2018-11-22

BEESWAX PRODUCTION, MARKETING AND QUALITY STATUS IN SELECTED DISTRICTS OF KAFA ZONE OF SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGION, ETHIOPIA

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BAHIR DAR UNIVERSITY

COLLEGE OF AGRICULTURE AND ENVIRONMENTAL SCIENCESGRADUATE PROGRAM

BEESWAX PRODUCTION, MARKETING AND QUALITY STATUS IN SELECTED DISTRICTS OF KAFA ZONE OF SOUTHERN NATIONS NATIONALITIES AND PEOPLES REGION, ETHIOPIA

MSc. Thesis

By

Tesfu Shegaw

November, 2018

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Tesfu Shegaw

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE (MSc.) IN APICULTURE

November, 2018

Bahir Dar, Ethiopia

THESIS APPROVAL SHEET

As members of examining boards of Masters of Science (MSc.) thesis open defense, we have read and evaluated this thesis prepared by Tesfu Shegaw entitled: **'Beeswax Production, Marketing and Quality status in Selected Districts of Kafa Zone of Southern Nations Nationalities and Peoples Region, Ethiopia'** and we hereby certify that it be accepted as fulfilling the requirements for the award of the degree of Master of Science (M.Sc.) in Apiculture.

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DECLARATION

Here is to certify that this thesis entitled '**Beeswax Production, Marketing and Quality status in Selected Districts of Kafa Zone of Southern Nations Nationalities and Peoples Region, Ethiopia'** submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in **Apiculture** to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University, through the department of Animal Production and Technology, done by **Tesfu Shegaw Yimer**(ID.N^{o} BDU0906124PR) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

Name of the Student: Tesfu Shegaw Yimer

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ACKNOWLEDGMENT

Above all, I would like to thank the almighty GOD without whose blessing, it would not been possible all my wishes to come into reality.

My sincerely gratitude goes to my Major advisor Dr. Asaminew Tassew and my co advisor Dr. Desalegne Begna those who provided me their inevitable supports in providing me their prestigious comments and advices from the very beginning designing till final write up of this thesis.

I would like to Acknowledge Bahir Dar University College of Agriculture and Environmental Science for accepting me to pursue my MSc. program and providing invaluable supports throughout whole my school stays.

I am also indebted to acknowledge Sekota Dry Land Agricultural Research Center with all its staffs especially I would like to give my special thanks for Ayalew Girmay, Addisu Bihonegne and Yusuf Ibrahim for their very benevolent and diligent supports and cooperation during my stay of laboratory analysis.

I am very indebted to give my special appreciation to Bonga Agricultural Research Center, Livestock Research Case Team staffs for their diligent cooperation throughout my tasks.

It is impossible to do any fruit full works without the cooperation of zone, Districts and PAs. Hence, my great thanks also goes to all the Zonal, Districts and PAs live stock experts for their wise cooperation in providing all the relevant information starting from site selection, arranging respondents and data collections.

I would like to thank all the respondent beekeepers, '*tej'* houses owners and cooperatives for providing me all valuable information with great patience and providing me study samples.

Finally, but not least, I would like to heartedly acknowledge the South Agricultural Research Institute (SARI) for providing me this chance and full budget supports during my entire school stays.

DEDICATION

This thesis is dedicated to my Families

ACRONYMS/ABBREVIATIONS

ARSD	Apiculture Research Strategy Document
ATA	Agricultural Transformation Agency
BfD	Bees for Development
CLI	Crop Life International
CSA	Central Statistical Agency
EAB	Ethiopian Apiculture Board
EMDIDI	Ethiopian Met and Dairy Industry Development Institute
EPOPA	Export Promotion of Organic Products from Africa
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
GDP	Growth Domestic Product
GDS	Global Development Solutions
g	grams
HBRC	Holeta Bee Research Center
Hec.	Hectare
JAICAF	Japan Association for International Collaboration of Agriculture and Forestry
KEBS	Kenyan Beeswax Standard
KTBH	Kenyan Top Bar Hives
KZBFED	Kafa Zone Bureau of Finance and Economic Development

m	Meter(s)
M	Mole
MAAREC	Mid Atlantic Apicultural Research and Extension Consurtium
mg	Milligram
ml	Milliliters
mm	millimeter
MoARD	Ministry of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
Pcs	pieces
QSAE	Quality and Standards Authority of Ethiopia
SD	Standard deviation
SPSS	Statistical Package for Social Sciences
Sq.Kms.	Square Kilometers
USAID	United States Agency for International Development
WCAHSE	Women's Collective Action in the Honey Sector in Ethiopia

Beeswax Production, Marketing and Quality Status in Selected districts of Kafa Zone, Southern Nations Nationalities and Peoples Region, Ethiopia

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ABSTRACT

The study was conducted in selected districts of Kafa Zone of SNNPR, Ethiopia with an intention to identify the production, marketing and quality status of beeswax. Three districts; Chena, Gimbo and Gesha and three PAs from each district were purposively selected based on their potentialities for honey and beeswax production and marketing. A total of 180 beekeepers and key informants were involved for the collection of survey data. Beeswax samples were taken from fresh combs, old combs, 'tej' houses and processors/cooperatives for quality analysis. According to the survey results, over 93% of beekeepers do not practice any processing of honey and sale it in crude form. Only about 24(13%) of individuals are practicing collection of beeswax while the rest majorities discard it as a byproduct. Of those who are collecting beeswax, only 7(29%) are practicing processing beeswax for selling and other local purposes such as foundation sheet making, smearing top bars, 'tuaf" making. This implies the trends of collection/processing and marketing of beeswax is infant at beekeepers level. Hence, local 'tej' houses and cooperatives (which are two in numbers) are considered as the only major actors engaged in processing and marketing of beeswax. Though local mead houses are the major sources where beeswax is readily available, due to poor handling practices and an intentional addition of foreign materials (salt and kocho)resulting for some deviations in certain parameters. According to the laboratory results, the mean value for melting point, refractive index, ash content, total volatile matter, acid value, saponification value, ester value, and ester to acid ratio is found to be 62.35± 0.76, 1.4416±0.0005, 0.0857±0.0744, 0.4156±0.1924, 22.689± 1.857, 94.7540±4.221, 72.065± 4.273, 3.201± 0.376, respectively. All the samples passed for paraffin and other waxes and fats and fatty acid tests. The result shows, no significant variation among study districts in all parameters. However, there is significant variation in some parameters based on sources at $p<0.05$. Accordingly, significantly higher value for refractive index, total volatile matters and ash contents recorded at samples from 'tej' houses. The overall laboratory results revealed that all the beeswax samples collected from various sources are within the acceptable ranges of national and international standards.

***Key words**: beeswax production, quality, marketing, Kafa zone.*

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CHAPTER 1. INTRODUCTION

1.1. Background and Justification

Agriculture has paramount contributions to the Ethiopian economy in terms of export, employment and subsistence covering about 50% of GDP, 85% of employments, 90% of export earnings and source for about 70% of industrial raw materials (USAID, 2012; CSA, 2015).

Beekeeping is an integral part of agricultural activity known for its valuable products (honey, beeswax, pollen, royal jelly, bee venom and propolis) used in foods, cosmetics, medicines, and engineering industries (ARSD, 2000; Gezahegn Tadesse, 2016; Espolov *et al.,* 2014; Gemechis Legesse, 2014). Another very important contribution of beekeeping is its indirect merits obtained from pollination services through which plays crucial roles in maintaining the natural ecosystem(Nyau, 2013; CLI,2013; BfD, 2006;2016) as well as sustaining world economy by enhancing productivities of various crops (Bradbear, 2009; Mohammed Ahmed *et al.,* 2013; Samuel Sarka, 2017).

Next to honey, Beeswax is considered as a major and oldest product used by mankind (Nyau, 2016). In the ancient times it had been using for making various paintings, sculptures, adhesives, as medicinal ingredients and healings (Bogdanov, 2016b). Later on with expansion of Christianity, it has been extensively used for making candles for daily ceremonies in churches (Hartman, 2004).

Nowadays, in related to the advancement of technologies and modernization, beeswax has been using for producing over 300 industrial products used in various fields including Cosmetics, foods, pharmaceuticals, arts, engineering and industries (Bogdanov, 2004a; Nuru Adgaba 2007b; Ayalew Kasaye, 2008) resulting for an ever increased demands for this product (Gemechis Legesse, 2014).

Ethiopia is endowed with immense natural resources which favors for the existence of over 10 million honeybee colonies potential for the production of huge amount of honey and beeswax (USAID, 2008; Getahun Tekle and Samuel Woldeyohanis, 2016). Of the total 10 million

colonies 6,189,329 (61.89%) are managed in various types of hives (i.*e.* 5,902,629(95.37%) in traditional hives, 80,832(1.3%) in transitional and 205,873(3.33%) in modern hives (CSA, 2016).

According to GDS (2009), the country owns a potential of producing 500,000 tons of honey and 50,000 tones of beeswax annually. However, currently it achieved only about 47,706 tons of honey and 5,542 tons of beeswax which is estimated to be only about 10% of its gross potentials (FAOSTAT, 2016). With such an amount it ranks first both in honey and beeswax production from its continent and ranks 10^{th} and 4^{th} worldwide for its honey and beeswax production respectively (Hartmann, 2004; SNV/Ethiopia, 2005; Sisay Fikru, 2015; Gemechis Legesse, 2016).

Beekeeping has huge economic benefits in support of the GDP of the country. With this regard, about 2 million individuals have been engaged in beekeeping activities using it as their major income sources. However, there are also a large number of individuals engaged in processing and marketing of honey and beeswax product benefiting from the sector as their major livelihood source (WCAHSE, 2013).

