in their honeybee colonies (OIE, 2011). Beekeeping in most of the states has been affected (Laurent *et al.*, 2015). In the winters of 2007/2008 and 2006/2007 alone, the drop in the number of managed honeybee colonies was estimated to 31.8% and 35.8% respectively (Bianco *et al.*, 2014).

The annual colony losses have created problem*s* and bee pollination services have severely hampered, specially, in the western regions (Paudel *et al.*, 2015). Recent studies predict the phenomenon of decline in bee numbers is not restricted to be the problem of western region alone (Jacquetta, 2013). It have been suggested that colony losses do occur in Africa at comparable levels like that of Europe or North America (Wanjama *et al.,* (2016). It has also been noted that bee population in East Africa is on the decline (Musyimi , 2014).

World honey production is estimated to 1.4 million tons, in the year 2006 (CBI, 2008), and the leading producers according to their production shares are China (22%), the USA (6%), Argentina (6%) and Turkey (5%). According to FAO (2005) estimate, Ethiopia ranked 10th in honey production in the world. According to MoARD (2003), Ethiopia accounts for about 23.58% of the total African and 2.13% of the world honey production.

The five biggest honey exporting countries in the world are: China, Argentina, Mexico, Germany and Brazil, accounted for more than 65% of world honey exports in 2004(CAP, 2008). World honey exports increased nearly2%per year from 1990 to 2004 (CAP, 2008). Germany and the United States was the biggest honey importing countries in 2004 with more than 20% market share (CAP, 2008). Germany is by far the leading honey market in the EU. Honey is produced in small quantities in many countries and primarily used for domestic consumption.

Of the total world annual honey production about 67% is marketed in its country of production and about 23% is traded in the export market (ITC, 2003 in MoARD, 2007). China has also become the world's biggest honey consumer, significantly increasing its share of the global market from 8% in 1993 to 16% in 2004 (CAP, 2008).

2.2.2. African Beekeeping Practices

Beekeeping in Africa is mostly carried out using traditional methods. In these methods, beehives are made out of logs, bark, reeds, gourds and pots among other materials. The enterprise is quite adaptable to various environments and circumstances although farmers are unable to access better markets due to the poor quality and low quantity of honey produced.

Beekeeping is a source of food (e.g. honey, pollen and brood), raw materials for various industries (e.g. beeswax candles, lubricants), medicine (honey, propolis, beeswax, bee venom) and provides income for beekeepers (James .A, 2007). Most of African honey is harvested by smallholder farmers, and the selling of bee products is one of the feasible practices which contribute to get out of poverty (Bee for development, 2006).

A study from Tanzania shows beekeeping activities involved both genders at different stages of honey and beeswax processing and marketing. Traditionally, men are responsible for honey harvesting which is normally carried out at night because they are scared of honey bees during the day (Lalika, 2008).

Beekeeping can add to the livelihoods of many different sectors within a society including village and urban traders, carpenters who make hives and stands, tailors who make veils, clothing and gloves and those who make and sell tools and containers (Brad, 2003). East African nations export tremendous quantities of wax. Ethiopia and Tanzania produce about2.5% and 1.15% of total world honey production, respectively. Keeping bees in beehives as practiced in Egypt, Kenya, Tanzania, is not well known in other part of Africa (Hussein, 2000).

2.2.3. Overview of Honey bee production in Ethiopia

In Ethiopia currently, bee keeping is being exercised traditional (Kassaye, 1990). It is characterized mainly by forest beekeeping that is common in forest covered South and Southwest Ethiopia and back yard beekeeping which is practiced in majority of the country (Nuru, 2007). The productivity of traditional hives is extremely low and the average yield is only about 5–8kg/per colony/per annum (MOARD 2007).

Even though it is one of the important and oldest farming activities in the country, there are no available records, which confirm when and where beekeeping was first started. Extension

activities on beekeeping started in Ethiopia in 1978 (Melaku Girma *et al.,* 2008). Since then, considerable efforts have been made to improve apiculture production through training, introduction of new technologies, production and distribution of equipment and institutional capacity building at the then Holeta Beekeeping Training Center (MOARD,2008).

Apiculture is practiced as an integral part of farming activities. It is also a source of additional income for urban communities. Other than areas with extreme climatic conditions, beekeeping is common in every village and at virtually all smallholder farms. Total honey production in 2008/9 is estimated at 39,650 tons and there are three different hive types by which the honey is produced: traditional, transitional (intermediate) and movable frame hives.
There are 5,013,848 traditional, 34,552 transitional and 100,843 frames hives in Ethiopia (GDS, 2009). Ninety-three percent of honey production comes from traditional hives. Oromia, Amhara, Southern Nation Nationalities and People (SNNP), and Tigray are the major honey producing regions with production quantities of 15,492 tons, 10,834 tons, 5, 847 tons and 3904.6 tons, respectively, (GDS, 2009).

One of the improved beekeeping practices is a transitional beekeeping. It is a type of beekeeping intermediate between traditional and modern beekeeping methods. Generally, top bar hive is a single story long box with slopping sidewalls inward toward the bottom (forming an angle of 1150 with the floor) and covered with bars of fixed width, 32 mm for east African honeybees (Segeren, 1995; Nicola, 2002 and Tessega Belie, 2009).

2.3. System of Honey bee Production in Ethiopia.

Ethiopia is blessed with plenty of water resources and a range of honeybee floras, which make productive ground for the development of beekeeping. Honey hunting and beekeeping have been practiced in the country for the exploitation of honey. In areas where wild colonies of bees living in hollow trees and caves are found, honey hunting is still a common practice in Ethiopia. Presently, in Ethiopia Traditional, Transitional and Modern beekeeping methods are exercised.

2.3.1. Traditional beekeeping

Traditional beekeeping is the oldest and the richest practice, which has been carried out by the people for thousands of years in Ethiopia. This beekeeping practice is extensive and closely tied to swarm management: beehives are hung up in trees to catch swarms and are then transferred and placed in the backyards with some kinds of hive sheds that protects them from the hot

temperature and rain. Traditional beekeeping is of two types: forest beekeeping and backyard beekeeping. In some places, especially in the western and southern parts of the country, forest beekeeping by hanging a number of traditional hives on trees is widely practiced. In other most parts of the country backyard beekeeping with relatively better management is common (Nuru, 2002).

2.3.1.1 Honey hunting

The earliest honey hunting evidence comes from rock paintings, equipment used and anthropological studies obtained first in Spain, which is dated back to 30,000-10,000 B.C. This practice (honey hunting), as a beekeeping system, is also widely practiced by some tribes of the south and southwest Ethiopia (like Messenger tribe in Gambela).

2.3.2. Transitional System of Beekeeping

This type of beekeeping is intermediating between traditional and modern beekeeping methods. It is one of the improved methods of beekeeping practices. The types of hives are Kenya Top Bar Hive (KTBH) and Tanzania Top Bar Hive (TTBH). The hives can be constructed from timber, mud or locally available materials. Each hive carries 27-30 frames on which honeybees attach their combs. The top bars have 3.2cm and 48.3cm width and length, respectively (HBRC, 2004). Transitional beekeeping has its own disadvantages such as top bar hives are relatively more expensive than traditional beehives, and combs suspended from the top bars are more suitable to break off (HBRC, 2004). Thus, as reported by, HBRC (1997) the types of beehives used more frequently in this system are the Kenyan top-bar hives (KTBH), Tanzania top-bar hives (TTBH) and Mud- block hives (MBH). Among these, KTBH is widely known and commonly used in many parts of the country.

2.3.4 Modern system of beekeeping

Modern beekeeping methods intend to gain the maximum honey, season after season, without harming bees (Nicola, 2002). Modern movable- frame hive consists of precisely made rectangular box hives (hive bodies) superimposed one above the other in a tier. The number of boxes is varied seasonally according to the population size of bees. Practical movable- frame hive was invented in 1851 by Lorenzo Lorraine Langstroth in U.S.A. (Crane, 1976; Vivian, 1985). Later on different countries developed their own movable frame hives (for instance

Zander, Dadant) and Langstroth was the prototype of movable frame hives used today. In many countries Langstroth hive boxes have proved to be convenient for handling and management.

As reported by, HBRC (1997) these box hives have an advantage over the others in the volume and quality of honey harvested (averagely 15-20 kg/year and in potential areas up to 50-60 kg harvested). Moreover, the hives allows swarm control through supering and colony management, it is easy to transport and allows the use of higher level technologies. However, equipment in this beekeeping system are relatively expensive, require skilled manpower, very less wax production only 1-2% of the honey yield Gezahegne Tadesse (2001) and needs very specific precaution.

2.4. Honey hive practices and products

2.4.1. Hive products harvesting and post handlings

The frequency and amount of honey harvested varied depending on flowering condition of major bee forage, colony management practices and number of beehive Kajobe *et al.,* (2009). 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 Gichora (2003), 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 can be harvested once or twice, while in some cases even three times in a year largely depending on the availability of bee forage as reported by (Haftu and Gezu, 2014 in Hadiya Zone of southern Ethiopia; Tessega, 2009 and Tesfa *et al.,* 2013 in Western Amhara region). Haftu and Gezu (2014) indicated even though the majority (75%) of the households do not store honey primarily because of high demand for cash but some farmers keep some amount for different purposes and store using plastic containers, gourd, tin and clay pots until consumption or sale.. Beekeepers sell the largest proportion of their honey during harvest at low price mainly to meet their demand for cash for social obligations Beyene and Phillips (2007).

Teferi *et al.*, (2011) indicated on average 33 and 16 kg of honey per hive was harvested from modern and traditional hives in the northern Ethiopian highlands respectively. Honey production is very low, only about an average of 8 to 15kg of honey could be harvested per hive per year but in areas where improved technology has been introduced, an average of 15 to 20 kg/hive/year has been harvested (Beyene and David, 2007). Addis and Malede (2014) and Chala *et al.*, (2012) reported that the average honey yield per year/colony was 7.20, 14.70 and 23.38kg for traditional, transitional and moveable frame hives, in around Gondar and in jimma zone, south-west Ethiopia respectively. Haftu and Gezu, 2014 in Hadiya Zone of southern Ethiopia also indicated 3.04, 4.9 and 8.2kg for traditional, transitional and moveable frame hives, respectively.

2.4.2. Honey bee flora

Beekeeping is more dependable on ecological suitability of an area than any other livestock production Adgaba(2002) 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.

Some important local honeybee plants (trees, shrubs, herbs and cultivated crops are known as a source of nectar and pollen in Ethiopia, namely Tebeb (Becium grandiflorum), Girbiya (Hypoestes forskaolii), siwakerni (Leucas abyssinica), kiliow (Euclea schimperi), Awhi (Cordia Africana), Bahirzaf (Eucalptus spp) Girawa (Vernonia amygdalina), Wanza (Cordia africana), Woyira (Olea Africana), Meche (Guizotia scabra), dogma (Syzygium guineese), Bisana (Croton machrostachyus) and, beles (Opuntia ficus-indica) identified as the major bee forage in different parts of the country (Yetimwork et al., 2015 in eastern part of Tigray; Haftom et al., 2013 in Debrekidan and Begasheka Watersheds of Tigray; Haftu and Gezu, 2014 in Hadiya zone of southern Ethiopia).

According to Tesfa *et al.,* (2013) reported in Western Amhara region beekeepers supplement sugar syrup, hot pepper, roasted pea flour, water, honey syrup, roasted bean flour, and roasted barley flour during dearth period. Yetimwork *et al*., (2015) reported Supplementary feeding and migratory beekeeping practices to overcome the feed shortage at the dry season is a common practice. Majority of the beekeepers provide besso (roasted and grounded barley flour), shiro (roasted spiced pulses flour), sugar syrup and honey with water mainly from February to May in eastern part of Tigray.

2.4.3. Honey Bee Products Demand and Consumptions

The estimate of total honey production in Ethiopia in 2011 is about 40 million kilograms of which the greater portion is harvested from traditional hives (CSA 2012). Recently, attempts have been made to address problems associated with production and marketing of honey. About 13% (of 169,000 holders contacted) have practiced honey and wax development package according to a survey by the same source. Currently, honey is produced in its crude form and consumed domestically largely by Tej (honey wine). However, Crude honey could be processed into several important marketable products. These products include purified honey, beeswax, propels, pollen, bee venom, and royal jelly. But, only a few enterprises are engaged in the processing of honey in Ethiopia and the processed products of those are limited to purified honey and beeswax (Gallmann and Thomas, 2012). Yetimwork *et al.,* (2015) in eastern part of Tigray declared that both in traditional and framed hive, honey production is increasing from time to time.

At present, supermarkets, grocery shops and hotels are some of the major buyers of processed honey. According to the information obtained from supermarkets, the increasing expat community is also expected to constitute significant consumption of the product. Though there is no comprehensive consumption data for processed products in the country, an attempt has been made to arrive at an estimate of present demand. Processed honey is considered to be a commodity whose demand arises from urban population. According to CSA (2016), the population is 82 million out of which 13.75 million is urban dwellers. On the other hand, the per capita natural honey consumption is 60 grams. The apparent consumption of the product will therefore be 825,000 kg (825 tons). Hence, this figure has been taken as the present domestic effective demand (for year 2012) for processed honey. Future domestic demand for processed

honey grows with the growth in urban population and income rise. Hence, the urban population growth rate, that is 4 %, is applied in projecting the future demand.

2.4.4. Economic Importance of Beekeeping in Ethiopia

Beekeeping in Ethiopia is a long-standing agricultural practice. It has been exercised as a sideline activity by many of the rural farming communities for its honey and beeswax production that contributes to income generation. The role it plays in enhancing food security, poverty reduction and food production through pollination of crops has become substantial in the recent years (MoARD, 2007).

It has been scarce information to generalize the economic benefits of beekeeping in Ethiopia due to not uniform data presentations from different bodies and lack of concrete knowledge to estimate properly Gidey *et al.,* (2010) it has been understood that beekeeping has a great role in supporting beekeepers' life and allows lots of business to people and establish their life.

Apiculture has also a great role in natural resource protection. Beekeeping is environmentally friendly activity and beekeepers are more aware about the importance of conservation of natural resource than any ordinary farmers (Nuru, 2007). Integrating natural resource conservation programs with income generating options like utilizing the forest resources, in the form of honey and beeswax, while maintaining the natural vegetation would be an appropriate approach Nuru, (2007).

Comparing with other agricultural activities beekeeping has many relative advantages because of several reasons Nuru, (2007). The investment and running costs are relatively low with minimal risk. Beekeeping is possible even for people with few resources; bees can be obtained from the wild, equipment can be made locally, and in most cases bees do not need the beekeepers' help. Unlike cultivation of crops and animal husbandry, beekeeping does not disturb the ecological balances of an area. Instead, it is an environmentally friendly activity. Beekeeping does not compete for resources with other agricultural activities. Hence, it can be integrated with annual and perennial crop production, animal husbandry and natural resource conservation. Beekeeping is light work; it can be done by women, aged men and persons with disabilities. Moreover, it is less labor intensive; it can be done as part time and side line activity. Beekeeping assists to utilize resources like pollen and nectar which otherwise are wasted. Man cannot utilize these resources without bees. Beekeeping can be run in areas which are not suitable for cultivation of

crops and animal husbandry such as hills and escarpments. The honeybee produces honey, beeswax and propolis. These commodities have long shelf life and can be marketed locally or abroad. Beekeeping can be run with little or no land, because bees can forage in any place around their foraging distances and it is useful for intensification of land and also in areas where there are shortage of land.

2.5. Major Constraint of Honey Bee Production

The most important constraints present in Ethiopia were bee forage, pests and predators, beekeeping equipments, absconding, honeybee colony, pesticides and herbicides, death of colony, water shortage, honey storage materials and swarming Yetimwork *et al.,* (2015) in eastern Zone of Tigray; Haftu and Gezu, 2014 in Hadya Zone of southern Ethiopia. Similarly, Kerealem *et al.*, (2009) declared that the major constraints that affect beekeeping sub-sector in Ethiopia are: lack of beekeeping knowledge, shortage of skills man power, shortage of bee equipments, pests and predators, pesticide threat, poor infrastructure development, shortage of bee forage and lack of research extension.

A study conducted by Tesfaye (2007), on honey production system in Adami Tulu to identify opportunities and threats on beekeeping and the results shows that most of the respondents (beekeepers) do not visit their bees regularly. Farmers did not have any type of beekeeping equipments and did not bother about their colonies while harvesting. The place where beekeepers put their beehives also considered as the major constraints. According to the beekeepers of Tigray Region, the critical constraints and problems affecting honey production include inadequate production technologies, limited availability of bee flora mainly due to deforestation, lack of beekeeping knowledge/skill, and marketing accessibility. And farmer's access to trainings is generally poor Gidey and Mekonen, (2008).But all these problems may not be constraints to all parts of the country and may not be equally pressing to every place. So it requires characterizing the constraints in their respective places to take an appropriate development measure.

The existing production constraints in the beekeeping development of Ethiopia are complex and to a large extent vary between agro-ecological zones and production systems (EARO, 2000). Most research reports that the pests and predators, shortage of bee forage, lack of skill and knowledge, low level of technology and honey bee disease, agro-chemical, are the top major

constraints in most part of the country Kerealem *et al*., (2009);Workneh and Puskur,2011; Gidey *et al*., (2012).

In addition, unpleasant behaviors of bees (aggressiveness, swarming tendency, and absconding behaviors), lack of skilled manpower and training institutions, low level of technology used, high price of improved beekeeping technologies, drought and deforestation of natural vegetation, poor hive products' postharvest management, misuse of agrochemicals, honeybee disease, pests and predators, poor extension services, absence of coordination between research, extension and farmers, lack of policy application in apiculture, shortage of records and up-to- date information, and inadequate research institutions to address the problems were also identified potential constraints in the previous year's HBRC, (2010); Ayalew Kassaye, (2001); Edessa Negera, (2002).

2.5.1. Shortage of Bee Forage

Shortage of Bee Forage: Beyene and Verschuur (2014) in south west shoa zone of Oromia indicated shortage of bee forage is directly related with deforestation of forest coverage from time to time for timber making, construction, fire wood and expansion of agricultural lands. To solve this problem beekeepers migrating their bee colonies from their area to other area during the dry season for searching bee forage., similarly, Haftu and Gezu (2014) in Hadiya zone southern Ethiopia declared shortage of bee forage was the most serious problem affect bee colony. The elimination of good nectar and pollen producing tree species in many areas make it difficult to maintain bee colonies without feeding (Kerealem *et al.,* 2009).Due to deforestation and poising of agro-chemicals, the honey bee population is in state of continues declining. As a result, it has become a serious challenge to get honey bee colonies to start and expand beekeeping (Nuru, 2007).Beekeeping sector is dependent on healthy flora and a healthy environment. Recent years have seen environmental changes in Ethiopia in terms of erratic rain fall patterns and deforestation.

2.5.2. Honeybee Pests and Predators

The honey bee colony is not immune from predation and it can take a variety of forms, from destruction of a comb by wax moth to physical dismembering of a colony by a hungry black bear. According to Yetimwork *et al.*, (2015) and Adeday *et al*., (2012) honey badger, ants, wax moth, spider are pests and predator that was reported by in other parts of the country Tessega

(2009) in Amhara region, Chala *et al.*, (2012) in Gomma district of Jimma zone, South-west Ethiopia, Nebiyu and Messele (2013) in Gamo Gofa zone of southern Ethiopia, Tariku and Mechthild (2013) in Sidama Zone, Southern Ethiopia and Tesfaw (2012) in Ada'a district of east Shoa Oromia region, Ethiopia. Ants are most disturbing to honey bees and bee keeping sector.

Ants (*Dorylus fulvus*) are one of important honey bees' enemies Desalegn (2001).They feed on honey, brood, bee wax, pollen and lead to absconding of bees and destroying the entire bee colony Tesfaye (2014) In Ethiopia ants were the series problem in bee keeping as reported by Awraris *et al*., (2012) in Keffa, Shaka and Bench- Maji zone; Tesfaye (2007 in Adami Tulu). In Tigray, Amhara, SNNPR and Oromia regional states in Jimma zone, bee keepers consider it is a serious problem Amsalu *et al.,* (2010). Bees are the first and most victim of the attack with ants followed by honey Desalegn, (2007).

2.5.3. Honeybee Disease

Honey bees diseases, pests and predators are causing a significant economic loss in honey bees and their products. The most commonly known honeybee diseases reported to exist in Ethiopia are Nosema, Amoeba and Chalk brood diseases Kerealem *et al.,* (2009)

Nosema is caused by *Nosema apis* and *Nosema ceranae*. It is a microsporidian fungal disease that infects the intestinal tract of adult bees. *Nosema* cause detrimental effects on honey bees, colony development, queen performance and honey production. In Ethiopia *Nosema* was reported in low infestation rate in the survey conducted by the initiation of FAO, (1989).and also reports Addis Abeba reported prevalence rate of 53.3% Desalegn and Yosef, (2005). In Ethiopia *Nosema* was also reported from different regions with varying prevalence rate such as 58% in Oromia, 60% Benishangul-Gumuz and 47% in Amhara regions Aster *et al*., (2007).

Amoeba is diseases of honeybee caused by a single celled parasite called *malpighamoeba mellificae.* The parasite affects malphigian tubules of honey bees and shortens the life cycle of bees FAO, (1989). Survey conducted in the year of 2000, Amoeba was reported in South and South parts of the country Amsalu and Desalegn, (2001). Diagnosis made on honey bees in field and laboratory at Addis Abeba reported a prevalence rate of 73% of amoeba infestation (Desalegn and Yosef, (2005). The diseases was also reported with high prevalence rate in different regional state of Ethiopia such as; Oromia region with prevalence rate (88%), Amhara region (95%) and 60 % in Benishangul- Gumuz Aster *et al*., (2007).

Chalk brood is an infectious disease of honeybee larvae caused by a fungus *Ascosphaeraapis*, which causes death and mummification of sealed brood of honeybee with consequent weakness of the colony .The occurrence of this disease in Ethiopia for the first time was reported around Holeta and at Gedeo demonstration (Desalegn, 2006). In Ethiopia the study reported an infection rate of 37.12%, 19.89%, 17.93% and distribution rate of 87.50%, 56.56% and 33.33% in Amhara, Oromia and Benshangul- gumuz Aster *et al*., (2010). American foulbrood (AFB) is an infectious disease of the larval stage of the honeybee *Apis mellifera.* It is caused by a Gram positive bacterium called *Paenibacillus(*Heyndrickx, (1996). European foulbrood (EFB) is caused by the bacterium *Melissococcus plutonius* (Bailey 1983).

Varroa destructor and *Varroa jacobsoni* are parasitic mites that feed on the bodily fluids of adult, pupal and larval bees. *Varroa* mites can be seen with the naked eye as a small red or brown spot on the bee's thorax. *Varroa* mites are carriers for many viruses that are damaging to bees. For example, bees infected during their development will often have visibly wings. *Varroa* mites have led to the virtual elimination of feral bee colonies in many areas, and are a major problem for kept bees in apiaries. Some feral populations are now recovering it appears they have been naturally selected for *Varroa* resistance Juliette *et al*., (2006).

2.5.4. Agrochemical

The use of different agro-chemicals or pesticides is an important and common practice in crop production to fight against most crop damaging pest populations and diseases to produce high quantity of food around the world. However, if they are not used properly (according to their prescription for time of application and dosage), they bring about very crucial damage to pollination fauna (the honeybees in our case), environment and human health. As a result, reduction in pollinating insect population, quantity and quality reduction in hive products and crop yield reduction are some of the associated risks encountered.

2.6. Honey Quality

Honey contains a complex mixture of carbohydrates, mainly glucose and fructose; other sugars are present as traces, depending on floral origin. It also contains small quantities of organic acids, lactones, amino acids, minerals, vitamins, enzymes, phenolic compounds, volatile compounds, pollen, wax and pigments (Crane, 1980). The contents of these components in honey are the

most important quality criteria of honey and indicate some important deterministic quality properties of the honey Sahinler and Gul, (2004).

Chemical composition of honey mainly depends on the vegetation sources from which it derives, though external factors like climate, harvesting conditions and storage can also influence it (Crane, 1980). Careless handling of honey can reduce its quality. Amongst the factors that most influence quality is high temperature, length of storage and moisture content greater than 21%
All these factors lead to fermentation, high levels of Hydroxymethylfurfural (HMF), loss of enzymatic activity, changes in flavor, darkening and microbial growth Moguel *et al.*, (2005). Moisture content is one of the most commonly monitored parameters as international quality standards for honey Codex Alimentarius Commission, 2001; Ethiopian Quality Standard Authority, (2005).

Ethiopian honey differs not only in color, taste and quality but also in the quantity produced and the timing of harvesting seasons that vary by region and type of honey. In Ethiopia, honey was harvested once or twice and in some cases even three times Beyene and Phillips, (2007). There are two major honey harvesting periods, November to December in the lowlands and midlands and from April to May in the highlands. However, in addition to these major harvesting periods, there are many small harvesting periods which depend on the availability of bee forage and rainfall patterns in different agro – ecologies as reported by Nuru (2007) and Beyene and Phillips (2007) and Haftu and Gezu ,(2014) in Hadiya Zone of southern Ethiopia; Tessega,(2009) in Western Amhara region), which experienced beekeepers and local people easily associate the harvesting season with the botanical origin of honey in their locality Tesfa *et al.*, (2013).

Moreover Teferi and his co-authors, (2011) reported that the main harvesting seasons in Tigray and Lalibela honey are October through December, with an additional harvest period for Tigray's white honey in June and July; November and December for yellow honey; April and May for white honey from the southwest and southeast Highlands and February, March, May and June for dark-brown varieties of honey. This shows the possibilities of harvesting and supplying different types of honey at different time implying the possibility of continuous supply of honey along the market chain.

3. Materials and Method

3.1. Study Area

The study was carried out in Sigmo district Oromia Regional State, Jimma zone which is located at a distance of 128 Km South west from Jimma town and 474 km South west from Addis Ababa and bordered by SNNPR in the South west, Setema in the North east, Gera in the South east and Ilubabor Zone in the North west.

Topography of this district ranges from gently sloping to hilly lands with ridges and valleys in between the lands. The total areas of the district are about 158,551 hectares. Among this area 110,202(69.5%) hectares are covered by both government and individual forest. The remains 48,349 (30.5%) hectares are used for cultivation of crops, swamp and shrubs, grass land, settlement (urban and rural) and construction for social services.

The number of total population of the district is about 124,497. The number of male and female are 61,817(49.7 %) and 62,680 (50.3%), respectively. In the present restructuring the district has 19 peasant associations & one urban center Sigimo. According to Sigimo district socio demography (2019) the dominant religion in the district is Islam religion. The most economic activities performing in the district are crop production (teff, maize, wheat, sorghum, barely etc), animal rearing (cattle, sheep, goat, horse, etc), rarely beekeeping and local trade of different commodities. This district grouped under dega and woina dega climatic zone. Its elevation lies between 2050 and 3200m.a.s.l. thus, the district found on highland area.

The mean annual rainfall of the district ranges from 2100mm-1600mm moist dega and woina dega respectively. Gaba, Bodeche, Pallo, Bishata, Onja and Suduma rivers are flowing through the district. According to the district agricultural office information, the major soil types, in the district include red soil, black soil and brown soil. High forest, Woodland, riverine and man-made forests are available in the district. Gaba, Timba, meti jara and Kullo forests are some of the forest found in the district.

3.2. Study Design

A cross-sectional study was carried out from January 2019 to June 2021 in South-West Jimma Zone, Sigimo district on honey bee colonies managed under traditional, transitional and modern beekeeping methods to investigate honey bee production systems and identifying of the major constraints and its quality by observing and collecting samples from the colonies and from beekeepers. For the purpose of this study, different data were collected from beekeepers, apiaries and honey bee colonies. Secondary data related to beekeepers, honey production and honeybee colonies were collected from Livestock and Fishery Resources Agency (LFRA) office of Sigimo district through desk discussion with office experts and reviewing of official records.