Ethiopia has a long lasting history in its beeswax production and trading (FAOSTAT, 2016). Even though the export trends of beeswax is steadily increasing from time to time, the Mean export level of last Eight years (2009-2016) reports revealed that it exported only 351 tons which is below 10% of its production level (5140tons)(Gemechis Legesse 2014; FAOSTAT, 2016; ATA, 2017).

Due to its stability and attractiveness beeswax is the only special animals' product of the country competing the European market (Aravindakshan *et al*, 2010).

Even though the small scale beekeepers are the major sources of beeswax, the production and processing of beeswax is under taken by very few individuals at this level. Hence, local mead houses, where about 80% of the total crude honey produce goes are the only major sources of beeswax product in the country with no interventions under taken so far at this market segment (Hartman, 2004; Melaku Girma *et al.,* 2008; Paulos Dessalegne, 2012).

The average Beeswax yield which will be obtained from traditional and modern hives is estimated to be 8-10% and 0.5-2% of its honey yield respectively (Johannis Agonafir, 2005; Melaku Girma *et al.,* 2008). This revealed that the high coverage of traditional hives accompanied with potential bee forages are considered as a golden opportunities for the production of maximum beeswax for fulfilling the export as well as local demands as input for modern hives (for foundation sheets) (Gemechis Legesse ,2014).

Kafa zone is one of the areas with huge and core forest places of the country with huge honeybee colony population predominantly managed in traditional hives. The zones coves about 40% of the regional potentials producing over 13, 20, 414 kg honey (excluding modern hives) (CSA, 2016).

Hence, to reduce the wastages and up taking the existing potentials of bee products in general and beeswax in particular, identifying the major constraints and opportunities along the various market actors in general and producers in particular is paramount. Moreover, identifying the quality status of the product along each actor will pave the way for further intervention so as to come up with producing internationally compatible product, which is the very issue of trading.

1.2. Statement of the Problems

Kafa Zone is one of the zones found in south Nations and Nationalities and Peoples Region (SNPR) enriched with immense natural resources very potential for beekeeping activity (ARSD, 2000; Gezahegne Tadesse, 2016; Awraris Getachew *et al.*, 2012, Kasa Tarekegne *et al.,* 2017). In the area, beekeepers are predominantly under taken in traditional ways of beekeeping systems mainly by hanging log hives in near forests (Hartman, 2004; Awraris Getachew *et al.,* 2012). As most parts of the country, honeybees are basically managed for honey production purposes aiming to fulfill the instant income needs of households (Joachim, 2017). The predominant traditional ways of beekeeping systems, presence of huge honeybee colonies are assumed to be the golden opportunities for production huge amount of beeswax. Moreover, due to the intense absconding nature of honeybee race (*Apis mellifera scutellata*)

in the area, a considerable amount of beeswax is being wasted without feasible economic benefits (Amssalu Bezabih *et al.,* 2004; Gallmann and Thomas, 2012; Awraris Getachew *et al*., 2012). Yet the production and marketing trend of beeswax is very limited in the areas. So far, there is no any veritable study undertaken regarding this product. Detailed information on practical aspects of production, product handling, marketing and quality status of the beeswax product is lacking. Moreover, available actors taking part in production, processing and marketing of the product are not yet identified. As a result, an intervention on addressing the constraints and opportunities of beeswax production and marketing of this product are very crucial to uptake the huge potentials of the areas.

1.3. Objectives of the Study

1.3.1. General objective

- The general objective of this study is to provide valuable information on production, marketing and quality status of beeswax product in selected districts of Kafa zone, Southern Nations Nationalities and Peoples Region, Ethiopia.

1.3.2. Specific objectives

- To assess the current beeswax production status, identifying the constraints and opportunities.
- To identify the market status of bees wax product.
- To identify the quality status of beeswax produced in the study areas.

1.4. Research Questions

- What is the current production status of beeswax in the study areas?
- What are the major constraints and opportunities of beeswax production and marketing in the study areas?
- What does the marketing status of beeswax looks like?
- Who are the possible actors involved in production, processing and marketing of bees wax in the study areas?
- What does the quality standards of bees wax produced in the study areas looks like?

CHAPTER 2. REVIEW OF LITERATURES

2.1. Role of Beekeeping

Beekeeping is an off farm activity practiced by man king for centuries mainly to obtain its valuable products (honey, bees wax, pollen, propollis, royal jelly, bee venom) used to attain the nutritional, medicinal and income requirements (ARSD, 2000; Gezahegne Tadesse, 2016; JAICAF, 2009 ; Espolov *et al.,*2014). However, its benefit will also extend to increasing the production and productivities of crops as well as maintaining the natural ecosystems through pollination services (JAICAF, 2009; USAID, 2012; Melaku Berhe *et al*., 2013; Janet and Andrian, 2014) which is considered as an indirect benefit of beekeeping. Moreover, it supports the GDP of countries through exports earnings from its products (Hilmi *et al.*, 2011)

2.1.1. Bee products

2.1.1.1. Honey

Honey is considered as the primary product incurred from beekeeping. The bees collect nectar and other secretions of plants which they transform by addition of enzymes and evaporating the water contents and leaving it in the combs to ripen for their later uses (QSAE, 2005; Nyau, *et al*, 2013).

It is a complex natural product composed of over 400 substances including various sugars, enzymes, amino acids, organic acids, proteins, aromatic substances, minerals, pigments, waxes, trace elements, etc (Dimins *et al.*, 2006). Sugars mainly glucose, fructose and Dextrose are considered as the major constituents of honey product accounting for about 80% of its compositions (Qaisar *et al.,* 2013). It is also used for healing against various health problems for humans and animals (Mutsaers, 2005; Gidey yirga and Kibrom Ftwi, 2010).

2.1.1.2. Beeswax

Beeswax is a valuable product obtained from honeybees secreted from four pairs of glands located underside of the abdomen of worker bees which is fully developed at 12 to 18 days of age and starts diminishing as their age is increasing and during feed shortages (Brown, 2010;

Carillo *et al.,* 2015). However, it will reactivate in times of emergency or during shortage of younger bees (Bogdanov, 2016a). Honeybees produce wax for constructing their combs and cell capping for storing honey, pollen and rearing broods (QSAE, 2005; KEBS, 2013).

It is composed of esters of fatty acids (67%) such as mono ester (35%), diester (14%), trimester (3%), hydroxyl monoester (4%), hydroxyl polyester (8%), various hydrocarbons (14%), free acids (12%), long chain alcohols (1%) and other substances (Brian, 2015; CBI, 2015). Pure beeswax is whitish in colour. However, presence of pollen and other substances triggering it become yellowish (Bogdanov, 2016a).

It is thought to have enormous economic benefits to mankind since ancient times. Despite its use for making foundation sheets, beeswax is also widely used in various fields including cosmetics, foods, pharmaceuticals, engineering and industries (Bogdanov, 2004b; 2016b; Hilmi *et al.,* 2011; Gemechis Legesse, 2014).

2.1.1.3. Pollen

The Pollen is a powder form male gametophytes produced by male organ/anthers of angiosperms. Pollination occurs when the pollen grain of a plant transferred to the stigma of female organ of the same plant or another of the same species (Alice, *et al.,* 2012). Honeybees collect pollen using their specialized organ called pollen basket/corbeculea found on their hind legs. It is bees' main source of essential amino acids, minerals, fats, vitamins, sugars, sterols and other substances (Maria *et al.*, 2010; Bogdanov, 2015c). However, its composition and biological values will vary based on the plant types it is collected from (Mutsaers, 2005). Pollen can be collected using pollen trap attaching at the hive entrance or picking from the comb cells inside the hives. It has therapeutic effects for diseases such as prostatitis, hay fever, and gastroenterology and serves as dietary supplements for human beings (Maria *et al.*, 2010; Bogdanov, 2011). It has no specific quality standards. However, its moisture content is considered as the major quality criteria which should be less than 6 percent of its total biomass（Bogdanov, 2004b).

2.1.1.3. Propolis (bee glue)

It is a resinous substance collected by honeybees from plant saps and resins or gums, mixing with their saliva and beeswax (Mutsaers *et al.*, 2005) used to seal cracks, reducing openings of their abode, strengthening the base of comb's attachments and masking dead bodies in hives which honeybees are unable to remove. Propollis contains about more than 300 natural compounds (Mahmoud, 2006). But, its composition might vary based on plant types it is collected from, location and seasons (Bogdanov and Gallmann, 2008; Edward, 2014; Shuai *et al.,* 2014). In spite of its compositional variations, it has very similar biological effects (Bogdanov, 2016d).

Generally, raw propolis is composed of 50-70% resins and balsams, 30-50% essential oils and waxes, 5-10% pollen and other constituents including amino acids, minerals, vitamins A, B complex, E and the highly active bio-chemical substance known as bioflavonoid(Vitamin P), phenols and aromatic compounds (Park *et al*., 2002; Mahmoud, 2006).

Due to its broad antimicrobial effects, propolis is known for its vast therapeutic purposes against various diseases such as ear infections, herbs, nail infections, dental and bone problems, blood sugars, carcinogenesis, and healing injuries or minor burns (Maria *et al.*, 2008; Bogdanov 2011; Edward, 2014; Bogdanov, 2015a; BfD, 2016).