For this study, the district was divided into two using elevation as a criteria and it is generally believed that and revealed in many studies that farming systems, mode of life and many more characteristics vary across altitude zones (Cochran, 1973). The two altitude strata were highland (3200m above sea level) and midland (2020m above sea level).

3.3. Population of the study

The populations of study participants were all traditional, transitional and modern honey beekeepers in Sigimo district, experts working related with honey production and key person who had better knowledge and experience of honey bee practice.

3.4. Sample and sampling techniques

There are 21 districts in Jimma zone, Sigimo is one of the districts found in it and have higher potential for honey production than other districts. There are 19 rural and 1 urban kebele administrations in Sigmo district. Among 20 kebeles of the district 4 kebeles Sarity, Onja, Yaddesso and Aterkeda were selected purposively based on their agro- ecology and beekeeping practices. A total of 120 respondents (70 respondents from moist dega and 50 from moist woinadega) and 25 traders were randomly selected. Moreover, 8 key informant interviews based on their knowledge and experiences 2 from each kebeles and 2 experts who were working with honey production were also included in the study. For key informants interview was held with issue related honey practice, honey qualities and constraints of honey production in the district. Generally, 155 respondents i.e. 120 beekeepers, 25 traders of honey, 8 key informants and 2 experts working related with honey bee productions were included for this study.

3.5. Instruments of Data Collection

Questionnaire was developed in order to collect data about honey bee practices, qualities and constraints from honey beekeepers households and traders. Interviews also held with key informant individuals who had better knowledge and experiences of honey production and experts working with honey production.

3.5.1. Questionnaire

Questionnaire was used to collect data from beekeepers and honey traders about potential, challenges and opportunities of beekeeping in the area: harvesting time, amount of honey harvested, honey storage facilities, potential honeybee plants and flowering time, water resources availability, honeybee pests and predators , agrochemicals and other chemicals applications was collected. These study questionnaires were translated into local language (Afan Oromo) by language expert in the study area.

3.5.2. Interview

Participants were interviewed to find out things that may not covered by questionnaires and to get deep responses. The interview was held with key informant individuals who were model beekeeper household and who had better knowledge and experiences of honey production and experts working with honey production. Key informant participant were interviewed at their farm gate by using their languages (Afan Oromo) for 1 hrs. Also experts were interviewed in their office for four days 2hrs in each day during study period.

3.5.3. Focus group discussions

In order to carry out this field survey study, discussion was undertaken initially with Sigimo district agriculture office head to tell them aim of the research to get permission. Some institutions were communicated before hand to receive permission and get required data from concerned bodies. Then the aim of study was explained to participants in order to get their full consent and agreement to be part of the study. Each focus group discussion consisted of 6 to 8 individuals and 2 group discussions were undertaken in the study area.

3.6. Secondary data

In the study, primary and secondary data were used to generate qualitative and quantitative information. In addition, the secondary data that has relevance to this study was collected from different recorded data from livestock office.

3.7. Data Analysis

3.7.1. Some components of honey quality analysis

This study was done with the help of laboratory to determine honey quality some components of honey such as moisture content, sugar content, ash content, and other physicochemical properties like pH was analyzed at Jimma University Environmental Health Science Laboratory. However, because of lack of instrument other chemical analysis of honey was missed.

Moisture content: Moisture content is the most important parameter of honey quality. It was obtained by drying 15 gram of honey sample in a hot air oven at 105°C until a constant weight was attained. Electrical conductivity of a solution of some gram dry matter of honey in 100 ml distilled water was measured using electrical conductivity cell at 20°C

Ash Content: First crucibles were washed, rinsed with distilled water and oven dried at 105oC. Twenty gram of honey samples was weighed and placed in a furnace first at 110oC for half an hour and then at 550 ^{0}C for two hours to constant weight. Then the honey samples were kept in open air for cooling and the constant masses after heating was measured. Finally ash content was calculated as g ash/100 g of honey (AOAC, 1995).

$$\text{Ash\%} = \frac{M_1 - M_2}{M0} * 100,$$

Where M0=weight of honey, M_1=weight of crucible + ash and, M_2=weight of crucible.

pH: For determination of pH of honey samples, two honey samples from Dega and Woinadega were collected. Ten gram of the honey samples was taken and dissolved in 75 ml of distilled water in 250 ml beaker and stirred with magnetic stirrer. Then the pH was measured with pH meter calibrated at pH 4.0 and 7.0 buffer solutions (QSAE, 2009).

Reducing sugars ;The reducing sugar composition of two honey samples was collected in Sigimo district fallen with in recommended range by Codex Almentarious Commission (1969) which is greater than 65%.

Reducing sugar content was determined by the modified method of the Lane and Eynon involving the reduction of Soxlet modification of Fehling solutions by titrating at boiling point (600 ^{0}C) against a solution of reducing sugars in honey using Methylene blue as indicator (Pearson, 1971). Sample of 20 g of honey was taken to 100 ml volumetric flask and 5 ml alumina cream was added to the flask. The honey was homogenized by stirring the honey with glass rode. The sample was diluted with water to the volumetric capacity (100 ml) of the flask at 20 ^{0}C and was filtered using asbestos.10 ml of this solution was diluted to a final volume of 500 ml with distilled water (diluted honey solution). The mixture was heated to boiling over wire gauze and maintained at moderate boiling for 2-3 min. Finally the result was calculated as:

$$C = (2/W) * (1000/Y)$$

Where C = g invert sugar per 100 g honey, W = weight (g) of honey sample, Y = volumes (ml) of diluted honey solution.

3.7.2. Descriptive statistical analysis

Statistical analysis was used in the study varied depending on the type of variables and information required. Descriptive statistics such as means, standard deviation, frequency and percentages were used to analyze the quantitative data using SPSS version 20 software were applied.

4. RESULTS AND DISCUSSION

4.1. Results

4.1.1 Demographic information of the study participants

Out of the total respondents, about 92 (76.7%) were male and 28 (23.3%) were female. This implies that both sexes are participating in honey bee production practices in the study area. The survey result indicates that bee keeping activity in the study area is dominated by male.

Bee keepers involved in honey production had age ranged from 20 to 76 years old. Majority of study participant 89.2% were Muslim religious follower while the remaining percent 10.8% were Christian religious followers. Concerning to marital status more than average 64.2% were married and the remaining ones 35.8 were single, widow and divorce. Concerning the educational background of the respondents, only 13.3% of the beekeepers had education level of Certificate up to diploma while 41.6% had education level of primary to secondary school. About 22.5% of the beekeepers had only basic education (read and write) whereas 22.5% were illiterate. The beekeepers that have different family size were engaged in beekeeping activity. The minimum and maximum family sizes of the respondents were 3 and 10 respectively.

Table 1 Socio demographic characteristics of study participants

Socio demographic variables	Response	Agro ecology				Overall F	Overall P
		Highland		Midland			
		F	%	F	%		
Sex	Male	54	77.14	38	76	92	76.7
	Female	16	22.85	12	24	28	23.3
Age	20-30	14	20	10	20	24	20.0
	31-40	19	27.14	13	26	32	26.7
	41-50	19	27.14	14	28	33	27.5
	51-60	10	14.28	8	16	18	15.0
	above60	8	11.42	5	10	13	10.8
	Total	70	100	50	100	120	100.0
Religion	Orthodox	6	8.57	4	8	10	8.3
	Muslim	62	88.57	45	90	107	89.2
	Protestant	2	2.85	1	2	3	2.5
	Total	70	100	50	100	120	100.0
Marital status	Married	45	64.28	32	64	77	64.2

	Single	16	22.85	11	22	27	22.5
	Widow	5	7.14	4	8	9	7.5
	Divorced	4	5.71	3	6	7	5.8
	Total	70	100	50	100	120	100.0
Education background	Illiterate	16	22.85	11	22	27	22.5
	Basic education	16	22.85	11	22	27	22.5
	Primary	18	25.71	13	26	31	25.8
	Secondary	11	15.71	8	16	19	15.8
	Certificate	8	11.42	5	10	13	10.8
	Diploma	2	2.85	1	2	3	2.5
	Total	70	100	50	100	120	100.0
Family member	below 3	22	31.42	16	32	38	31.7
	3-7	21	30	15	30	36	30.0
	7-10	26	37.14	19	38	45	37.5
	Above 10	1	1.42		0	1	.8
	Total	70	100	50	100	120	100.0

Where F=is the number of respondent, %=is percentage

Majority of the study participants (48.57%, highland and 14% midland) were holding land 2.5-5ha and (37.14%, highland and 8% midland) that of land holding above 5 hectors and (14.28% highland, 78% midland) had 0.5-2ha. This indicates there was used large land for honey bee production, cultivation of crop and poultry in highland area. The survey result indicated (50% highland and 52% midland) of the respondents had 16-20 years of experiences in beekeeping and (40% highland and 12% midland) had above 20 years experience and (2.85% highland and 22% midland) of respondents had less than 10 years of experience in beekeeping.

Table 2, land holdings and beekeeping experiences of study participants

Variable	Response	Highland		Midland	
		frequency	percentage	frequency	Percentage
Land Holding	0.5-2hec	10	14.28	39	78
	2.5-5 hector	34	48.57	7	14
	Above 5 hector	26	37.14	4	8
	Total	70	100.0	50	100.0
Experience in beekeeping activity (years)	1-5	0	0	2	4
	6-10	2	2.85	9	18
	11-15	5	7.14	7	14
	16-20	35	50	26	52
	Above 20	28	40	6	12
	Total	70	100.0	50	100.0

4.1.2. Practices of honey bee hives

4.1.2.2. Type of Hive Owned by respondents and Colony Distribution

Three types of hives are used in the study area, namely traditional, transitional and modern hives. Traditional hive is the richest and oldest practice which has been used by people for thousands of years. Transitional hive is intermediating between traditional and modern hives and is of three types include Kenya top bar, Tanzania top bar and mud block hive. Modern hive is the method intends to gain maximum of honey season after season without harming bees. It is the improved bee hive and is less in the district because of its high cost.

According to study respondents a total of 8927 traditional, 226 transitional, and 314 modern beehives, respectively, were owned by the 120 respondents. The average traditional 74.39%, transitional 1.88% and modern 2.67% beehives owned per respondent respectively. Also 45.85% of the traditional hives, 88.11% of the transition hives and 88.65% the modern hives were colonized bees while the remaining were empty. A total of 4577 bee colonies with an average of 38.14% colonies per households were owned by the study participants.

Table 3, hive owned and colony distribution

Number of bee hive owned by respondent	Min	Max	F	%	Mean	Std. Dev
Number of colonized traditional hives	20	70	4093	45.85	34.11	13.64
Number of empty traditional hives	26	92	4834	54.15	40.28	18.89
Total			8927	100	74.39	
Number of colonized transition hives	3	7	202	88.11	1.7	1.14
Number of empty transition hives	0	2	24	11.89	0.18	0.61
Total			226	100	1.88	
Number of colonized modern hive	3	8	282	88.65	2.35	1.66
Number of empty modern hives	0	2	32	11.35	0.32	0.70
Total			314	100	2.67	

4.1.2.3. Sources of bee hives, bee colonies and Reason to engage in bee keeping activities

Table4 sources of bee hives to start beekeeping activity.

Variables	Types of bee hives	Sources	F	%
Sources of bee hives	Traditional	Constructed by him/her self	87	72.5
		Constructed locally and bought	27	22.5
		Heritage from ancestor	6	5
		Total	120	100.0
	Transitional beehives	Constructed locally and bought	34	28.3
		Constructed by him/her self	14	11.7
		Supplied by Government on credit	-	-
		Supplied by GOs	-	-
		Total	48	40.0
	Modern beehives	Supplied by GOs on credit	42	35
		Bought from market	17	14.2
		Supplied by GOs on free	-	-
		Total	59	49.2

According to table 4, Regarding to sources of traditional hives, 87(72.5%) of respondents reported that they constructed by them self; 27(22.5%) reported they bought locally constructed and 6(5%) reported started beekeeping by heritage from their ancestors. Existences of huge indigenous knowledge on practicing beekeeping hive which might differ from beekeepers to beekeepers.

Plate: 1 Types of materials used to construct bee hives in the study district. (Photo by the author 2020)

Concerning to transitional hive, 34(28.3%) bought locally constructed and 14(11.2%) constructed by them self. There was no supply of transitional hive either by government or by NGO in the study area. This implies the attention of both governments and NGO on improving this hive type was low

Plate 2: Transitional hive constructed from bamboo trees (photo from livestock office 2021)

Sources of modern hive reported by study participants showed that. 42(35%) of them that owned from governments on credit and 17(14.2%) reported they bought from market. The number of modern hive in the study area was less.

Plate3: Modern bee hive found in Yadeso kebele (photo from livestock office 2020)

Table 5.Source of bee colonies to start beekeeping activities in the study area

Variables	Agro ecology				Overall F	Overall %
	Highland		Midland			
	F	%	F	%		
Natural bee migrant in the area	31	44.28	23	46	54	45.0
Gift from parents	9	12.85	7	14	16	13.3
By catching swarms	27	38.57	19	38	46	38.3
Buying the honeybee colony	2	2.85	2	4	4	3.3
Through inheritance						
Total	70	100.0	50	100.0	120	100

As presented in table5, 31 (44.28%) highland, 23(46%) midland of respondents revealed that they started beekeeping by natural bee migrant in the area; 27(38.57%) highland, 19(38%) midland by catching swarms; 9(12.85%) highland, 7(14%) midland by getting gift from parents and 2(2.85%) highland, 2(4%) midland buy honey bee colony.

Table 6 Reason to engage in beekeeping activities

Variables	Agro ecology				Overall F	Overall %
	Highland		Midland			
	F	%	F	%		
Income generating	48	68.57	34	68	82	68.3
Easy to perform with other activity	6	8.57	4	8	10	8.3
Inherited from parents	6	8.57	4	8	10	8.3
House expense	10	14.28	7	14	17	14.2
As indication of wealth	1	1.42		0	1	0.8
Total	70	100	50	100	120	100

Where F=is the number of respondent, %=is percentage

As indicated in table 6, sampled beekeepers reported as they engaged in beekeeping activities for different reasons. 48(68.57%) of highland, 34(68%) midland of respondents were reported as they engaged in beekeeping practice to generate income; 10(14.28%) highland, 7(14%) midland to cover house expense; 6(8.57%) highland, 4(8%) midland due to its easy nature to perform with other activities and 6(8.57%) highland, 4(8%) midland inheriting from parent, respectively while only 1(1.42%) highland of beekeepers gave their reason of being engaged in beekeeping because it is an indication of wealth.

Table 7 Placements of bee hives

Variables	Agro ecology				Overall F	Overall %
	Highland		Midland			
	F	%	F	%		
Back yard	10	14.28	7	14	17	14.1
Under the eaves of the house	15	21.42	10	20	25	20.8
In area closure	17	24.28	12	24	29	24.2
Hanging near home stead	7	10	5	10	12	10
Hanging in the forest	22	31.42	15	30	37	30.8
Total	70	100	50	100	120	100.0

Where F=is the number of respondent, %=is percentage

According to the result, Majority of beekeepers in the study area kept their traditional bee hives (31.42% highland, 30% midland) hang in the forest around their areas; (24.28% highland, 24% midland) in area closure to their home;(21.42% highland, 20% midland) kept under the eaves of the house; (14.28% of highland and 14% of midland) backyard and (10% of high land, 10% of mid land) beekeepers in the study area kept their traditional bee hives around their homestead.

Plate4: Hives kept under the eaves of the house found in Seriti kebele (by Gezali Ahmed

Plate 5: Back yard and forest bee keeping in Sigimo district (photo by the author 2020

4.1.2.4. Duration of honey bee stay in hive and harvesting frequency

Table 8 Duration of honey bee stay in hive and harvesting frequency

Description				Total Mean &Std. Dev	
Duration of honey bee remains in the hive.		F	%	Mean	Std. Dev
Traditional	6 month to 1 years	38	31.7	2.26	1.25
	1-2 years	9	7.5		
	1-3 years	19	15.8		
	1-4 years	21	17.5		
Transitional beehives	6 month to 1 years	4	3.3	3.37	0.94
	1-3 years	21	17.5		
	1-4 years	20	16.7		
	more than 4 years	3	2.5		
Modern	6 month to 1 years	4	3.3	4.1	1.17
	1-3 years	13	10.8		
	1-4 years	11	9.2		
	more than 4 years	31	25.8		
Harvesting frequency per year		Maximum per years		Minimum per years	
Traditional		3		1	
Transitional beehives		2		1	
Modern		4		2	

As table 8, above indicates, the average traditional 2.26, transitional 3.37 and modern 4.1 beehives stayed in their hives, respectively. Also, majority of tradition hive honey bee

38(31.7%) stayed in their hives only for 6 month to 1 years, in modern hives 31(25.8%) honey bee stayed for more than 4 years and in transitional hive 21(17.5%) stayed for 1-3 years. This implies traditional hive were used migrant hive which stayed no more years in their hive while transitional and modern hives catch bee and make to stay in the hive for more years.

Regarding to harvesting frequency, from traditional hive honey harvested for 1- 3 time in a years , transitional honey 1- 2 time per years while modern honey 2- 4 time per years.

4.1.2.5. Types of hive products and season harvest, and kinds of honey produced

Table 9 Hive products and season of harvest, and kinds of honey produced

Type of hive products produced		Over all frequency	Percentage
	Honey	8	6.7
	Bees wax	3	2.5
	Honey and beeswax	80	66.
	Honey and bee colony	29	24.2
Peak season of production			
	October to December	15	12.5
	January to February	6	5.0
	May to April	75	62.5
	June to July	24	20.0
Season of honey harvesting in quality and quantity			
	1 kello (yellow) during November- December	28	23.3
	2 Buto during April May	71	59.2
	3 Sendere during June –July	21	17.5
Among honey kinds demanded by consumer.			
	1 Kello (yellow)	19	15.8
	2 Buto during April –May	87	72.5
	3 Sendere during June –July	14	11.7
Price of honey by their color type			
	Kello	135-150	
	Buto	150-200	
	Sendere	100-130	

1 ‘Kello honey’ yellow color honey produced from in Afan Oromo called kellow flower in Amharic Aday abeba during October to December

2 ‘Buto honey’ mostly white and red color honey produced from flower of tree called in Afan Oromo ‘Gatamaa’ in Amharic Gatam during April to May

3 ‘Sendere honey’ white and red color honey produced from flower of tree called in Afan Oromo ‘makkaniisa’ in Amharic ‘bisana’ during June to July.

As it is showed on table 9, majority 80(66.7%) of beekeepers in the study areas reported that they were practice honey bee hive for the production of honey and wax; 8(6.7%) for honey production only and 3(2.5%) for bees wax production only.

In line with results interview conducted with Sigimo district, annually 1222 tone of honey from traditional hive, 437tone of honey from modern hive and 317tones from transitional hive produced. In the district from traditional, transitional and modern honey production total of 1976 tone honey produced. Also the amount of wax produced in the district from traditional 122.2 tones, from modern 43.7tone and from transitional 37.7tone of wax produced per year. So in the district annually total of 197.6 waxes was produced from traditional, transitional and modern honey production according to Sigmo Agriculture office report (2020)

Table10. Major bee flora found in Sigimo district from study respondent and secondary data from livestock office.

No.	Local name	Scientific name	Flowering time
1	Kelo (adey abeba)	*Bidens macroptera*	September to December
2	Gatama	*Schefflera abyssinica*	March to May
3	Wadesa(Wanza)	*Cordia Africana*	October to March
4	Makanisa(Bisana)	*Croton macrostachys*	April to July
5	Lafto(girar)	*Acacia Species*	January to May
6	Ambabesa(Sasa)	*Albizia gummera*	January to April
7	Walensu(qorch)	*Erythrina brucei*	November to February
8	Bargamo(bahirzaf)	*Eucalyptus species*	Throughout the year
9	Badesa	*Syzygium guineense*	December to May
10	Kerero	*Aningeria altissima*	November to January
11	Gravillea	*Gravillia robusta*	April to May
12	Buna(coffee)	*Coffee Arabica*	Throughout the year
13	Seo	*Allophyllus abyssinica*	May to November
14	Ebicha(Grawa)	*Vernonia amygdalina*	January to February
15	Lolchisa(Azamr)	*Bersama abyssinica*	December to May
16	Kefo(Beso bila)	*Ocimum bacilicum*	Throughout the year
17	Tenadam	*Ruta chalepensis*	Throughout the year
18	Baqela(beans)	*Vicia faba*	September to December
19	Avocado	*Persea Americana*	October to December
20	Ater(pea)	*Pisum sativum*	September to October
21	Boloke	*Phaseolus volguris L.*	August to September
22	Metti(zimbaba,selien)	*Pheonix reclinata*	October to December

According to the report of Sigimo district Agriculture office, there are different bee plants in the district and their flowering time is varies from season to season. Kefo (besobila), tenadam, coffee, bahirzaf (Eucalyptus species) are produce flower throughout the year while the remaining are produce flower through the season.

Plate 6: Some of major bee flora found in Sigmo district (photo by livestock office expert)

4.1.2. 6. Honey productivity, Household income and prices of crude honey and wax

Table 11 Honey production per hive in Kg and frequency from respondent beekeeper

Honey production per hive in Kg	Minimum	Maximum	Mean	Std.dev.
Traditional per hive in (Kg)	3	10	6.8	2.79
Transitional per hive in (Kg)	10	15	7.89	2.97
Modern hives per hive in (Kg)	11	18	14.17	2.71

According to table 11, the mean average of the honey production per hive of tradition, transitional and modern honey was 6.8kg, 7.9kg and 14.17kg, respectively. The minimum honey per hive from traditional hive was 3kg and maximum was 10kg; the minimum honey per hive of transitional honey was 11kg and maximum was 15kg and the minimum and maximum honey per hive of modern honey production was 15kg and 18kg respectively

Table 12, Different kinds of Honey productivity in kg per household

Variable	Agro ecology					
	High land			Midland		
	Min.	Max.	Mean	Min.	Max.	Mean
Traditional per household in (kg)	70	600	359	20	200	110
Transitional per household in (kg)	32	96	63.02	12	52	32
Modern hives per household in (kg)	24	140	93.10	30	120	75

The average annual honey production per household of the surveyed beekeepers of highland traditional honey was 359Kg; highland transitional honey was 63.02 kg and the mean highland modern honey production per households was 93.1kg. The average annual honey production per household of the surveyed beekeepers of Midland traditional honey was 110kg, midland transitional honey was 32 kg and the mean modern honey production per households in the midland was 75kg.The minimum annual honey production of traditional honey was 70kg and the maximum honey per households was 600kg; the annual production of transitional honey mimimum32kg and maximum96kg and the minimum and maximum annual honey production of modern honey were 24kg and 140kg respectively in the highland.

Table 13 Prices of colony, hives and types of honey from respondent beekeeper, trader and experts

Prices	minimum	Maximum	Mean	Std.dev
Prices of colonies (ETB)	50	150	107.0	3.81
Price of one transitional bee hive (ETB)	50	100	78.55	16.5
Price of modern bee hive (ETB)	2000	2500	2288.3	200.91
Prices of white honey	150	200	160.09	1.63
Prices of red honey	70	170	96.24	1.71
Prices of mixed honey	85	190	10.84	2.3
Prices of yellow honey	130	165	148.62	1.36

The minimum and maximum prices of transitional hive were 50ETB and 100ETB respectively while the minimum price of modern hive was 2000 birr and its maximum was 2500birrs. The mean of transitional hive was 78.55 while the modern hive was 2288.33. The minimum prices of bee colonies were reported 50 birr and the maximum price was 150 birr (from study respondent and from livestock office expert).

4.1.2.7 Supplementary feeding, Sources of water and migratory beekeeping practice

Table 14Supplementary feeding, Sources of water and migratory beekeeping practice

Variables		Agro ecology				Over all F	Overal l
		Highland		Midland			
		F	%	F	%		
Supplementary feeding of honeybees for dry season used by the respondent	Basso	11	15.71	8	16	19	15.8
	Shiro and other powder	11	15.71	8	16	19	15.8
	Sugar syrup	10	14.28	8	16	18	15.0
	honey and water	9	12.85	6	12	15	12.5
	Grain flour	13	18.57	9	18	22	18.3
	over all	16	22.85	11	22	27	22.5
Sources of water for honeybees	River	29	41.42	20	40	49	40.8
	Well	15	21.42	10	20	25	20.8
	Ponds	9	12.85	6	12	15	12.5
	Streams	13	18.57	9	18	22	18.3
	Lakes	3	4.28	2	4	5	4.2
	Water harvest structure	2	2.85	1	2	3	2.5
	Taps water	1	1.42		0	1	.8
Occurrence of migration of bee in the area	Yes	70	100	50	100	120	100
	No	0	0	0	0		
reason for bee colonies migration	Fetch of forage and water	24	34.28	18	36	42	35.0
	Honey production	46	65.71	32	64	78	65.0
	Total	70	100	50	100	120	100.0

As indicated in above table 14, Supplementary feeding of honeybees for dry season especially for transitional and modern honey bee used by the study respondent were, powders of basso, shiro and other powder, sugar syrup, honey and water and other grain flour

As results of table 14 showed, Sources of water for honey bees reported by study participants was river, well, streams, ponds, leaks and etc. Regarding occurrence of migration of bees in their areas, all 120 participants were answered yes and reason for bee colonies migratory practice was reported78(65%) for honey production and 42(35%) for fetch of forage and water.

Plate 7: Production of wax and transferring of bee from traditional hive to modern ones (photo from district livestock office, 2020)

Table 15 Hive inspection trend of study respondent

Trend of hive inspection	Overall frequency	Percentage
Every day	8	6.67
Every week	14	11.67
Every two week	31	25.83
Every month	40	33.33
During honey harvest	27	22.7
Total	120	100

As result indicates, majority of study respondent 71(59.16%) inspect their hives every two weeks and every months. While the remaining respondents 49(40.84) inspect their hives every day, every week and during honey harvest.

4.1.2.8 Trends of bee keeping production

Table 16, Trends of bee keeping practice

Description	Response	Agro ecology				Over all F	Overal l %
		Highland		Midland			
		F	%	F	%		
Trend of bee keeping product since starting bee keeping activity	Sharply increased	12	17.14	9	18	21	17.4
	Decreased	9	12.85	7	14	16	13.2
	Increased	13	18.57	9	18	22	18.2
	significantly decreased	3	4.28	3	6	6	5.0
	no change	1	1.4		0	1	.8
	Total	38		28		66	54.5
Reason for increase in trend in number of bee colonies and honey yield over the years	Good market price	7	10	5	10	12	10
	Use of new technologies	4	5.71	3	6	6	5
	Added more bee colonies	7	10	5	10	12	10
	Government helps	3	4.28	2	4	5	4.1
	Total	20	28.57	15	30	35	28.9
Reason for decrease in trend in the number of bee colonies and honey yields	migration	1	1.42	1	2	2	1.6
	Pest and predator	4	5.71	3	6	7	5.8
	Chemical application	6	8.57	5	10	11	9.1
	lack of water	4	5.71	2	4	6	5.0
	death of colony	7	10	5	10	12	9.9
	Drought	10	14.28	8	16	18	14
	Disease	2	2.85	2	4	4	3.4
	Lack of budget	1	1.42	1	2	2	1.6
	lack of bee forage	2	2.85	2	4	4	3.4
	Total	39	55.71	27	54	66	54.5

Were F=is frequency, %=is percentage

Table 16 showed that decreased trend of bee keeping product was reported by 12(17.14%) highland and 9(18%) midland of the respondent sharply increased, 13(18.57%) of highland and 9(18%) of midland increased, 3(4.28%) of highland and 3(6%) of midland significantly decreased 9(12.85%) of highland and 7(14%) of midland decrease and 1(0.8%) of highland and none of midland reported no changes. From study participants the reason of increased production was reported as 11(15.17%) highland, 8(16%) midland because of good market price and use of new technology while 7(10%) highland, 5(10%) midland said because of added more bee colonies and 3(4.28%) highland, 2(4%) midland said due to government helps.