2.1.1.4. Royal jelly (bee milk)

It is a homogenous milky white liquid substance derived from the hypo pharyngeal glands of the honeybees used for feeding their larvae. It is also predominantly valued for its various biological and therapeutic effects such as anti bacterial, anti viral, bio-stimulating, immune modulating, anti-aging, radio protective, anti carcinogenic (Bogdanov, 2011; 2015b). It contains sexual hormones (testosterone, progesterone, prolactine, and estradiole) which will increase the fertility of both sexes as well as improving the male's endurance (Edward, 2014).

The queen and worker bees are originated from the same eggs types (fertilized eggs). However, due to the difference in amount and quality of royal fed, the queen appears with

conspicuous fertility, prominent body and abdominal sizes, enriched with hormones which used to govern her families (Bogdanov, 2016c).

Royal jelly needs elegant technological capacities for producing, processing and preserving processing. Consequently, it appears as commercial product only in certain specialized countries like china which appears to share about 95% of the total world royal jelly markets (Zhing and Liang, 2015). However, there is no veritable results in developing countries (Bogdanov and Gallmann, 2008; JAICAF, 2009).

2.1.1.5. Honeybee venom

It is a clear, odorless, liquid substance produced by a pair of venom glands and stored in venom sac at the base of sting apparatus of worker bees. It is composed of Mellitin (40-60%), Phospholipase-A (10-12%), Apamine (2-3%), MCD-peptide (2%), histamine (1%). Of all bee products, the venom has by far the greatest number of biological effects, known for its wide apitherapic effects due to its wide antibacterial, anti inflammatory, immune activation, immune suppressive, analgesic, radio protective, and anti carcinogenic effects (Bogdanov, 2011; 2016c).

The newly emerging worker bees will start secreting the venom after three days of age and the maximum secretion will be attained during their two to three weeks of age. An adult bee may contain up to 0.3mg of liquid venom in its venom sac (Mutsaers *et al,* 2005; Hilmi *et al.,* 2011) and one sting may contain about 100μg of dry weight venom(Bogdanov, 2016e).

2.1.2. Pollination services

The pollination service provided by animals results for crucial ecosystem services in general and humanity in particular through provision of dietary sources and other wise (BfD, 2006; Abou-shaara, 2014).

Of all animal species, insects are thought to have the greatest shares of pollination services for about 75% of globally important crop species and responsible for about 35% of world crops yield (Klein *et al.,* 2007; Clara *et al.,* 2012). Of all insect species, honeybees are known for their greatest shares of pollination services due to their consistence, hairy covered bodies and

higher visiting intensities(Schieraw, *et al.,* 2012; Alice *et al.*, 2012) and considered as essential components of almost all world's terrestrial ecosystems(JAICAF, 2009; Espolov, *et al.,* 2014; FAO, 2016; BfD, 2016).

Globally, about 90% of pollinator dependent crops are reliant on honeybees (Lee, 2014). Despite its merits from yield increments, honeybees are highly responsible for improving the qualities of seeds and fruits of pants through cross pollination (Hilmi *et al.,* 2011).

Even though the economic benefits obtained from pollination services might vary based on the types of crops and location, the overall profit obtained from bees' pollination worldwide is estimated to reach $210 billion or €153bn (Schieraw *et al.,*2012 and CLI, 2013). This indicates the benefit obtained from pollination service is by far exceeding the merits obtained from its products (Kremen *et al.* 2002; Hartmann, 2004; Garibaldi *et al.* 2009).

Moreover, developing countries, like Ethiopia with relatively higher dependence on natural resources; climate change and environmental degradation causes a serious risks to economic developments. As a result, the development priorities which are highly reliant on maintaining the natural ecosystem bases are very relevant (Klein *et al.,* 2007; Brian, 2015).

2.2. Beekeeping in Ethiopia

Ethiopia is a country endowed with very diverse agro-climatic features which favors for the existence of diverse flora and faunas (Ayalew Kassaye and Gezahegn Tadesse, 1991; Beyene Tadesse and Phillips, 2007; Getahun Tekle and Samuel Woldeyohanis,2016) which supports a huge number of honeybee colonies (USAID, 2008).

According to FAOSTAT (2016), the country owns about 6,189,329 hived colonies. Of which the predominant, 95.37 %(5,902,629) are managed in traditional hives while the rest 1.3% (80,832) and 3.33 %(205,873) are managed in transitional and modern hives respectively. About 2 million households engaged in beekeeping (WCAHSE, 2013).

Beekeeping appears an ancient off farm activity practiced by most rural communities of the country with a long lasting tradition and cultural linkages (Mekonnin Teferi and Gidey Yirga,

2011; Takele Geta, 2014; Seid Guyo and Solomon Legesse, 2015; Gemechis Legesse, 2016; Fenet Belay and Alemayehu Oljira, 2016).

Honey and beeswax are also known for having extended social and cultural values for century (Gidey Yirga and Mekonen Teferi, 2010).
Except in some extreme areas, beekeeping can be undertaken in almost all parts of the country. However, the most potential regions are Oromia (3,009,745), Amhara (1,328,235), SNNP (992,633), Tigray (263,961) and Benshangul Gumuz (219,448) (CSA, 2016).

Based on the type of hives used and ways of managements, the beekeeping practice of the country is broadly categorized in to four systems. These are: traditional forest, traditional back yard, transitional and modern systems (Haftey Sahle *et al.*, 2018). However, due to its highest coverage, the traditional beekeeping systems (back yard and forest) have the highest shares for honey and beeswax production accounting for 64% of honey and 85% of beeswax produced in the country (Kaleb Shiferaw, 2015 and Demisew Wakjira, 2016).

Generally, though the country is known to be the leading from its continent and one of the top ten countries for its honey and beeswax production worldwide, more has to be done to develop the sector into a robust industry offering significant income generation opportunities (BfD, 2007; USAID, 2008).

2.3. Major Bee products in Ethiopia

Honey and beeswax are the major bee products produced and marketed in Ethiopia. However, the information on production and utilization of other products such as pollen, propolis, royal jelly and bee venom are almost non- existent though these products have a privilege demands at Global markets (MOARD, 2013; Kaleb Shiferaw, 2015). Other bee products includes products other than honey and beeswax which includes pollen, propolis, royal jelly, bee venom, bee brood, and package bees (Gallmann and Thomas, 2012; Qaiser *et al.*, 2013; Haftu Kebede *et al*., 2015; Bakalo *et al*., 2016).

With regard to other products, except some studies under taken by HBRC-on the effect of pollen and propollis production on the general performance of honeybees, there are no

veritable research results and production trends of these products. Accordingly, the study result on pollen production on performance of colonies showed that averagely a colony may yield up to 100g of pollen monthly during active season without significantly affecting the performance of the colony (Desalegne Begna *et al.*, 2015).

According to the study on, induction of propollis production by *Apis mellifera bandansii* in traditional basket and moveable frame hives revealed that significantly higher amount (24.2±22.5g) of propollis obtained in induced box hives than the control ones (9.5±5.8g). Similarly, significantly higher yield (12.7±8.6g) obtained from induced traditional basket hives than obtained the control group(4.8±2.4g/hive) with in a 19 months of stays without significantly affecting the performance of colonies(Desalegne Begna *et al*., 2015). This revealed the country has a possibility of producing these valuable products without affecting its honey and beeswax yields.

According to GDS (2009) the country owns a potential of producing 500,000 tons of honey and 50,000 tons of beeswax annually. However, currently it achieved only about 47,710 tons of honey and 5,344 tones of bees wax annually (CSA, 2016) which is estimated to be around 10% of its potentials. With such an amount, it ranks first both in honey and beeswax production from its continent; tenth and fourth worldwide in its honey and bees wax production respectively (SNV/Ethiopia, 2005; Gemechis Legesse., 2016).

With the existing huge apicultural resources, Ethiopia has potentials to meet its honey and beeswax requirements. However, due to its retarded production enhancement efforts under taken and an ever increasing population and urbanization, the domestic demand for both products is steadily increasing from time to time to the extent of competing the export level (Sarah and Jeroen, 2011; EMDIDI, 2017).

2.3.1. Honey

Honey production has long been an integral part of subsistence economy of most rural communities of Ethiopia (BfD, 2010).

Honey is produced in almost all parts of the country (USAID, 2012; Samuel Sarka, 2017). Due to its broad economic, cultural, nutritional and medicinal values, honey is considered as

the main product sought from beekeeping (Abebe Shiferaw *et al.,* 2009; Melaku Berhe *et al.*, 2013; Fenet Belay and Alemayehu Oljira, 2016).

Despite its use for direct consumption, honey is widely using to produce various products like honey wine, sweets, cosmetics, candles, cereals, tobacco, pharmaceuticals and bakery products which are considered as an indirect consumption of honey(Aravindakshan *et al*, 2010; Takele Geta, 2014).

Presence of diverse floral species which are flowering at various seasons and locations enables the country to produce various types of honey products characterized by its distinctive color, quality and consistence (BfD, 2006; 2007; ATA, 2015; Haftu Kebede, 2015; FAO, 2016) which are also considered as a major criteria for determining its pricing levels (USAID, 2012; Taye Beyene and Verschuur, 2014).

Ethiopia shares about 2.5% of world and 23.7% of African honey production (USAID, 2012). Of the total honey produced, about 10% is used for home consumption by the producers whereas, 90% will be destined to local markets to fulfill their instant income needs (McGill, 2016). Of which, about 80% is consumed by local mead houses (MoARD, 2003; Hartman, 2004; Johannes Agonafer, 2005; BfD, 2007).

According to FAOSTAT, (2016) and ATA, (2015) the export amount of honey is reported to be not exceeding 2% of its production. However, due to its complex market chains and inevitable illegal exports the exact amount of exported honey is uncertain (BfD, 2007; MoARD, 2013). However, according to Demisew Wakjira (2016), about 30% of the national production amount is illegally exported across different boards of the country.

In the country, over 95 percent of beekeepers follow traditional systems (BfD, 2010; CSA, 2016). Due to its difficulty for manipulation(inspection and proper harvesting), limited volumes, lack of appropriate post harvest management by most beekeepers, lack extracting and storage materials, the traditional beekeeping system results for minimum amount of honey yield which is also hardly to meet the required international market standards (Tessega Belie,2009; Aravindakshan *et al.*,2011; EAB, 2012).

According to CSA (2016) reports, the average annual crude honey productivities of traditional, transitional and modern hives is estimated to 8.30kg, 18.28kg and 15.5kg respectively. However, the country owns potentials of producing up to 10 kg, 40 kg and 60 kg per each type of hives respectively. This indicates the overall beekeeping practices and management system of honeybees in the country is very poor.

Honey is a very complex natural product composed of various constituents which determine its quality status (Diminis *et al.,* 2006). Its' hygroscopicity aggravates for its immediate loss of its qualities up on mishandling. As a result, the overall management practices and cares taken throughout its pre and post harvesting stages will highly determine its quality status (Alice *et al*, 2012). The local materials such as hides and skins, '*chocho'*, bamboo stems, clay pots, gourd pot which are commonly used to store and transport honey products in the country are not safe enough to keep its qualities (Johannis Agonafir, 2005; Melaku Girma *et al.,* 2008; HBRC, 2015; Yetimwork Gebremeskel, 2015; Gezahegne Tadesse, 2016).

Due to its complex value chains and poor handling practices across each actor resulting for a considerable quality deterioration of the honey product in the country (USAID, 2012; MoARD, 2013).

Moreover, intentional adulterations with foreign materials such as molasses, banana, sugar, candies, Maize or wheat flour syrups, sweat potatoes are also a great concern having undeniable impacts on its nutritional and organoleptic quality consequences resulting for the higher demand for crude comb honey and low involvement of processing industries due to lack of trusts (USAID, 2012; Haftu Kebede, 2015; Meseret Gemeda and Taye Nagera, 2017).

2.3.3. Beeswax

Next to honey, beeswax is considered as the major product obtained from beekeeping (Gemechis Legesse, 2014; Bakalo *et al.,* 2016) and has been used as a main trading commodity for years with a long lasting cultural values in Ethiopia(USAID, 2012; Seid Guyo and Solomon Legesse, 2015; Gezahagne Tadesse, 2016; Ayalew kasaye, 2016).

2.3.3.1. Beeswax production and collection

According to FAOSTAT (2016) estimates, the country is producing 5,542 tons of beeswax annually which accounts for 33 % of African and 8% of the world's yield estimate. However, the above production amount is estimated based on the gross honey production potentials and colony population of the country and it excludes the amount of beeswax wasted in the rural areas (Save the Children UK, 2006). Similarly, a considerable amount which an estimate of 25% of the total produced beeswax is wasted due to spitting out of wax after the consumption of crude honey (Gezahagne Ayele *et al.*, 2006; Melaku Girma *et al.,* 2008).

Due to the small amount of beeswax produced by small scale beekeepers, it is not as such easy to manage the product obtained from each beekeeper (Bradbear, 2009). As a result, most of the beeswax produced in rural areas is wasted as byproducts (Nuru Adgaba and Iddosa Nagara, 2004; Aravindakshan e*t al,* 2010). According to Awraris Getachew *et al* (2012), about 2-3 kg crude beeswax will be wasted in rural areas from each ten traditional hive whose colonies absconded.

In the country, the rural beekeepers are the primary sources for beeswax production and local mead houses are the primary suppliers of beeswax (MoARD, 2003; Hartman, 2004; Johannes Agonafir, 2005). Majorly the country follows the traditional system of beekeeping that has a paramount contribution for beeswax production (Awraris Getachew *et al.*, 2012; Yetimwork Gebremeskel *et al.*, 2014).

A case in point, study by HBRC (2012) cited in Johannis Agonafir (2005), on beeswax yield comparison of the three hive types showed that the traditional and intermediate hives are able to produces 8-10% of its crude honey yields. While only 0.5-2% of its honey yield will be obtained from movable frame hives.

Study on comparison of different hive types on its honey and beeswax productivities and colony performance in south and south western parts of the country showed that 2.92 ± 0.27kg, 1.57 ± 0.22kg and 1.54 ± 0.09kg and 0.3 ± 0.03kg of beeswax was obtained from Ethio-chefeka, traditional and movable frame hives respectively (Awraris Getachew *et al*., 2015).

On the other study on performance of *Apis mellifera* species on honey and bees wax production in different types of hives at Enda mekonnin woreda of Tigray region indicated that 4.12 kg, 3.20kg, 0.24kg and 0.0329kg of beeswax obtained from traditional, KTBH, clay frame and modern hives respectively with a significant higher yield obtained from traditional hives than modern and clay hives. However, insignificant variation between traditional and KTBH (Gebreagziabher Aregawi *et al.,* 2014).

According to Haftu Kebede and Gezu Tadesse (2014), survey results on honey production system, challenges and opportunities in selected areas of Hadiya zone indicated that lack of awareness, lack of market accesses, lack of processing skill and lack of processing materials are considered as the major constraints of beeswax production sharing 39.2%, 21.5%,20.5% and 18.5% respectively. Likewise, study by Addisu Bihonegne *et al.* (2017) at Debub Wollo zone indicated that lack of awareness, knowledge gap and market problems are the major problems for beeswax production sharing 80%, 59.17% and 55.83% respectively. Generally, according to Gemechis Geleta (2014), declared that lack of awareness, skills of collection, processing and marketing are considered as the core constraints of potential beeswax producing areas of the country.

2.3.3.2. Beeswax processing and handling

The Crude beeswax obtained from different sources such as old combs, '*tej sefef*' would be cleansed and formed into a block. Even though there are a number of mechanical and chemical rendering methods, the steam wax melter, the solar wax melter, the wax presser, wax and honey separate and electric melters are the commonly applied methods (Bradbear, 2009).

Due to lack of awareness, skill and inputs the overall processing and handling systems of beeswax in the country is under taken in traditional ways are inefficient in producing optimum amount of product as well as with preferred qualities (Nuru Adgaba and Iddosa Negera, 2004; Hilmi *et al*., 2012;Gemmechis Legesse, 2014; Samuel Sarka, 2017). The country looses about more than 40% of its annual production due to the traditional ways of processing practices (Demisew Wakjira, 2016)

According to the study by HBRC (2016) on the yields and quality status of beeswax produced through manual, Submerged and solar rendering methods revealed that there is a significant yield variation of beeswax obtained through three methods. Accordingly, the manual and Sub merged methods have better yields with 44.2% and 49.6% respectively than solar method which has only 26.4% yield. However, the solar extraction method has better quality of wax product which is less viable to be attacked by wax moths (Bogdanov, 2009).

On the other study by Nuru Adgaba and Iddosa Negara (2004) on the profitability of processing crude honey indicated that amount of crude beeswax obtained from crude honey will vary from 5 to 65.62% with a mean of 27.5% and the percentage of pure beeswax obtained compared to its crude beeswax yield ranging from 45.8 to 92.2% with a mean of 73.61%.

In the country processing of beeswax is not a common practice at beekeepers level. However, '*tej'* houses in part are engaged in supplying crude and semi processed beeswax in the form of blocks. Cooperatives and Private companies like Apinec, Tutu, Beza mar, Amar ,Yeshi mar etc which are estimated to reach up to 30 in number are the major sources for marketable beeswax product (Johannes Agonafir, 2005; Aravindakshan *et al*., 2010; Demisew Wakjira, 2016).

2.3.3.3. Beeswax quality

Beeswax is relatively expensive and there is always been a tendency of people to try to falsify or dilute it with cheaper materials (Bradbear, 2009)

The naturally obtained beeswax immediately used for construction of honeybees' combs looks bright in color. But, gradually it tends to yellowish due to mixing with pollen stored in the comb cells, silk and larval debris (Bogdanov, 2016a).

As beeswax in widely used for food, cosmetics and pharmaceutics, keeping its quality is very mandatory and level of contaminants should be minimum as much as possible (Bogdanov, 2009). Nowadays, various plagiaristic products and toxic contaminants are becoming the

major threats impairing the quality of natural beeswax (Bodanov, 2004a; EPOPA, 2006; Gemechis Legesse, 2014).

Wax quality can be detected by different methods. Sensory characteristics such as Colour, breakability, chewing test, uniformity, Odor, cutting test, consistence, splinter test and rubbing tests are the simplest and quickest quality detection methods (Table 2).

Pure beeswax has a good aroma, and when a wax block is broken, it shows a grainy surface. That is not the case if it is adulterated with paraffin, fat or other oil. It does not stick to the teeth up on chewing, and when rolled between fingers it softens but does not stick to the fingers. When paraffin wax is mixed with beeswax, it becomes more transparent and slightly greasy to the touch (Table 1). However, detail physico-chemical quality analysis including melting point, Refractive index, Acid value, Ester value, saponification value, test for paraffin and other waxes(Table 1) are paramount for surely detecting its quality.

According to various studies acknowledged that the quality status of beeswax produced in the country is found to be within the acceptable range of national and international standards in its most parameters (Nuru Adgaba, 2007b; Bekele Tesfaye *et al.,* 2016; Addisu Bihonegne *et al*., 2018; Yeshitila Eshete *et al.,* 2018). This shows the beekeeping system in the country is practiced under natural based without use of any therapeutic chemicals for honeybee diseases and pests (Wilmart *et al*., 2016).