4.1.3. Major constraints of honey bee productions

Table 17 constraints of honey production

Major constraints of honey bee productions	Rank	Frequency	Percentage
Shortage of bee colony	1st	17	14
Lack of training/skill of beekeeper	2nd	16	13.2
Careless handling	3rd	14	11.5
Lack of government intervention	4th	13	10.7
Storage material	4th	13	10.7
Marketing	4th	13	10.7
Harvesting condition	5th	12	9.9
High temperature	6th	11	9.1
Bee flora	6th	11	9.1
Total		120	100

Nowadays, beekeepers are facing a number of difficulties and constraints that limit the efficiency of honey production. Respondents raised a number of constraints that hinder beekeeping in their area. The major challenges and constraints recognized in the target area are listed in table 14 were shortage of bee colony, lack of training/skills of bee keeper, careless handling, storage materials, lack of government intervention and marketing, harvesting condition, bee flora, climate and high temperature.

4.1.3.1. Pest and predator found in the study area

Table 18 Pest and predator found in the area from study respondent

No	Pest and predator	Frequency	Percentage	Rank
1	Ants	57	47.5	1st
2	Wax moth	19	15.8	2nd
3	Honey badger	19	15.8	2nd
4	Mites	15	12.5	3rd
5	Spider	10	8.35	4th
6	Lizard	10	8.35	4th
7	Birds	9	7.5	5th

According to table 18, majority of study participants rank and responded 57(47.5%) ants was 1st of the most pest and predators; honey badger and wax moth 19(15.8%) 2nd; mites 15(12.5%) 3rd; spider and lizard 10(8.35%) 4th and last was birds 9(7.5%) pets and predators of honey bee in the study area respectively.

Plate 8: wax moths which is found in movable frame hives (photo by bee expert)

Table19. Traditional control method of pest and predators used by the respondent

Pest and predators	Traditional control method used by study beekeeper
Ants	Place ash as natural repellent and clean apiary, plastering hive stands with plastics and use of green eucalyptus tree as fumigation, destroying ant's home, plastering of thin rubber sheet and metal between the hive and hive stands.
Wax moth	Making the colonies to be strong, giving additional foods, reduce hive entrance, smoking/fumigating the hive
Honey Badger	Use of chasing dogs, use of "wotmed" to kill, fencing the apiary site with strong fence, hanging hives by rope on long trees.
Spider	Cleaning apiary site always, removing the spider webs, putting ash around hive stand
Bee-eating birds	Placing a pole seems the image of humans around the hive(by using cloth, plastic materials), spin around the hive, killing using stone or other materials
Mites	Cleaning apiary, destructing its home, burning.
Lizard	Lengthening hive stand and fixing smooth iron sheet on hive stand, cleaning apiary site, coating legs of the hives with engine oil.

As table 19 indicates they use their own traditional control method for pest and predator that challenge them in bee keeping activities. They use chasing dog and wotmed for larger predator, cleaning apiary, narrowing hive entrance, using plant leaves for fumigation, lengthening hive stand, coating legs of the hives with engine oil, using ash to remove ants and so on for smaller predator like ants, spider, mites, lizard, wax moth and wasps.

Table 20 Agrochemical

Types of agrochemicals used by the respondent	Frequency	Percentage
Herbicide	32	26.67
Pesticide	25	20.8
Both herbicide and pesticide	43	35.8
Others	20	16.67
Total	120	100

The respondent interview and farmers in the study area uses different agrochemicals for weed control and crop pest control herbicide and pesticide respectively. Also others use fertilizer and round up in the first growth stage of farming crop. Indiscriminate uses of those agrochemicals have side effect on honey bees and other pollinating insects. According to table 15 26.67% of respondent use herbicide for weed control, 20.8% use pesticide for crop pest control, 35.8% use both and 16.67% use others such as fertilizer and round up.

4.1.4 Quality of honey production

4.1.4.1. Traders perception on honey storage qualities

Table.21 honey storage qualities

Description	Response	Frequency	Percentage
Honey storage situation for a long time	Yes	25	100
	No	0	00
Years of honey storage taken by respondent	One to six month	12	48.0
	One to two years	8	32.0
	More than two years	5	20.0
Honey storage materials used by the respondent	Plastered sac	13	52.0
	Plastic container	8	32.0
	Barmel	8	32.0
	Animal skin	2	8.0
	Pot	2	8.0
factors influence honey quality responded by participants	Careless handling	6	24.0
	Temperature	5	20.0
	Climate	5	20.0
	Storage materials	4	16.0
	Harvesting condition	3	12.0
	bee flora	2	8.0

As table 21 above indicated, for the question do you store honey for a long time majority or trader 25(100%) said they had stored honey. 12(48%) reported they had stored honey for one to six month, 8(32%) they had stored for one to two years and 5(20%) they had stored for more than two years. On the other hand majority of traders reported they had stored honey in plastic

sack some of the traders reported they had stored honey in plastic container and Barmel, pot and animal skin which is locally known as qalqalloo. The way and materials in which honey stored can affect the quality of honey. Among the traders study participants honey quality may affected by careless handling, temperature, climate, storage materials, harvesting condition and bee flora in order of decreasing importance.

Plate 9: Honey storage materials used in Sigimo district

4.1.4.2. Customers preference and quality of honey

Table 22 customer preference and quality of honey

Description	Response	Frequency	Percentage
factors that govern the price of honey in your localities	Color and taste of honey	15	60.0
	Distance from market	4	16.0
	Season of the year	4	16.0
	Traditional ceremonies	2	8.0
Customers of the honey	Consumers	8	32.0
	Retailers	6	24.0
	Whole sellers	6	24.0
	Cooperatives	5	20.0
Honey preferred by customers	Pure white honey	14	56
	Any pure extracted honey	6	24.0
	Any crude honey	3	12.0
	Pure red honey	2	8.0

Table 22 above indicated factors that govern the price of honey in locality were color and tastes of honey, distance from market, season of the year and traditional ceremonies. Regarding to customer of their honey traders reported that majority of their customer were consumers and less are retailers, whole sellers and were cooperatives respectively. According to trader respondents types of honey more wanted by customer were responded as 14(56%) were reported pure white honey, 6(24%) reported any pure extracted honey, 3(12%) said any pure honey and 2(8%) said pure red honey.

4.1.5. 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).

Table 23 honey quality laboratory results of highland and lowland area

Types of honey(agro-ecology)	Parameters	Unit	Current study			Mean and SD
			Minimum	Maximum	Range	
Highland	Ash	g/100g	73.71	75.61	1.90	74.67±1.05324
	Moisture	g/100g	70.21	87.30	17.10	78.77±7.55011
	PH	g/100g	3.66	3.68	0.02	3.67 ±.00816
	Reducing sugar	g/100g	66.03	66.92	0.89	66.47 ± 0.780
Midland	Ash	g/100g	71.82	73.52	1.70	72.67 ±.96611
	Moisture	g/100g	67.93	86.92	18.99	77.4 ±7.98265
	PH		3.69	3.71	0.02	3.7 ±.00957
	Reducing sugar	g/100g	66.5	67.04	0.54	66.77 ± 0.890

4.2 Discussion

4.2.1. Type of Hive Owned and Colony Distribution

The minimum and maximum of bee colonized hive of transitional hives was 3 to 7 with mean 1.7. The minimum and maximum bee colonized hives of modern hives was 3 to 8 with mean of 2.35 were bee colonies owned of transitional and modern hives respectively. 54. 15% of traditional owned hive were empty while only 11.89% transitional hives and 11.355 modern hives were without bee colonies. This result implies that even if the number of transitional and modern hives were small in the study area, more than 88% of both transitional and modern hives had bee colonies. In contrast, numbers of traditional hives were large and below average 45.85% hive only had bee colonies while more than average 54.15 of traditional hives were without bee colonies due to different factors. Among the factors number of hive in the districts and number of bee colony was equal, the way and experiences of hive holders handle their hive was another problems, absconding due to the prolonged temperature coldness happen sometimes killed large number of bee colony and the migratory nature of bee colony was also main problems of emptiness of traditional hives. This indicates that beekeepers are not aware of intensive colony management during the shortage of availability of honeybee forage, on the one hand there is less follow-up by extension workers when problem emerged.

Regarding to transitional and modern hives experts working on the area reported that, the numbers of both transitional modern hives were small when compared with traditional hives. This interview related with research results of Temesgen *et al*., (2018) in Chiro district of West Hararghe Zone total of 502 bee colonies with an average of 4.22 colonies per head were owned

by the farmer respondents. The number of bee colonies owned in traditional hives ranged from 1 to 50 with an average of 4.04. Only 15.2% of the respondents had modern hives with and without bee colonies and none of the respondents had transitional hives. The relatively lower numbers of modern hives owned that traditional hives owned could be attributed to the respondents' inadequate level of awareness and know-how on its operation (39.7%), high costs of modern hives (40.5%), and unavailability of modern hives in the area (19.8%).

4.2.3. Sources of bee hives, bee colonies and Reason to engage in bee keeping activities

According to table 4, Regarding to sources of traditional hives, 87(72.5%) of respondents reported that they constructed by them self; 27(22.5%) reported they bought locally constructed and 6(5%) reported started beekeeping by heritage from their ancestors. Existences of huge indigenous knowledge on practicing beekeeping hive which might differ from beekeepers to beekeepers.

Concerning to transitional hive, 34(28.3%) bought locally constructed and 14(11.2%) constructed by him/herself. There was no supply of transitional hive either by government or by NGO in the study area. This implies the attention of both governments and NGO on improving this hive type was low. Teklu and Dinku (2016) said the only problem for constructing top-bar hive (KTBH) by beekeepers were inabilities keeping the specific size of top-bars. Due to this problem the hive distribution was very low.

Sources of modern hive reported by study participants showed that. 42(35%) of them that owned from governments on credit and 17(14.2%) reported they bought from market. The number of modern hive in the study area was less. Birhanu *et al.,* (2016), the main reasons for low adoption rate of modern bee hives in the study area were lack of finance to buy input and provide short training for farmers, shortage in supply of beehive accessory. Movable frame hives allow appropriate colony management and use of a higher level technology, with larger colonies, and can give higher yield and quality honey but are likely to require high investment cost and trained man power.

As presented in table5, 31 (44.28%) highland, 23(46%) midland of respondents revealed that they started beekeeping by natural bee migrant in the area; 27(38.57%) highland, 19(38%) midland by catching swarms; 9(12.85%) highland, 7(14%) midland by getting gift from parents and 2(2.85%) highland, 2(4%) midland buy honey bee colony.

This means there is a potential in the area for natural migrant honey bees starting beekeeping activities. This results contrary with findings of (Kalayu *et al.,* 2017), 38.3% of respondents revealed that they started beekeeping by catching swarms. This means there is a potential in the area for starting beekeeping activities because of there is high migrant honey movements in the areas.

This finding which is different from the result reported in other parts of northern Ethiopia, where 88.8% of the beekeepers collect their colonies by catching either flying or jangle swarms (Yirga *et al.,* 2012). More than 96% of the beekeepers in the Gamo Gofa zone, Ethiopia, also collected their foundation colony by catching swarms Yemane *et al.,* (2013). A study report in the Jimma and Illubabor zones of Oromia Regional State indicated that more than 50% of beekeepers start their bee farms by catching swarming colonies Welay *et al.,* (2017). These generally indicate that the result is different when compare to this finding.

As indicated in table 6, sampled beekeepers reported as they engaged in beekeeping activities for different reasons. 48(68.57%) of highland, 34(68%) midland of respondents were reported as they engaged in beekeeping practice to generate income; 10(14.28%) highland, 7(14%) midland to cover house expense; 6(8.57%) highland, 4(8%) midland due to its easy nature to perform with other activities and 6(8.57%) highland, 4(8%) midland inheriting from parent, respectively while only 1(1.42%) highland of beekeepers gave their reason of being engaged in beekeeping because it is an indication of wealth. Beekeepers revealed as they practiced beekeeping for getting cash income, consumption, dowry or gift and for breeding in descending order. This was similar with the findings of Yemane and Taye (2013) who reported that the main purpose of beekeeping was for both income and household consumption depending on their importance.

According to the result, Majority of beekeepers in the study area kept their traditional bee hives (31.42% highland, 30% midland) hang in the forest around their areas; (24.28% highland, 24% midland) in area closure to their home;(21.42% highland, 20% midland) kept under the eaves of the house; (14.28% of highland and 14% of midland) backyard and (10% of high land, 10% of mid land) beekeepers in the study area kept their traditional bee hives around their homestead.
In contrast Kalayu, *et al.,* (2017), reported 47% beekeepers in the study area kept their traditional bee hives around their homestead (backyard); 20.2% put inside the house; 15.4% put under the eaves of the house; 7.8% put in the area closure; 6.6% hanging near homestead whereas 3%

hanging their beehives in the forest. On the other hand, beekeepers of transitional and modern hives kept 58.4% in backyard and 41.6% in area closure. This result is in agreement with (Belie, 2009) who reported that 47.1% of beekeepers kept their traditional hives in the backyard mainly to enable close supervision of colonies.

4.2.3. Duration of honey bee stay in hive and harvesting frequency

As result indicated, the average traditional 2.26, transitional 3.37 and modern 4.1 beehives stayed in their hives were, respectively. Also majority of tradition hive honey bee 38(31.7%) stayed in their hives only for 6 month to 1 years, in transitional hive 21(17.5%) stayed for 1-3 years and in modern hives 31(25.8%) honey bee stayed for more than four years. This implies traditional hive were used migrant hive which stayed no more years in their hive while transitional and modern hives catch bee and make to stay in the hive for more years.