Table 1: Quality criteria for beeswax

PARAMETERS	**REQUIREMENTS**
Sensory characteristics	
Colour	Yellow to yellow-brown
Odor	Pleasant and Honey-like when heated
Chewing test	Should not stick to teeth
Breakage test	Should have a fine-granular, blunt, not crystalline structure
Cutting test	Should not stick to the knife upon cutting
Consistency	Workable with fingers, should not stick to them

Splinters test	Scratch with nail or knife, splinters should have a spiral form
rubbing test	Kneading for 10 minutes, wax should be plastic
Physico-chemical properties	
Melting point	61-65^{o}C
Density	0.950-0.965
Refractive index (at 75^{o}C)	1.440-1.445
Acid value	18 – 23
Ester value	70 – 80
Saponification value	87-104
Peroxide value	At least 8
Test for paraffin	Absent
Contamination	Free of acaricides residues

Source: - (Bogdanov, 2004b, 2009).

Table 2. Beeswax Specifications of Ethiopian and the European Pharmacopodia standard

Property Specification	**Ethiopian Standard**	**Requirements for natural wax**	**European Pharmacopeias**
Specific gravity at 20^{o}C	0.9550-0.9800	0.9500-0.9600	0.950-0.965
Melting point(^{o}C)	61-66	62-65	61-65
Refractive index at 75^{o}C	1.4400-1.4450	1.4398-1.4455	1.440-1.445
Ash % by mass max.	0.20	0.6	-
Total Volatile matter % mass, max	0.75	-	-
Acid value, max	17-24	17-24	18-23
Saponification value min.	85-105	88-102	87-104
Ester value	70-80	70-79	70-80
Peroxide value	-	-	At least 8
Fats and Fatty acids	To pass test	To pass test	-
Paraffin and other waxes	To pass test	To pass test	Absent

Source: - (QSAE, 2005; KEBS, 2013).

2.3.3.4. Beeswax composition and properties

Beeswax is a highly complex product composed of over 300 constituents (Bogdanov, 2004b). However, only 284 are identified (Hilmi *et al,* 2011). It is composed of four main types of long chain carbon compounds (Hydrocarbons (14%), Organic acids (12%), Alcohols (1%) and Esters (67%), others (6%)). In addition, it also contains 50 aromatic compounds. Generally, it includes 74 major and 210 minor components (Table 3).

It is more stable and has longer shelf life compared to other bee products due to its resistance to hydrolysis and natural oxidations (Bogdanov, 2009). Beeswax has higher melting points (61 to 65^{o}C) than other waxes. Hence, adulterating with other wax types can lowers its melting points. It doesn't boils when exposed to more heats. But, it will be decomposed when exposed to 120^{o}C. It is solid at room temperature and brittle at less than room temperature and pliable at 35-40^{o}C. Heating beeswax for longer time at extremely higher temperature will damage its property and darken its colour. Beeswax is insoluble in water and many acids. But, readily soluble in most organic solvents such as acetone, ether, toluene, xylon, chloroform, tetra chloro methane and benzene. The beeswax does not fully dissolve at room temperature in any of these solvents. Hence, it should be heated above its melting point to be readily dissolved in all of the above solvents including ethanol (Bogdanov, 2016a).

Table 3: Beeswax composition

Component	**Number of components in fraction**		
	Quantity %	**Major**	**Minor**
Monoesters	35	10	10
Diesters	14	6	24
Trivesters	3	5	20
Hydroxy Monoesters	4	6	20
Hydroxy Polyesters	8	5	20
Acid Esters	1	7	20
Acid Polyesters	2	5	20

Hydrocarbons	14	10	66
Free Acids	12	8	10
Alcohols	1	5	?
Others	6	7	?
Total	**100**	**74**	**210**

Source: - (Bogdanov, 2009, 2016a)

2.3.3.5. Beeswax marketing

Ethiopia is known to be the leading beeswax producer in Africa and one of the 4 biggest beeswax trading countries in world next to China, Mexico and Turkey (Johannis Agonafir 2005; SNV/Ethiopia, 2005; Tessega Belie, 2009; Gemechis Legesse, 2014). Due to its pliability and softness, Ethiopian Beeswax is highly demanded at global markets as it is more suitable for blending waxes from other sources (Nuru Adgaba, 2007b).

Beeswax is considered as an opportunistic commodity to fetch foreign currencies. However, due to an ever increased domestic demands and low production the country is trading only about 420 tons or (10%) of its production (Nuru Adgaba and Eddosa Negera, 2004; Gemechis Legesse, 2014; ATA, 2015). However, the total amount of beeswax being traded will reach up to 3000tons when the illegal export amount is concerned (BfD, 2007).

Due to various actors taking part in marketing of beeswax, the issue of traceability is the major concern (Gemechis Legesse, 2014).

Even though, the marketing channels of the honey and beeswax seems very complex and lacking formal linkages, three channels; namely *'tej'* house channels, the processors and exporters channels, and the beeswax channels are considered as the major honey and beeswax market channels in the country (MoARD, 2013).

According to the available export reports from 2009-16 revealing that the export level of beeswax is very minimum which is below 10% of its production amount even though it is dramatically increasing (Table 4).

Table 4. Beeswax production and exports trends during the period 2009-2016(in tons)

Parameters	2009	2010	2011	2012	2013	2014	2015	2016	Average
Total produced(tons)	4600	5150	5000	5000	5000	5310	5523	5542	5140
Amount export(tons)	360	311	358	365	341	443	416	217	351
Income (1000 US$)	1678	1518	1905	2367	2696	4103	4276	2367	2614

Source: FAOSTAT (2016)

2.3.3.6. Beeswax utilization

In areas where most or entire honey product is consumed locally and where there is no local use for beeswax, pieces of wax comb are often discarded (Bradbear, 2009). Of the total wax produced in the country, most of which is utilized for domestic markets. Basically, for making *'tuaf'* and candles which are used for daily ceremonies in Ethiopian Orthodocs churches.

In the country there are about more than 25,000 Orthodocs churches consuming at least 3pcs of '*tuafs'* every day which could be estimated about 1000pcs annually. The demand for '*tuaf*' by every Ethiopian Orthodox Church is estimated to be 1000pcs of '*tuaf*' annually. Hence, the total the demand is estimated to be 25,000,000pcs which is about 750 tones (based on the calculation of 30g of beeswax per each pcs.). In the country, Even though the amount is low, beeswax also used for smoking and rubbing the hives for attracting the swarms and making strips for top bars. Despite its uses for huge domestic consumptions, the Ethiopian beeswax is also widely exported around the Globe especially to Japan, USA and Greece (USAID, 2008). An ever increasing number of improved movable frame hives in the country also resulting for a projected local demand for beeswax for making foundation sheets (Beyene Tadesse & Phillips, 2007).

2.4. Challenges and Opportunities of Beeswax Production, Quality and Marketing.

2.4.1. Challenges

According to various literatures stated that there are various challenges that hamper the production and marketing of beeswax in the country. These includes lack of detail beekeeping

knowledge and skills, shortage of trained man power, shortages of beekeeping technologies, diseases (Hailegebriel Tesfay, 2014), pests and predators, fires, agrochemicals (Desalegne Begna, 2007; 20015; Chala kinati, *et al.* 2013; Martha Zelalem and Teriku Jibat, 2014; Birhanu Tesema 2016) absconding (Seid Guyo and Solomon Legesse, 2015), lack of market access and infrastructures, lack of incentive payment for quality producers, lack of quality control units (EPOPA, 2006; USAID, 2012; Getahun Tekle and Samuel Woldeyohanis, 2016; Kerver, 2016), recurrent droughts, lack of improved bee forages, colony migration, poisonous plants(Taye Beyene and Vershuur,2014; Kaleb Shiferaw and Berhanu Gebramedhin, 2015; Haftey Sahle, *et al.,* 2018), lack of appropriate extension services, credits services (Alemayehu Kebede, 2016), Poor access for trainings and technical supports, lack of special skills and researches(Gidey Yirga and Mekonen Teferi, 2010) are the major constraints related to production level of the beeswax.

Lack of processing and packaging materials and skills, an ever increasing adulteration, lack of traceability and quality controlling efforts, poor packaging systems, higher domestic prices resulting for less competitiveness at international markets, training and technical supports (Johannes Agonafir, 2005; Sarah and Jeroen, 2011; Sisay Fikru, 2015; Kerver, 2016) are considered as major problems related to processing and marketing of beeswax product in the country.

2.4.2. Opportunities

Existence of huge potential of beekeeping as major opportunities to engage on beekeeping clearly evidenced by availability of diversified natural bee forages, suitable agro-ecology, indigenous knowledge and long lasting experiences, an ever increasing market demands for beeswax (MoARD 2007). Existence of ample water sources, availability of huge number of honeybee colonies (Malede Birhan *et al.*, 2015). An increasing demands for beeswax due to its various local values and emerging beekeeping approaches like organized unemployed youth groups engaged on integrated beekeeping with watershed management plays significant opportunistic roles for beekeepers to join the sector (Tezera Awoke, 2013). The predominant traditional beekeeping system (Johannes Agonafir, 2005; Awraris Getachew, 2015), an ever increasing development partners who take part in beekeeping subsector, an increasing uses of

movable frame hives has created a huge demand for beeswax for foundation sheet makings (Gemechis Legesse, 2014). Moreover, an ever increasing processing and exporting entrepreneurs taking part in production, processing and marketing of beeswax (Kaleb Shiferaw and Birhanu Gebremedhin, 2015; Demisew Wakjira, 2016) are also considered as the golden opportunities for beeswax production in the country.

2.5. Beeswax market chain actors and their contribution

Beeswax has a series of market chains actors though it has a limited market chain actors compared to honey products and mostly when we talk about the market chains actors of beeswax product we consider the whole actors who are engaged in marketing and processing of crude honey too. Except '*tej'* houses and some final and intermediate processors, most of the actors who are engaged beeswax production and marketing have no consistencies in their wax productions and marketing. Hence, the beekeepers, '*tej'* houses, traditional beeswax extractors, collectors, whole sellers, retailers, processors, exporters and consumers are listed as the major market chain actors of beeswax product having distinctive roles each.

Producers: these include beekeepers; cooperatives which are considered as major actors who perform most of the value chain functions from the procurement of the inputs to harvesting and marketing. They can play pivotal roles in deciding what to produce, how to produce, how much to produce, when to produce, and where to sale. At this level of value chains characterized as low level of productions and supplies compared to the growing domestic demands. Mostly separation of beeswax from its honey is uncommon at producers' levels and it is sold as one commodity.

***'Tej'* brewers/Local mead houses:** these are the major and intermediate sources of beeswax supplies. They purchase the crude honey from the producers, wholesaler or retailers. Selling '*Tej*' leftovers/waxes to the retailers, wholesalers or traders in the form of crude wax/'*Sefef/*' or the semi processed or block form. Even though tej houses are serving as the major and year round sources of beeswax, the intervention taken to enhance the production status is almost nonexistent at this market segment.

Traditional beeswax extractors: During processing, beeswax, often in straw form, remains as a by-product. Traditional beeswax extractors are the other intermediate sources who supply the beeswax in rough blocks.

Collectors: these are middle men who will gather the bee products from each producer, processors or '*tej'* houses and conveying to large scale traders or directly to exporters. They also conveying to the domestic processors for '*tuaf*" and candle making.

Wholesalers: are those who will provide the product in bulky amounts to various retailers with optimum combinations of functions and perform desired distribution functions for processors too.

Retailers: these are middle men, including supermarkets and other large-scale retailers who divide large-scale consignment of produce, selling it to consumers in small units. Super markets and small retailers are the centre of distribution for honey and beeswax product while the '*Tej'* houses and beeswax collectors are important stakeholders for beeswax business

Processers: are chain actors who practice further processing or semi processing and selling to final consumers. Processers may purchase a bulk of semi processed beeswax and proceeding to final processing.

Exporters: are those who deliver beeswax obtained from all over the regions and exporting after cleaning and bulking. In Ethiopia there are about eight honey and beeswax exporters which together forming the Ethiopian Honey and Beeswax Exporters Association (EHBEA). These are Beza Mar Agro industry, BWAP Export PLC, Amar honey collection, production and marketing, APINEC PLC, Harmony agricultural enterprise, East Shoa beekeepers association, Tutu and her family commercial PLC are actively working on the sub sector. Among the members four of them are engaged in exporting beeswax only whilst the rest four are in honey exporting. The exporters will collect the ample amount of honey and beeswax during the harvesting season. However, they run out of supply during most off seasons. As a result, the processing industries need to waste their huge capital in collection of the honey and beeswax product from local producers which appears an additional task for them.

Consumers: These are those in the last link of marketing chains including beekeepers, BoA, NGOs, Research Centers, pharmaceutical, food processing industries and the likes (Hertman,2004; Johannis Agonafir, 2005; Melaku Girma *et al.*, 2008; Aravindakshan *et al*., 2010; USAID,2012; Demissew Wakjira, 2016).

CHAPTER 3. MATERIALS AND METHODS

3.1. Description of the Study Areas

The study was conducted in three districts (Chena, Gimbo and Gesha) of Kafa zone which are purposively selected based on their relative beekeeping potentialities.

3.1.1. Location

Kafa zone is one the zones found in Southern Nations Nationalities and peoples region (SNNPR) situated at 6°14'28" to 8°7'11'' N latitude and 35°26'37" to 36° 47'28'' E longitude covering an area of 10,602.7 sq. kms (Wikipedia, 2017). Bordered by Dawro zone to the East; South Omo zone to the South; Sheka and Benchi Maji zones to the West; and Oromia Region to the North Directions(Figure.1)

The zone includes ten districts; namely, Gesha, Chena, Gimbo, Menjieo (Adiyo), Tello, Cheta, Bita, Gewata, Saylem and Decha and one zonal administrative town (Bonga).

Chena district is situated at 07°18'48" N-latitude and 036°16'25" E- longitude; covering an area of 921.9sq.km. It is located at 78 kms far from Bonga town and 543 kms from Addis Ababa to the South west direction. It is Bordered by Decha district and Benchi Maji zone to the South, Gewata district to the North, Bita district to the West and Gimbo district to the East directions (Figure 1).

Gimbo district is situated at 07°16'71 N- latitude and 036°10'54'' E- longitude covering an area of 824.17sq.kms. Located at 447 kms far from Addis Ababa and 18 km far Bonga. Bordered by Decha district to the South; Chena and Gewata districts to the West; Oromia region to the North; and Adiyo district to the East directions (figure 1).

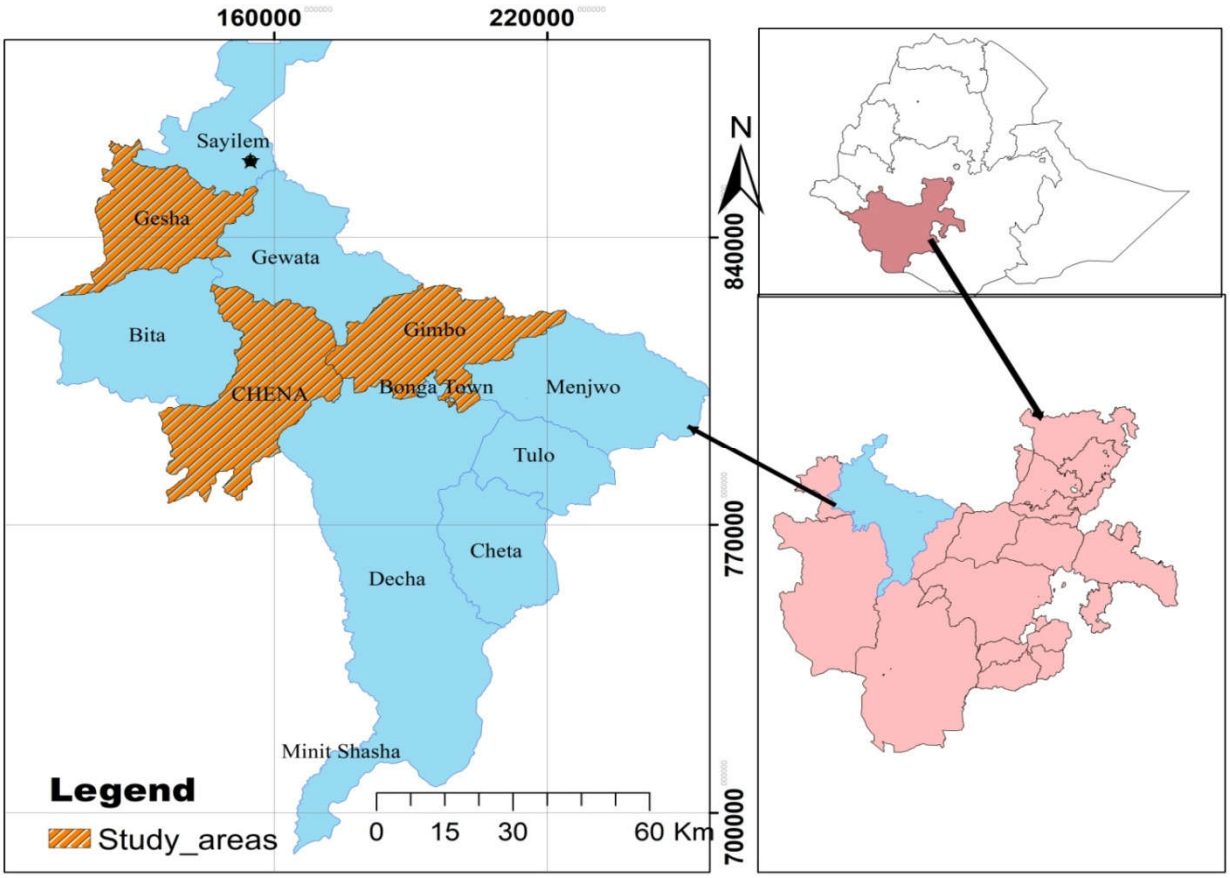

Figure 1. Map of Kafa zone

3.1.2. Demographic data

According to CSA (2017) population estimate data, Kafa zone is expected to have a total population size of 1,102,278(541,682 male and 560,596 female); of whom 963,852(87%) are rural inhabitants and the rest 138,426(13%) are urban inhabitants. Chena district has a total population of 199,553(97,865 male; 101,688 female); of whom 174,777(88%) are rural inhabitants and 24,776(12%) are urban dwellers. Gesha district has a population size of 104,509 (50,900 males and 53,609 females); of whom 97,221(93%) are rural inhabitants and 7,288 (7%) are urban inhabitants. Gimbo district is also expected to have a total population size of 116,051(57,250 males and 58,801 females). Of whom 95,568 (80%) are rural inhabitants while about 20,483(20%) are urban inhabitants.