Regarding to harvesting frequency report of study participants shows , traditional honey hive harvest maximum 2 time in years and minimum 1 time per years; transitional honey hive maximum 3 time and minimum 1 time per years while modern honey hives maximum 4 time and minimum 2 time per years. Bekele *et al.,* (2017) reported about 82.8% of study participants harvest honey twice within the year, whereas only 7.2, 5.6 and 4.4% of the sample farmers responded that they harvest once, more than three, three times, respectively in a year. According to CACC (2003) report the average frequency of production for all the three type of hives used in Amhara region were once and ranged from one to two.

4.2.4. Types of hive products and season harvest, and kinds of honey produced

As it is showed on table 7, majority 80(66.7%) of honey beekeepers in the study areas reported that they were practice honey bee hive for produce honey and wax; 8(6.7%) for honey production only and 3(2.5%) for bees wax production only.

In line with results interview conducted with Sigimo district agriculture office bee experts show that, in the annually 1222 tone of honey from traditional hive, 317 tones from transitional hive and 437 tone of honey from modern hive produced. In the district from traditional, transitional and modern honey production total of 1976 tone honey produced per year. Also the amount of wax produced in the district from traditional 122.2 tones, from transitional 31.7tone and from

modern 43.7 tone of wax produced per year. So in the district annually total of 197.6 waxes was produced from traditional, transitional and modern hives.

Regarding to season of honey production majority of respondents 75(62.5%) reported they harvest their honey during month of May to April. On the other hand 71(59.2%) of participants responded that they got more honey from 'Buto' honey types which was harvest during April to May time. This data revealed that majority of honey type produced in the study area was 'buto.' 24(20%) of participants responded they were harvest their honey during months of June to July While 15(12.5%) of respondents were reported they were harvest their honey during months of October to December. 28(23.3%) of participants reported they got honey type called sendere in local name and 21(17.5%) reports they got honey type called 'kello'(yellow) honey. However Kalayu *et al.*, (2017) reported majority of the respondents (73%) collect large amounts of honey once during November to December in a year followed by twice (25%) during the mentioned time and May and June. Similarly, Teferi *et al.,* (2011) reported that the main harvesting seasons in Tigray and Lalibela honey are October through December, with an additional harvest period for Tigray's white honey in June and July; November and December for yellow honey; April and May for white honey from the southwest and southeast Highlands; and February, March, May and June for dark-brown varieties of honey. Harvesting period is different from region to region. This shows the possibilities of harvesting and supplying different types of honey at different time implying the possibility of continuous supply of honey along the market chain.

Regarding honey kinds (kello, buto and sendere), more demanded honey by consumer, majority of respondents 87(72.5%) reported 'buto' honey at first demanded, 19(15.5%) 'kello' honey second demanded and lastly 14(11.7) participants responded 'sendere' demanded.

4.2.5. Honey productivity, Household income and prices of crude honey and wax

The mean average of the honey production per hive of traditional, transitional and modern honey was 6.8kg, 7.9kg and 14.17kg respectively. The minimum honey per hive from traditional hive was 3kg and maximum was 10kg; the minimum honey per hive of transitional honey was 11kg and maximum was 15kg and the minimum and maximum honey per hive of modern honey production was 15kg and 18kg respectively. Similarly, research finding by different researchers by Teferi *et al.,* (2011) indicated on average 33 and 16 kg of honey per hive was harvested from modern and traditional hives in the northern Ethiopian highlands respectively. Honey production

is very low, only about an average of 8 to 15kg of honey could be harvested per hive per year but in areas where improved technology has been introduced, an average of 15 to 20 kg/hive/year has been harvested (Beyene and David, 2007). Addis and Malede (2014) and Chala *et al*., (2013) reported that the average honey yield per year/colony was 7.20, 14.70 and 23.38kg for traditional, transitional and moveable frame hives, in around Gondar and in jimma zone, south-west Ethiopia respectively. Haftu and Gezu, 2014 in Hadiya Zone of southern Ethiopia also indicated 3.04, 4.9 and 8.2kg for traditional, transitional and moveable frame hives, respectively.

According to study participant and livestock office expert, the minimum and maximum prices of transitional hive were 50ETB and 100ETB respectively while the minimum price of modern hive was 2000 birr and its maximum was 2500birrs. The mean of transitional hive was 78.55 while the modern hive was 2288.33. The minimum prices of bee colonies was reported 50 birr and the maximum price was 150 birr.

The average annual honey production per household of the surveyed beekeepers of highland traditional honey was 359Kg; highland transitional honey was 63.02 kg and the mean highland modern honey production per households was 93.1kg. The average annual honey production per household of the surveyed beekeepers of Midland traditional honey was 110kg, midland transitional honey was 32 kg and the mean modern honey production per households in the midland was 75kg.The minimum annual honey production of traditional honey was 70kg and the maximum honey per households was 600kg; the annual production of transitional honey mimimum32kg and maximum96kg and the minimum and maximum annual honey production of modern honey were 24kg and 140kg respectively in the highland.

Honey beekeepers reported as they got revenue from different types of beekeeping practice such as income from selling crude honey, crude bees wax's and from the sale of bee colonies. According to beekeepers response, the average annual income per household from selling the crude honey was 7876.77ETB; the average annual income per household from selling crude bee wax was 5610.23ETB; the average annual income per household from selling bee colonies was 1363.71ETB. The minimum and maximum income beekeepers got from selling of crude honey was 1, 800 and 20,000 respectively; the minimum and maximum income bee keepers got from selling of crude wax was 420 and 17,000 ETB respectively.

The minimum and maximum price of white honey was 150birr and 200birr; The minimum and maximum price of red honey was 70birr and 170birr; the minimum and maximum price of mixed honey was 85birr and 190birr; and the minimum and maximum price of yellow honey was 130birr and 165birr; respectively. The mean income household got from selling white honey was 160.09; the mean income from selling of red honey 96.24; the mean income of selling mixed honey 108.4 and the mean income of yellow honey was 146.62 respectively. Similarly, Yirga, Koru, Kidane, and Mebrahatu, 2012) reported that domestic honey prices in Ethiopia differ substantially by region and type of honey. The highest prices for honey are observed in Tigray, where the white honey that is most popular with Ethiopians is produced. In this region, as of July 2012, farm-gate prices for white honey reached 120 ETB to 130 ETB/kg, with observed differences depending on micro regional honey-quality characteristics, such as purity of wax content and intensity of white color.

4.2.6 Supplementary feeding, Sources of water and migratory beekeeping practice

Supplementary feeding of honeybees for dry season especially for transitional and modern honey bee, 27(22.5%) of honey beekeepers reported they provide their honey bee powders of basso, shiro and other powder, sugar syrup, honey and water and other grain flour. Among honey beekeepers participants 19(15.8%) feed their honey bee basso; 19(15.8%) feed shiro and other powder; 18(15. %) feed sugar syrup; 15(12.5%) feed honey and water and 22(18.3%) feed grain flour respectively. Similarly, Kalayu *et al.*, (2017) as reported by beekeepers honeybee feed shortage occurred mainly during January to May (65.7%) followed by February to August (23.9%), June to August (7.5%) and September to January (2.9%). To address this challenge, beekeeper replied as they provide supplementary feed in the dry season such as: basso, shiro, sugar syrup, honey and water as well as grain flour as indicated. During dry period, 47.59% of the respondents provide supplementary feeds to their bee colonies (Beyene, and David, 2007).

As results indicated, Sources of water for honey bees reported by study participants mostly 49(40.8%) was river, 25(20.8%) was well, 22(18.3) was streams, 15(12.5%) was ponds respectively. Only 5(4.2%) reported as leaks was sources of water for bee; 3(2.5%) reported water harvest structure and 1(0.8%) reported taps water used for honey bees.

Regarding occurrence of migratory beekeeping practice in their areas, all 120 participants were answered yes and reason for bee colonies migratory practice was reported78(65%) for honey

production and 42(35%) for fetch of forage and water. Nuru (2002) reported that beekeepers of Amahra and Tigray Regions, unlike other areas, move their colonies for better forage. This sources add, in some places of Gojjam beekeepers move their colonies to other places not only for better forage but also to protect them from certain seasonal diseases. For maximization of honey production and efficient utilization of resources, migratory beekeeping can be exercised in areas where honey forages provide rich honey flows in succession (Kerealem *et al.*, 2005).

4.2.7 Trends of bee keeping production

Table 16 showed that decreased trend of bee keeping product was reported by 21(30%) highland and 12(24%) midland of the respondent sharply increased, 20(28.57%) of highland and 6(12%) of midland increased, 6(8.57%) of highland and 18(36%) of midland significantly decreased 22(31.4%) of highland and 14(28%) of midland decrease and 1(0.8%) of highland and none of midland reported no changes. From study participants the reason of increased production was reported as 26(63.4%) highland, 6(33.32) midland because of good market price and use of new technology while 10(24.39%) highland, 8(44.44%) midland said because of added more bee colonies and 5(12.19%) highland, 4(22.22%) midland said due to government helps. Similarly, Kerealem *et al.,* (2005) reported that 34.0%, 33.3% and 39.0% in traditional, intermediate and modern hive respectively of the respondents have replied that the trends of bee products in the given years have increased. These respondents assumed the increased trend of bee products to be getting of additional colonies, adoption of improved beekeeping practices and afforestation programs.

Among study participants who said there was decreasing trends honey production, by indicating different reason (35.71% highland and 25% midland) due to bee migration,(28.57% highland and21.87% midland), because of pest and predators, (10.71% highland and 12.5% midland) different chemical applications, (3.57% highland and 15.62% midland) due to death of colony, (10.71% highland, 15.62% midland) because of disease and (7.14% highland, 9.37 midland) due to lack of budget. The current result is similar with Beyene and Verschuur (2004) reported that out of the total respondents, about 67% beekeepers were replied as honey yield has decreased continuously due to different challenges such as deforestation, agrochemical application, pest and predators etc. Also Kerealem (2005) reported that the mean amount of honey produced over the years of 2000-2004 in Amaro district declined while that of Enebse was relatively constant. Also (Bekele, Genet, and Temaro,2017) reported about 72.6% of the respondent reported that

beekeeping production decreased with regards to the yields of hives and the number of honeybees populations, this is because of climatic change from time to time as they said flowering plants found in the area previously diminished.

4.2.8. Major constraints of honey bee productions

Nowadays, beekeepers are facing a number of difficulties and constraints that limit the efficiency of honey production. Respondents raised a number of constraints that hinder beekeeping in their area. The major challenges and constraints recognized in the target area are listed in table 12 1st shortage of bee colony, 2nd lack of training/skills of beekeeper , 3rd careless handling, 4th storage materials, lack of government intervention and marketing, 5th harvesting condition, 6th bee flora, climate and high temperature. The most important constraints present in Ethiopia were bee forage, pests and predators, beekeeping equipment, absconding, honeybee colony, pesticides and herbicides, death of colony, water shortage, honey storage materials and swarming (Yetimwork *et al.*, 2015 in eastern Zone of Tigray; Haftu and Gezu, 2014 in Hadya Zone of southern Ethiopia). Similarly, Kerealem *et al.,* (2009) declared that the major constraints that affect beekeeping sub-sector in Ethiopia are: lack of beekeeping knowledge, shortage of skills man power, shortage of bee equipments, pests and predators, pesticide threat, poor infrastructure development, shortage of bee forage and lack of research extension. According to Adeday *et al.*, (2012) conducted in Wukro district Eastern Zone of Tigray indicated that water scarcity or drought to be one of the main problems of beekeeping. According to SOS-Sahel-Ethiopia the major constraints in Ethiopia are lack of beekeeping knowledge, shortage of trained manpower, shortage of beekeeping equipment, pests and predators and inadequate research and extension services to support apiculture development programmes Wilson RT (2006).

4.2.9. Pest and predator found in the study area

According results, majority of study participants rank and responded 57(47.5%) ants was 1st the most pest and predators; honey badger and wax moth 19(15.8%) 2nd; mites 15(12.5%) 3rd; spider and lizard 10(8.35%) 4th and last was birds 9(7.5%) pets and predators of honey bee in the study area respectively. Similarly, different research findings mentioned the same pets and predators of honey such as Yetimwork *et al.*, (2015) and Adeday *et al.*, (2012) honey badger, ants, wax moth, spider, birds, lizard and snake are identified as pests and predator to the bees in eastern part of Tigray. Similar honeybee pests and predator was reported by in other parts of the country Tessega (2009) in Amhara region, Chala *et al.*, (2012) in Gomma district of Jimma zone, South-

west Ethiopia, Nebiyu and Messele (2013) in Gamo Gofa zone of southern Ethiopia, Tariku and Mechthild (2013) in Sidama Zone,Southern Ethiopia and Tesfaw (2012) in Ada'a district of east Shoa Oromia region, Ethiopia.

4.2.10 Quality of honey production

4.2.10.1. Traders perception on honey storage qualities

Concerning honey storage for a long time majority or trader 25(100%) said they had stored honey. 12(48%) reported they had stored honey for one to six month, 8(32%) they had stored for one to two years and 5(20%) they had stored for more than two years. On the other hand 13(52%) of traders reported they had stored honey in plastic sack, equally 8(32%) of traders reported they had stored honey in plastic container and Barmel and equally 2(8%) of traders responded as they had stored honey in pot and animal skin. The way and materials in which honey stored can affect the quality of honey. Among the traders study participants honey quality may affected 6(24%) by careless handling, 5(20%) by temperature, 5(20%) by climate, 4(16%) by storage materials, 3(12%) by harvesting condition and 2(8%) by bee flora. Beekeeping is still operating in the old traditional ways implying the need for modernization. Low productivity and poor quality of bee products are the major economic impediments for rural beekeepers (Nuru, 1999); however, they face another primary economic concern; i.e. lack of skill to manage their bees and bee products. Most of the rural beekeepers cannot afford to invest in modern beekeeping inputs, processing, packaging, and transport their products to market to maximize profit.

4.2.10.2. Customers preference and quality of honey

Table 21 above indicated that factors that govern the price of honey in the study area were 15(60%) color and tastes of honey, 4(16%) distance from market, 4(16%) season of the year and 2(8%) traditional ceremonies. Regarding to customer of their honey traders reported that 8(32%) of their customer were consumer, 6(24%) retailers, 6(24%) whole sellers and 5(20%) were cooperatives respectively. For the question which honey is more wanted by your customers? The traders responded that 14(56%) were reported pure white honey, 6(24%) reported any pure extracted honey, 3(12%) said any pure honey and 2(85) said pure red honey.

4.2.11. Honey quality laboratory result

According to the result of the current study Average of honey ash contents of highland was 1.90% while the honey ash contents of lowland was 1.70%. The highland honey ash mean contents were 74.67% and that of lowland was 72.67%.

Honey moisture contents of highland was minimum 70.21 to 87.30 maximum with range of 17.10% while the moisture contents of lowland honey was minimum 67.93 to 86.92 maximum with range of 18.99%. The highland honey moisture mean was 78.77 and that of lowland was 77.41. This result indicates both honey samples are with the ranges of world standards. PH of honey contents of highland was minimum 3.66 to 3.68 maximum with range of 0 .02 while the PH of honey contents of midland was minimum 3.69 to 3.71 maximum with range of 0.02. The PH of highland honey mean was 3.67 and that of low land was 3.70.

The reducing sugar composition of two honey samples was collected in Sigimo district fallen with in recommended range by Codex Almentarious Commission (1969) which is greater than 65%, from highland ranging from 66.03% – 66.92% with mean value of 66.5% (Table 23). Reducing sugar of midland honey was ranging from 66.5-67.04% with the mean value of 66.77%**.** Total reducing sugar contents in all honey samples are within quality requirement limits (≥65%) (QSEA; CAC; EU). All honey samples had a total reducing sugar content above the minimum limits of local and international honey quality standards.

Almost all samples of honey examined were within the acceptable range of world and national standard. So, honey produced in the study area is good in its quality.

5. Conclusion and Recommendation

5.1. Conclusion

Sigimo district have adequate natural resources and a long tradition and culture of beekeeping. However, because of lack of technological changes, institutional supports and access to market and value chain development, the district in general and the rural beekeeping households in particular have not been sufficiently benefited from the sub sector. The most widely used type of beekeeping in the study area is traditional due to the high cost of the improved hives and their accessories. From the study it was understood that the colony population is decreasing from time to time due to destruction of forest areas for crop cultivation and different constraints particularly pesticides, predators and bee diseases.

The majority of district beekeepers still used traditional methods not getting benefit that matches with their efforts. This is because traditional methods wait for migratory bees which have low probability to get bee colony. Despite all the constraints and challenges currently facing the beekeeping subsector, there are still enormous opportunities and potentials to boost the production and quality of honey products in Sigimo district.

The area is suitable for honeybee production because of availability of honeybee colony, different bee forages in different season and better experience in rearing beekeeping. An increase in honeybee colony and honey price triggers the farmers to participate in this sector. However, the majority of beekeepers in study area did not use improved beekeeping technologies instead, they practiced traditionally. Most beekeepers have limited attention for different operational beekeeping activities. Moreover, consecutive drought, lack of bee forage associated with deforestation, prevalence of pest and predators, poor farmer's awareness and indiscriminate agrochemical utilizations, shortage of beekeeping equipment were reported by the respondent households as the most important constraints of honey production in the districts

The major constraints to exploit the untapped potential of beekeeping activity in the district are lack of beekeeping equipment, lack of skill or knowledge, agrochemical bee poisoning, shortage of bee forage, incidence of pest and diseases. Majority of the beekeepers follow traditional colony management, harvesting and processing methods to produce honey and most are not in use.

5.2. Recommendation

Based on the result of this study the following recommendations are forwarded.

- Improving and encouraging increased use of transitional and introducing modern bee-hives with full packages (sufficient training of the use and availing all the required accessories), facilitating participatory research and extension with relevant organizations operating in the area such as field days, enhancing farmers knowledge and skills about beekeeping management (including colony multiplication techniques) and pre- and post-harvest handling of hive products, encouraging more farmers to participate in beekeeping and enhancing the capacity of the exiting beekeepers to increase sustainable and adequate supply of quality honey are important for rapid promotion of apiculture to the district.
- Increasing the productivity, production and quality of honey by improving the management of the traditional hives and introducing improved beehives, increasing the productiveness of bee colonies by improving bee forage and providing feed and water and introducing bee plants is very important.
- Since the majority of beekeepers are unable to transfer their colonies, unable to harvest, some are not trained, and 56% box traditional hives are empty. These all indicates the importance of adequate and practical training and strong extension both for beekeepers and development agents. Therefore, establishing and supporting regular training programs to develop experienced and skilled experts, development agents and farmers in beekeeping management and marketing should be the major concern.
- Efforts should also be geared to alleviate the main constraints that hindered beekeeping development in the district. Therefore, there is a great need for attention in providing beekeeping equipment, minimizing of the effect of chemicals with involvement of regional government by developing strategies, and planting multipurpose and drought resistant honey bee flora, conservation of existing vegetation, integrating beekeeping with agro forestry and crop production is important.

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Appendices

JIMMA UNIVERSITY

DEPARTMNET OF BIOLOGY SCHOOL OF GRADUATE STUDIES

Questionnaire to Be Completed By Honey Beekeeper for Honey Bee Production Practices and Honey Quality

PART ONE: INTRODUCTORY PART

Objective: This questioner aims to collect data for master‘s thesis in partial fulfillment of Masters of Sciences in Biology. The study focuses on Honey bee production practices and Honey quality in Sigmo district of Jimma zone Southwestern Ethiopia. Your information will be worth and very helpful for the success of the study. Therefore, the information you reveal will be used for academic purpose. I kindly request you to give your correct experience. Please complete it as per the instructions.

Thank you for co-operation

PART TWO: DEMOGRAPHIC INFORMATION

Direction: This part focuses on identifying the demographic information of the participants. Please read each question and give your answers accordingly.

1. Sex: A. Male Female
2. . Age: A. 20- 30
   B. 31- 40
   C. 41- 50
   D. 51- 60
   E. Above 60
3. Religion of household, A. Orthodox ☐ B. Muslim ☐ Protestant ☐
   D. Other specify_____
4. Marital status: A. Married ☐ B. Single ☐ C. Widowed ☐ D. Divorced ☐
5. Education level of house hold:
   A. Illiterate ☐ B. Basic education ☐ C. Primary school ☐
   E. Secondary school ☐ F. Certified ☐
6. Family number
   A. Below 3 ☐ B. 3-7 ☐ C. Above 7 ☐
7. Land holding
   A. 0.5- 2 hectares
   B. 2.5.- 5 hectares
   C. Above 5 hectares
8. Experience in beekeeping activity (years)
   A. 1-5
   B. 6-10
   C. 11-16
   D. 16-20
   E. above 21 years

Part Three: Bee keeping production practices

Instruction**:**

- Write clear answer in the blank space and use **"**√**"**tick mark in the given box.
- Use pen or pencil and finish at the given time.

9. Types and honeybees number per household head

Types of bee hive	**With colony**	**Empty**	**Total**
Traditional hives only owned/households			
Transitional hive only owned/HH			
Framed hive only owned/ HH			
Traditional and Transitional hive owned/households			
Traditional and Modern hive owned/households			
Transitional and Modern hive owned per households			
Traditional, Transitional and Modern hive owned/HH			

10. Where did you get bee hives**?**

Sources of bee hives		
Traditional	1. beehives Constructed by him/her self	
	2. Constructed locally and bought	
	3. Heritage from ancestor	
Transitional	Constructed by him/her self	
	Constructed locally and bought	
	Supplied by Government on credit	
	Supplied by GOs on free	
	Supplied by NGO on credit	
	Supplied by NGO on free	
Modern beehives	Bought from market	
	Supplied by GOs on credit	
	Supplied by GOs on free	
	Supplied by NGO on credit	

11. Sources of bee colonies to start bee keeping activities

Source of bee colonies to start beekeeping activities in the study area	By catching swarms	
	Gift from parents	
	Natural bee migrant in the area	
	Buying the honeybee colony	
	Through inheritance	
	From Agriculture office	
	NGO	

Placements, sources of bee colonies and reason for engaging

12. Where did you keep your bees?

No	Site or Placement of the hives	Traditional	Transitional	Modern
1	Backyard			
2	Inside the House			
3	Under the eaves of the house			
4	Hanging on the trees near the house			
5	Hanging on trees in the forest			
6	In area closure			
7	Others			

13. What is the reason to engage in beekeeping activities?

0A. Income generating B. Easy to perform to gather with other activity
C. House expense D. Inherited from parents
E. Training F. As indication of wealth

Duration of honey bee stay in hive and harvesting frequency

14. For how long your honey bee remains in the hive?

1. Traditional: Minimum _____years Maximum _____years
2. Transitional: Minimum _____years Maximum _____years
3. Modern: Minimum _____years Maximum _____years

15. Harvesting frequency per year.

No.	Types of hives	Maximum time in years	Minimum time in years
1	Traditional		
2	Transitional		
3	Modern		

Hive products and season of harvest, and harvesting frequency

16. Type of hive products produced		
	Honey	
	Bees wax	
	Honey and beeswax	
	Honey and colony	
17. Peak season of production		
	October to December	
	January to February	
	May to April	
	June to July	
18. In which season do you get more honey in quality and quantity?		
	Yello (keello) during November- December	
	Buto during April –may	
	Sendere during June –july	
19. Among honey kinds listed on question 19 which one more demanded by consumer in order. indicate by writing first, second and third		
	Yello (keello)	
	Buto during April –may	
	Sendere during June –july	
20. Price of honey by their type (kello, buto and sendere) by honey keepers		
	Kello	
	Buto	
	Sendere	

Honey productivity, Household income and prices of crude honey in color

21. Honey production per hive in Kg and frequency	Minimum	Maximum
Traditional per hive in (Kg)		
Transitional per hive in (Kg)		
Modern hives per hive in (Kg)		
22. Different kinds of Honey productivity in KG per household		
Traditional per house hold in (Kg)		
Transitional per household in (Kg)		
Modern hives per household in (Kg)		
Prices of colonies (ETB)		
Price of one transitional bee hive (ETB)		
Price of modern bee hive (ETB)		
Honey production per house hold		
23. Household income and prices of crude honey in color (Ethiopian	Minimum	Maximum

birr).		
Household income for sale of crude honey		
Household income for sale of crude bees wax		
Household income for sale of bees colonies		
Prices of white honey		
Prices of red honey		
Prices of mixed honey		
Prices of yellow honey		

24. Does water available for your honeybees at all the time? 1. Yes ☐ 2. No ☐

25. If yes, where do your honeybees get water?

A. Streams ☐ B. Ponds ☐ C. Rivers ☐ D. Lakes ☐ well ☐ water ☐

E. Others: specify_____

26. If your response is no, how do you provide water to your bee colonies?

27. Do you provide additional feed to your honeybee during shortage of feed?

Yes ☐ No ☐

28 If yes, what do you feed your honeybees?

A. Sugar ☐ B. Barely flour ☐ C. Shiro ☐ D. Honey ☐

E. grain flour ☐ F. Others_____

29. Is there occurrence of migratory beekeeping practice in your area?

A. Yes ☐ B. No ☐

30. What is the reason for bee colonies migratory practices?

A. Fetch of forage and water ☐ B. Honey production ☐

Pest and predator

31. From the following pests and predators found in the area, which is mostly destroy your honey bee? Rank them.

No	Pest and predator	Rank
1	Wax moth	
2	Ants	
3	Spider	
4	Mites	
5	Birds	
6	Lizard	
7	Beetle	
8	Hamagot(honey badger)	
9	Others	

Trends of beekeeping activities

32. What is the trend of your colony number and honey yield?

Types of hive	No harvest	Decreasing	Increasing	Stable
Traditional				
Transitional				
Modern				

33. If there is an increase in trend in number of bee colonies and honey yield over the years, what is the reason behind?

A. Good market price ☐ B. Added more bee colonies ☐

C. Use of new technologies ☐ D. Others (specify) _____

34. If there is a decrease in trend in the number of bee colonies and honey yields, what is the reason behind?

No	Causes	Rank	Season of occurrence	Measures taken
1	Lack of bee forage			
2	Lack of water			
3	Pesticides and herbicides application			
4	Death of colony			
5	Pests and predators			
6	Absconding			
7	Migration			
8	Drought			
9	Lack of budget			
10	Diseases			
11	Others specify			

35. Did you find dead bees around the farm after you apply the chemicals A. Yes B. No ☐

36. If yes, for what purpose do you use agrochemicals?

A. Crop pest control ☐ B. Weeds control ☐ C. Others (specify): _____

37. What are the major signs observed on honey bees related to these chemicals?

A. Massive death ☐ B. Aggressiveness ☐ C. Dead brood ☐

D. Queen death ☐ E. worker bee's death ☐

38. What factors can influence honey quality?

No	What factors can influence honey quality?	Rank
1	Storage materials	
2	Lack of government intervention	
3	Climate and high temperature	
4	Careless handling	
5	Lack of training/skill of beekeeper	
6	harvesting condition	

Appendix 2: Questionnaires of honey quality for traders and others. Circle for question with choice and Write your answer on the blank space for blank space questions.

1. Do you store honey for a long time? 1. Yes 2. No
2. If yes for how many years you store it?
   A. One to six month B. One to two years C. More than two years
3. In what types of materials you store honey?
   A. Plastic container B. Plastered sac C. Pot D. Animal skin E. Barmel
4. What factors influence honey quality?
   A. Storage materials B. Temperature C. Climate D. Careless handling
   E. Harvesting condition F. bee flora
5. What are the factors that govern the price of honey in your locality?
   A. Color and taste of honey B. Traditional ceremonies
   C. Distance from market D. Season of the year
6. Who are your customers?
   A. Retailers B. Whole sellers C. Consumers D. Cooperatives
7. Which honey is more wanted by your customers?
   A. Pure extracted honey from moist dega
   B. Pure extracted honey from moist woinadega
   C. crude honey from Dega
   D. Crude honey from woinadega.

Appendix3. Questionnaires for Expert

1. What types of bee hives are found in the district?
2. How many hives and bee colonies are owned by beekeepers in the woreda?