3.1.3. Altitude and climatic features

Kafa zone includes altitudes ranging from 500 to 3500 *m.a.s.l.* with most parts lying at higher altitudes with rolling plateaus. The agro ecological classification of the zone includes 11.64% (Highlands), 59.45% (mid land) and 28.91% (low lands). The area receives almost a year round rain falls with major rainy seasons occurring through March to October (Friis, 1992, USAID, 2005). The mean annual rainfall of the zone is ranging from 1001 to 2200 mm (Minyahil, 2015) and the minimum and maximum temperature of the zone is 10.1 and 27.5°C respectively.

Chena district includes 15% (highland), 80% (Mid lands) and 5% (low lands). The mean monthly temperature of the district ranges from 16^{o}C to 28^{o}C and receiving 1356 mm rain falls annually. Gesha district includes the most high altitudes areas of the zone with about 18.5% its land lies in altitudes ranging from 1500 to 2000 m.a.s.l. characterized as midlands; about 78.5% lies in 2001 to 2500 m.a.s.l. characterized as high lands and about 3% lies in 2501-3500 m.a.s.l. characterized as extreme high land areas. The mean annual Rain fall of the district is 1294mm and the minimum and maximum temperature of 15^{o}C and 20 ^{o}C respectively. Gimbo district lies at altitudes ranging from 800 to 1800 m.a.s.l. The mean annual rain fall of the district is 1850mm with minimum and maximum temperature of 15.5^{o}C and 25^{o}C respectively (KZBFED, 2017).

3.1.4. Livestock and bee colonies potentials

Kafa zone has an estimate of 898,979 Cattles, 465,734 sheep, 265,713goats, 80,817 horses, 11,485 mules, 870 donkeys, 1,030,071 poultries and 3,13,914 honeybee colonies which are kept in different types of hives (CSA, 2016). Especially, the zone is well known for its prominent sheep breed/Bonga breed/ which is widely known nationwide. The existence of immense natural forests enables the zone to become one of the most potential zones for beekeeping activities covering about 40% the honey and beeswax production potentials of the region/SNNPR (Janet and Andrian, 2014; CSA, 2016). It is also home for diverse species of stingless bees which are not yet clearly identified.

3.2. Study Areas and Sample Respondents Selection.

The study was conducted in three purposively selected districts of the zone namely Chena, Gimbo and Gesha. From each district three PAs were purposively selected based on their production potentials and marketing of honey and beeswax. The numbers of Sample respondents were determined based on ***Yamane's*** **(1967)** *calculation**;***

$$SS = {}^{N}/_{1 + Ne^2}$$

Where; SS= Required Sample size; N= Total population; e=margin of error (5%)

The total numbers of beekeepers in selected PAs were estimated to be 330. However, the number of respondent beekeepers from each PA was determined based on the available population size using the above formula. Hence, a total of 180 sample sizes were taken from the nine selected PAs.

3.3. Methods of Data Collection

3.3.1. Scope and coverage

The study was undertaken following two main components of data collection. The first one is through collection of surveys data and secondly through sample collection and laboratory analysis of beeswax collected from different sources of the study areas. Available primary data were collected from respondent beekeepers, key informants and from laboratory analysis results. Secondary, data were collected from various published and unpublished documents and reports.

3.3.1. Sampling frame and techniques

The study was under taken in purposively selected districts of Kafa zone based on their potentialities for production and marketing of honey and beeswax products. From each district again three PAs were purposively selected and the numbers of respondents were determined using **Yamane's** calculation accordingly a total of 180 respondents were considered for the collection of survey data. The questionnaire was developed and pretested before the collection the actual survey data. In addition, other available actors who will take part in production, processing and marketing of honey and beeswax such as '*tej*' house owners, retailers and

cooperatives, whole sellers and private processors were also incorporated for the collection of survey data using open ended questionnaires.

3.3.2. Sample collection and laboratory analysis

The available beeswax samples were collected following the market channels of the three districts (Chena, Gesha, and Gimbo). Accordingly, the samples were collected from fresh combs, '*tej*' houses, processors and old combs. Beeswax samples for laboratory analysis were taken from different parts of the containers. From each sample source a minimum of 500gm of wax samples were taken by keeping increasing the amount based on the amount of available wax source. The collected samples were rendered/purified and put into clean, dry and sealable containers in order to minimize adventitious contaminants and labeled before being sent for laboratory analysis. The laboratory analysis was undertaken at Sekota Dry Land Agricultural Research Center (SDARC) laboratory for its detail physico-chemical qualities status. The physico-chemical qualities including melting point, Saponification point, Refractive index, Acid values, Easter values, paraffin and other waxes, Total volatile matters, Fats and fatty acids were investigated based the detail procedures of Ethiopian Beeswax quality specifications ET-1203-2005(QSAE, 2005) as listed below.

3.3.2.1. Melting point

Apparatus

1. Thermometer-of a suitable type, with an accuracy of 0.1°C and graduated at every 0.1°C.
2. Test-Tube-with a centrally bored cork to take the thermometer. The cork shall have a slit so as to permit circulation of air.
3. Water-Bath- of a suitable type, with a thermometer.

Procedures

1. Melt the material by warming it in a water-bath at a temperature just sufficient to melt it.
2. Dip the thermometer and withdraw, so as to get the bulb thinly coated with the wax and let it stand for 24 hours.
3. Insert this thermometer into the test-tube through the bored cork and then place the test-tube in the water-bath.

4. Raise the temperature gradually, at the rate of 1°C in 3 minutes. Note the temperature, accurately to 0.1°C, at which a transparent drop forms on the end of the thermometer bulb.
5. Record the temperature at which the first drop occurs which is taken as the melting point of the material/wax.

3.3.2.2. Refractive index at 75^0C

Apparatus

1. Refractometer
2. Water bath thermostatically controlled and maintained at 75 ± 1^0C

Procedures

1. The sample shall be melted and filtered through fast filter paper to remove any impurities and last traces of moisture.
2. The temperature of the refractometer shall be adjusted at 75 ± 1^0Cby circulating water from the water bath.
3. Place few drops of the sample on the lower prism. The prism shall be closed tightened firmly allowed to stand for one or two minutes
4. Read and record the refractive index after the sample has attained the test temperature.

3.3.2.3. Ash (%) by mass, max

Apparatus

1. Platinum porcelain or silica Dish - having a capacity of 100 ml.

Procedure

1. Heat the platinum dish to redness, cool to room temperature in desiccators and weigh. Take about 50 g of the material in a watch-glass and weigh accurately.
2. Transfer about three-quarters of this quantity to the platinum dish and heat on a Bunsen burner so that the material burns gently at the surface. When about half of the material is burnt away, stop heating, cool and add the remainder of the material.
3. Weigh the watch-glass again and find, by difference, the exact mass of sample transferred to the platinum dish. Heat again as before until the material is completely charred.

4. Incinerate in a muffle furnace at 550°C to 650°C for 1 hour. Cool to room temperature in desiccators and weigh. Repeat incineration, cooling and weighing until the difference between two successive weightings is less than one milligram:

Calculation

Ash, percent by mass = $\frac{100M2}{\text{M 1}}$

Where, M2= mass in g of the ash; Ml = mass in g of the material taken for the test.

3.3.2.4. Total volatile matter, % by mass, max.

Apparatus

1. Oven maintained at 105 ^{0}C
2. Analytical balance
3. Metal or aluminum dish

Procedure

1. Weigh accurately about 10 gm of the material in a suitable dish, previously dried and weighed and place it in an oven maintained at 105 ^{0}C for 6 hours.
2. Cool the dish in desiccators and weigh with the lid on. Heat the dish again in the oven for 30 minutes.
3. Repeat the process until the loss in mass between two successive weightings is less than one milligram. Record the lowest mass obtained.

Calculation

Total volatile matter at 105^{0}C percent by mass= $\frac{100(M1-M2)}{\text{M1}-\text{M3}}$

Where; M1- mass in gram of the dish with the material before heating; M2- mass in gram of the dish after heating; M3- mass in gram of the empty dish

3.3.2.5. Acid value, max.

Principles

The acid value is determined by titrating the material in benzene-alcohol medium with potassium hydroxide solution.

Reagents

1. Benzene - neutral to phenolphthalein indicator.
2. Rectified Spirit - neutral to phenolphthalein indicator
3. Standard Potassium Hydroxide Solution 0.5 N
4. Phenolphthalein Indicator Solution Dissolve 0.1 g of phenolphthalein in 60 ml of rectified spirit and dilute with water to 100 ml.

Procedures

1. Mix the material thoroughly, making it entirely liquid before weighing.
2. Weigh accurately about 5 g of the material in a 250-m1 conical flask. Add 75 ml of a mixture of two parts of benzene and one part of rectified spirit.
3. Heat under reflux until the sample is dissolved. Allow it to cool to room temperature and titrate with standard potassium hydroxide solution using phenolphthalein as indicator.

Calculation

Acid value = $\frac{\mathbf{56.1}\boldsymbol{VN}}{\boldsymbol{M}}$

Where;

V = volume in ml of standard potassium hydroxide solution used,

N = normality of standard potassium hydroxide. Solution, and

M = mass in gram of the material taken for the test.

3.3.2.6. Saponification cloud point, min.

Principles

The material saponified by refluxing with a known excess of alcoholic potassium hydroxide solution. The alkali consumed for saponification is determined by titrating the excess alkali with standard acid.