   I Traditional hive

   II Transitional hive

   III Modern hive
3. How many beekeepers are there in the district?
4. Do you have contact with beekeepers? A. Yes B. No
5. If yes, how many times do you contact per years?

   A. Within a month

   B. within three month

   C. Within six month and above
6. How do you help the beekeepers?

   A. Training

   B. Improving new technologies

   C. Awareness creation

   D. others_____
7. What types of Agrochemicals may affect honey bee?

   A. Herbicide

   B. Pesticide

   C. Roundup and fertilizer

   D. Other_____
8. in what growth stage farmers use agrochemicals?

   A. First growth stage

   B. Mid growth stage

   C. Late growth stage
9. What methods are possible to protect honey bee from agrochemicals?
10. By what methods honey quality can be improved?

Appendix 4: Questionnaires translated to local languages.

Yuunivarsitii Jimmaatti Gaafannoo Qorannoo Yaalii Horsiisa Kanniisa Dammaafi qulqullina dammaa aanaa Sigimoo

Ajaja:

- Deebii ifaa ta'e bakka duwwaa irratti barreessuun saanduqa kenname keessatti immoo mallattoo "√" barreessuun guuti.
- Yeroo siif kenname fayyadamuun xumuri.

1. Haala walii Gala hirmaattotaa

1.1 Saala_____ 1.2 Umurii_____

1.3 Naannoo_____ Godina_____ Aanaa_____ Ganda_____ Garee_____

1.4 Amantii deebii kennaa A. Muslima ☐ B. Ortodooksii ☐ C. Kaatolikii ☐

D.Protistaantii ☐ E Kan biraa_____

1.5 Haala fuudhaafi heerumaa A. Kan hin fuune/hin heerumne ☐ B. Kan fuudhe/ heerumte ☐

C. kan hiike /hiikamte ☐ D.Kan abbaan warraa irraa du'e ☐

1.6 Sadarkaa barumsaa A. kan hin baranne ☐ B. Barnoota bu'uuraa ☐

C. sadarkaa 1ffaa ☐

D. sadarkaa 2ffaa ☐ E. sertifikeetii ☐

1.7 Baayina miseensa maatii A.3 gadi ☐ B. 3-7 ☐ C. 7 oli ☐

1.8. Walii gala lafaa (heektaaraan) _____

A. heektaara 0.5_2 ☐ B. heektaara 2-5 ☐ C. heektaara 5 ol ☐

2. Horsiisa Kanniisaa

2.1 Kannisa ni eegdaa A. Eeyyee ☐ B. miti ☐

2.2. Kanniisa eeguu yoom eegalte?_____

2.3. Kanniisa horsiisuu akkamitti eegalte?

A. Hoomaa kannisaa qabachuun ☐ B.Kennaa maatii ☐

C.hoomaa kanniisaa bitachuudhaan ☐

D. Dhaalaan kan argame ☐ E. kan biraa yoo jiraate ibsi_____

2.4 Hoomaan kanniisaa naannoo keetti ni gurguramaa?

A. Eeyyee ☐ B. miti ☐

2.5 Eeyyee yoo jette gatiin hoomaa tokkoo qarshii meeqa?_____

2.6 Gaagura meeqa Qabda?

Gosa gaguraa	Hoomaa kanniisaa waliin	Duwwaa	Waliigala
Gaagura aadaa qofa			
Gaagura ce'umsaa qofa			
Gaagura ammayyaa qofa			
Gaagura aadaa fi ce'umsaa			
Gaagura ce'umsaa fi ammayyaa			
Gaagura aadaa fi ammayyaa			
Gaagura aadaa, ce'umsaafi ammayyaa			

2.7. gaagura kanniisaa eessaa argatte?

Madda gaaguraa		
Aadaa	Gaagura ofii hojjatachuun	
	Wantoota naannoo irraa hojjachuun/bitachuun	
	Dhaalaan kan argame	
Ce'umsa	Wantoota naannoo irraa hojjachuun	
	Bitachuudhaan	
	Liqiidhaan mootummaa irraa kan argame	
	Tolaan mootummaa irraa kan argame	
	Liqiidhaan miti mootummaa irraa kan argame	
Ammayyaa	Gabaa irraa bitachuun	
	Mootummaa irraa liqiin kan argame	
	Mootummaa irra tolaan kan argame	
	Dhaabbata miti mootummaa irraa kan argame	

2.8. Eessatti hoomaa kanniisaa kee eegda?

T/L	Bakka eegumsa gaaguraa	Gagura aadaa	Gagura ce,umsaa	Gagura ammayyaa
1	Mana keessa			
2	Mana jala			
3	Muka naannoo manaa irratti fannisuun			
4	Muka bosona jiru irratti fannisuun			
5	Naannoo manaa			
6	Kan biraa			

2.9 Kanniisni kee waggaa hammamiif gaagura keessa turuu danda'u?

1. Kan aadaa waggaa_____ Hanga _____ 2. Kan ce'umsaa waggaa _____Hanga ____

3. Kan Ammayyaa Waggaa _____ Hanga waggaa_____

2.10 Waggaatti damma marsaa fi kilograama meeqa oomishta?

T/L	Waggaa	Gaagura Aadaa		Gaagura Ce,umsaa		Gaagura ammayyaa	
		Marsaa	Baayina(kg)	Marsaa	Baayina(kg)	Marsaa	Baayina(kg)
1	2010						
2	2011						
3	2012						

2.11. Gaagura duwwaa qabdaa? A. Eeyyee ☐ B. Miti ☐

2.12. Eeyyee yoo jette baayina gaagura duwwaa jiru ibsi.

Gosa gaaguraa	Baayina	Sababa inni duwwaa ta'eef
Aadaa		
Ce'umsa		
Ammayyaa		

2.13. Wantootni kanniiisa miidhuu danda'an maal fa'i jettee yaadda? Sadarkeessii ibsi.

T/L	Maxxantootaafi nyaattota kanniisaa	Sadarkaa	Mala to'annaa
1	Mixii		
2	Jirbi footuu		
3	Rirma		
4	Lootuu		

5	Simbirroo		
6	Billaacha gaga		
7	Hamaa		
8	Kan biraa		

2.14 Baay'ina kannisa keetii wajjin wal qabatee bu'aan ati argattu maal fakkata?

Gosa gaaguraa	Bu'aan hin jiru	Xiqqaadha	Olaanaadha	Dhaabbataadha
Aadaa				
Ce'umsa				
Ammayyaa				

2.15 Baay'inni kannisa keetiif bu'aan ati argattu kan dabalu yoo ta'e, Sababni isaa maali?

A. Hoomaa kannisaa itti dabaluu ☐ B. teekinoolojii haaraa fayyadamuu ☐

C. Gatii gabaa gaarii argachuu ☐ d. Sababa biraa_____

2.16 Baayinni kanniisa qabduufi bu'aan waggaatti argattu kan gadi bu'u yoo ta'e sababni isaa maali?

No	Sababoota	Sadarkaa	Waqtii itti mudatu
1	Hanqina nyaata kanniisaa		
2	Dhabamuu bishaanii		
3	Keemikaala garaa garaa		
4	Godaansa kanniisa		
5	Gogiinsa		
6	Dhukkuba		
7	Dhabamuu baajataa		
8	Kan biraa yoo jiraate ibsi		

2.17 Itti fayyadamni keemikaala qonnaa naannoo keetti ni argamaa? A. eeyyee ☐ B. miti ☐

2.18 Eeyyee yoo jette faayidaa maaliitiif itti fayyadamu? A. Maxxantoota midhaanii ittisuuf ☐

B.Aramaa ittisuuf ☐ C. Kan biraa yoo jiraate ibsi_____

2.19 Keemikaalicha yeroo akkamii fayyadamtu ji'a kam keessa?_____

2.20 Itti fayyadama keemikaalaa booda naannoo lafa qonnaatti kannisa du'an argitee beektaa?

A. eeyyee ☐ B. miti ☐

2.21. kanniisa irratti keemikaalli qonnaa dhiibbaa qabaachuu hubattee jirta?

A. eeyyee ☐ B.miti ☐

1. Eeyyee yoo jette sababa keemikaalaatiin hoomaa kanniisaa meeqa dhabde?_____

2. keemikaalaan wal qabatee mallattoon kanniisa irratti mul'atu maal fa'a?

A. du'a walii galaa ☐ B. finciluu kanniisaa ☐ C. jiisaan du'uu ☐

D. mootiin du'uu ☐ E. dalagduun du'uu ☐ F. kan biraa_____

3. Kannisni akka keemikaalaan hin hubamne tooftaa maaliitti fayyadamta?_____

2.22. Kannisni kee yeroo hunda bishaan argachuuf haala mijataa qabuu?

A. eeyyee ☐ B. miti ☐

1. Eeyyee yoo jette bishaan kana eessaa argatu? A. laga ☐ B. Haroo ☐

C. galaana ☐ D. Kan biraa yoo jiraate ibsi_____

2. miti yoo jette bishaan haala kamiin dhiheessuufii dandeessa?_____

2.23. Kannisa keetiif nyaata dabalataa ni laattaafi? A. eeyyee ☐ B. Miti ☐

1. eeyyee yoo jette gosa nyaataa maal kennitaaf? A. Sukkaara ☐ B. daakuu garbuu ☐

C. shiroo ☐ D. damma ☐ E. Kan biraa yoojiraate_____

2.24. Kannisni kee amala akkamii qabu? A.amala gaarii ☐ B. Amala finciluu ☐

2.25. kannisni kee Garee kannisa biraatti akka hin makamne ni dhorkitaa?

A. eeyyee ☐ B. miti ☐

1. eeyyee yoo jette tooftaa maaliitiin?_____

2.26. Bakka kanniisni kee itti eegamu ni qulqulleessitaa? A. eeyyee ☐ B. miti ☐

1. eeyyee yoo jette yeroo hammamiitiin_____

2. miti yoo jette, maaliif_____

2.27. Waqtii(ji'a) kam keessa damma baay'inaafi qulqullinaan argachuu danda'ama?

A. Keelloo Ji'a November- December

B. Buto (gatamaa) April –may

C. sendere (makkanniisa) June –july

2.28. Mukkeen naannoo keetti argaman kan kanniisni damma irraa qopheessuu danda'an tarreessi.

Maqaa gaafataa_____ Mallattoo_____ Guyyaa_____

Galatoomaa

Kutaa 2ffaa: Godina Jimmaa aanaa Sigimootti Gaafannoo qulqullina dammaa irratti Daldaltoota dammaatiif qophaa'e.

Ajaja: Gaaffii filannoo qabuuf qubee deebii sirrii qabu itti marsi, akkasumas bakka duwwaa irratti immoo deebii ifaa barrreessuun guuti.

1. Damma yeroo dheeraaf ni keessaa? A. Eeyyee B. Miti
2. Eeyyee yoo jette yeroo hammamiif tursiista?
   A. Ji'a tokkoo hanga ji'a jahaa
   B. waggaa tokkoo hanga waggaa lama
   C. waggaa lamaa ol
3. Meeshaan damma ol kaa'uuf itti fayyadamtu maali?
   A. Pilaastikii (baaldii) B. qalqalloo C.Huuroo
   D. Barmeelii D. Kan biraa _____
4. Wantootni rakkoo qulqullina dammaa ta'an maal fa'i?
   A. Meeshaa itti kuusan
   B. Tempireechara
   C. Jijjirama qilleensa
   D. qabiinsa seer malee
   E. haala yeroo muramuu F. Gosa daraaraa
5. Wantootni gatii dammaa irratti dhiibbaa qaban maal fa'i?
   A. Halluufi dhandhama dammaa
   B. dhiheessii aadaa
   C. fageenya gabaa irraa qabu
   D. Waqtiiee waggaa
6. Maamilli kee eenyu?
   A. daldaltoota waliigalaa B. Nyaattota C. Waldaalee
7. Gosa dammaa kamtu caala filatamaadha?
   A. Damma calalamaa kan baddaa B. Damma calalamaa badda daree
   C. Damma baddaa kan hin calalamin D. damma badda daree kan hin calalamin

Kutaa 3ffaa: Godina Jimmaa aanaa Sigimootti gaafannoo horsiisa kanniisaa dammaa irratti ogeessota kanniisaatiif qophaa'e.

A. Gosoota gaaguraa akkamiitu aanattii keessatti argama?
B. Namootni kanniisa horsiisan gaagura meeqaafi hoomaa kanniisaa meeqa qabu?
    A. Gaagura aadaa_____ Hoomaa kanniisaa_____
    B. Gaagura ce'umsaa _____ Hoomaa kanniisaa_____
    C. Gaagura ammayyaa_____Hoomaa kanniisaa_____
C. Aanattii keessatti namoota meeqatu kanniisa horsiisa?
D. Namoota kanniisa horsiisan wajjin qunnamtii qabdaa?
    A. Eeyyee B. Miti
E. Eeyyee yoo jette, waggaatti al meeqa qunnamta?
    A. Ji'a tokkoon
    B. B. ji'a sadiin
    C. C. ji'a jahaafi isaa ol
F. Namoota kannisa horsiisan haala kamiin deeggarta?
    A. Leenjii kennuufiin
    B. Teeknoolojii haaraa uumuu
    C. Horsiisa kanniisaa irratti hubannoo uumuu
    D. Kan biraa yoo jiraate ibsi_____
G. Gosootni keemikaala qonnaa kanniisa miidhuu danda,an maal fa'a?
    A. Qoricha farra aramaa
    B. Qoricha maxxantootaa
    C. Xaa'oo fi roundup
    D. Kan biraa_____
H. Sadarkaa guddina biqilootaa kamirratti qonnaan bultoonni keemikaala qonnaa fayyadamu?
    A. Sadarkaa guddina jalqabaa
    B. Sadarkaa guddina gidduu
    C. Sadarkaa guddina xumuraa
I. Kanniisni keemikaalaan akka hin hubamne gochuuf tooftaa maaliitu gaariidha?
J. Tooftaa maaliitiin qulqullinni dammaa fooyya'uu danda'a?