Apparatus

1. Conical flasks - 250 to 300 ml capacity made of alkali-resistant glass.
2. Reflux condenser - at least 65 cm long.
3. Balance readable to 1mg
4. Hot plate or water bath

Reagents

1. Methyl Ethyl Ketone

2. Rectified Spirit
3. Alcoholic Potassium Hydroxide. Solution -Dissolve 30 g of potassium hydroxide in rectified spirit and make up to 1 liter. Allow to settle overnight in a dark place, decant the clear liquid and keep in a bottle closed tight with cork or rubber stopper.
4. Phenolphthalein Indicator Solution
5. Standard Hydrochloric acid 0.5 N.

Procedure

1. Weigh accurately about 2.0 g of the material in a tarred conical flask.
2. Add 25 ml of methyl ethyl ketone, followed by 25 ml of alcoholic potassium hydroxide solution.
3. Add a few pieces of pumice stone and connect the reflux condenser to the flask.
4. Heat the flask on a water-bath or electric hot-plate for about 2 hours.
5. Boil steadily but gently.
6. After the flask and condenser have cooled, wash down the inside of the condenser with about 10 ml of rectified spirit.
7. Add about 1 ml of phenolphthalein indicator solution and titrate with standard hydrochloric acid. Carry out a blank determination at the same time.

Calculation

Saponification value = $\frac{56.1(B-S)N}{M}$

Where,

B = volume in ml of standard hydrochloric acid required for the blank;

S=volume in ml of standard hydrochloric acid required for the material;

N =normality of standard hydrochloric acid, and

M = mass in g of the material taken for the test.

3.3.2.7. Ester value

The Easter value can be calculated by subtracting the acid value determined from the saponification value.

Therefore, Ester value = Saponification value - Acid Value

3.3.2.8. Fats and fatty acids

Reagents

1. Sodium Hydroxide Solution - 10 percent.
2. Dilute Hydrochloric Acid - approximately 4N

Procedures

1. Boil 5.0 g of the material for about 10 minutes with 80 ml of sodium hydroxide solution. Replace the water lost by evaporation.
2. Cool and filter the solution through glass wool.
3. Make the filtrate acidic with dilute hydrochloric acid.
4. The material shall be taken to have passed the test if the solution does not become turbid after acidification.

3.3.2.9. Paraffin and other waxes

Apparatus

1. Balance readable to 0.1g
2. Conical flask 250 ml
3. Reflux condenser
4. Water bath or hot plate

Reagents

1. Alcoholic Potassium Hydroxide Solution approximately 0.5 N, prepared by dissolving potassium hydroxide in 95 percent ethanol
2. Ethanol 95%

Procedure

1. Weigh 1.0 g of the material and place it in a conical flask fitted with a water-cooled reflux condenser. Add 10 ml of alcoholic potassium hydroxide solution. Boil under reflux for one hour. Detach the flask from the condenser, insert suitably a thermometer into the liquid in the flask and allow to cool, stirring constantly.
2. The material shall be taken to have passed the test if the following conditions are satisfied:

   a) The liquid does not become cloudy at a temperature higher than 61°C but becomes cloudy at a temperature between 61°C and 59°C, and

b) Precipitation of large flocks occurs at not more than 2°C below the temperature at which the liquid becomes cloudy.

3.4. Data Management and Statistical Analysis

The available qualitative and quantitative data were analysed using Statistical Package for social Science (SPSS-version 20) soft ware.

Presences of association between different beeswax quality parameters of independent samples were tested. The Correlation among different quality tests were used to justify the standards of beeswax in the study areas. Generalized Linear Model (GLM) at $P<0.05$ level of significances was used to separate the means whenever ANOVA showed statistically significant variations.

The following analysis of variance (ANOVA) model was used for data analysis.

$$Y_{ij} = \mu + \alpha_i + \epsilon_{ij}$$

Where:

Y_{ij} = quality of beeswax

μ = overall mean

α_i = the effect of the i^{th} location or source of beeswax

ϵ_{ij} = random error

CHAPTER 4. RESULT AND DISCUSSION

4.1. Socio economic Characteristics of the Respondents

4.1.1. Household characteristics

The survey data were collected from 60 selected individual from each district and hence a total of 180 beekeepers were involved in the study. Of whom 170(94.4%) are male and 10(5.6%) are females. The female engagement of the study areas is less than the Basketo special woreda which is reported to be 10.5%. The difference might be due to the difference in hive placement where the predominant numbers of hives (61%) are placed at back yards (Elfiyos Seyoum and Abera Anja, 2018). Whereas, in the study areas, the predominant number of hives (70%) are placed in forest trees which is difficult for females' engagement in beekeeping activity.

The age distribution (Mean±SD) of respondents is 40.45±9.12; 38.56±8.67; 37.75±8.75years for Chena, Gimbo and Gesha districts respectively which is non significant age variations among districts at ($P<0.05$). The overall age (Mean±SD) of study area is found to be 38.92±8.87 years ranging from 18 to 72 years. The current result is equivalent with the mean age of beekeepers in Benishangul gumuz region and Gomma district which is reported to be 38 and 40.47 years respectively (Alemayehu Abebe *et al,* 2015 and Chala Kinati *et al.,* 2013). According to survey result on age distribution of the respondents, about 73% of the respondents are found within in a range of 18 to 45 years, 23% of them within 46 to 60 years and 4.4% are more than 60 years of age (Table 5). This implies most of the respondents are found within younger age groups. According to Tezera Awoke (2013), individuals with in an age group of 15-60 are considered as economically active age groups.

Table 5. Sex and Age group of the respondents

House Hold Characteristics	**Variables**	**Districts (frequency and percentage)**			
		Chena	**Gimbo**	**Gesha**	**Over all**
Sex	Male	58(97%)	59(96.7%)	56(91.7%)	170(94.4 %)
	Female	3(5%)	2(3.3%)	5(8.3%)	10(5.6%)
	Total	60(100%)	60(100%)	60(100%)	180(100%)
Age of House Hold head	(Mean±SD)	40.45±9.12	38.56±8.67	37.75±8.75	**38.92±8.87**^{NS}
	Range	25-67	20-65	18-72	18-72
	18– 45	38(63.3%)	44(73.3%)	48(80%)	130(72.2%)
	46-60	21(35%)	13(21.7%)	8(13.3%)	42(23.3%)
	61and above	1(1.7%)	3(5%)	4(6.7%)	8(4.4%)

4.1.2. Educational status of the respondents

The educational status of the respondents determines the proportion of each literacy levels of the communities of a given localities. Identifying of the literacy level will help us to determine the types, ways and levels of interventions for designing successful developmental schemes.

The mean comparison for colony holding of the respondents based on their educational level was under taken by classifying the respondents into clusters of literacy levels as illiterate, basic education, grade 1-4, grade 5-8, and grade 9 and above. Accordingly, 50(27.78%) of the respondents are illiterates; 44(24.44%) basic education (who are able to read and write), 58(32.22%) grade 1-4; 19(10.56%) grade 5-8 and 9(5%) of them have grade nine and aboves (Table 6). The result indicates the predominant number (about 60%) of beekeepers have attended lower level of education. Similar reports by Tessega Belie (2009); Taye Beyene and MarcoVarschuur (2014); Sisay Fikru *et al.* (2015) and Birhanu Tessema (2016) indicating that higher portion of beekeepers in the country are having lower education levels or illiterates. This revealed that beekeeping is considered as a simple venture that can be ran without detail knowledge and skills. However, the mean comparison of colony holding of the respondents based on their education level indicates that the colony holding of the respondents is getting higher as their education level is increased (Table 6). This might be resulted from the perception and awareness difference of individuals taking beekeeping as a major business and adopting new technologies or practicing of improved ways of beekeeping (back yard system) is highly influenced by their literacy levels. Similar results by Assemu Tesfa *et al.* (2013) and Addisu Bihonegne *et al.* (2017) also indicated that individuals with higher literacy levels are better in grasping trainings and changing into action as well as considered as golden opportunities to harmonize others too.

Table 6. The relationship between education status and colony holdings

Educational Level	N	%	Colony number/HH (Mean±SD)
Illiterate	50	27.78	10.08 ± 3.77^{b}
Basic education (able to read and write)	44	24.44	14.73 ± 6.28^{b}
Grade1-4	58	32.22	16.12 ± 9.49^{b}

Grade 5-8	19	10.56	26.05±17.12[ab]
Grade 9 and above	9	5.00	46.78±14.58[a]

* Letters with different superscript indicaates significant varion of colony holding of respondents based on their literacy levels at p<0.05.

4.1.3. Colony holding of the study areas

The household colony holding (Mean+SD) of the study area is found to be 14.40±10.29, 15.36±11.99 and 20.28±13.49 for Chena, Gimbo and Gesha districts respectively. As observed from (Table 8), there is a significant variation among districts in terms of colony holding. Accordingly, Gesha district has significantly higher colony holding than Gimbo and Chena districts. However, there is no significant variation between Chena and Gimbo districts at (P<0.05). The mean colony holding of the area is found to be 16.68±12.21 (Table 7). Similar comparable results, 13 and 15 colonies were reported by Kasa Tarekegne *et al.* (2017) and Awraris Getachew *et al.* (2012) respectively. However, it is somehow greater than the average colony holding of Dello Mena district which is reported to be 10.3±2 (Bekele Tesfaye, 2016). According to Figure 2, almost half of the respondents owning 11 to 20 colonies. Whereas, 25% from 6 to 10; 18.3% from 21 to 50, 3.3% over 50 and 2.8% of them have less than 5 colonies. This indicates over 70% of the respondents owning more than 10 colonies.

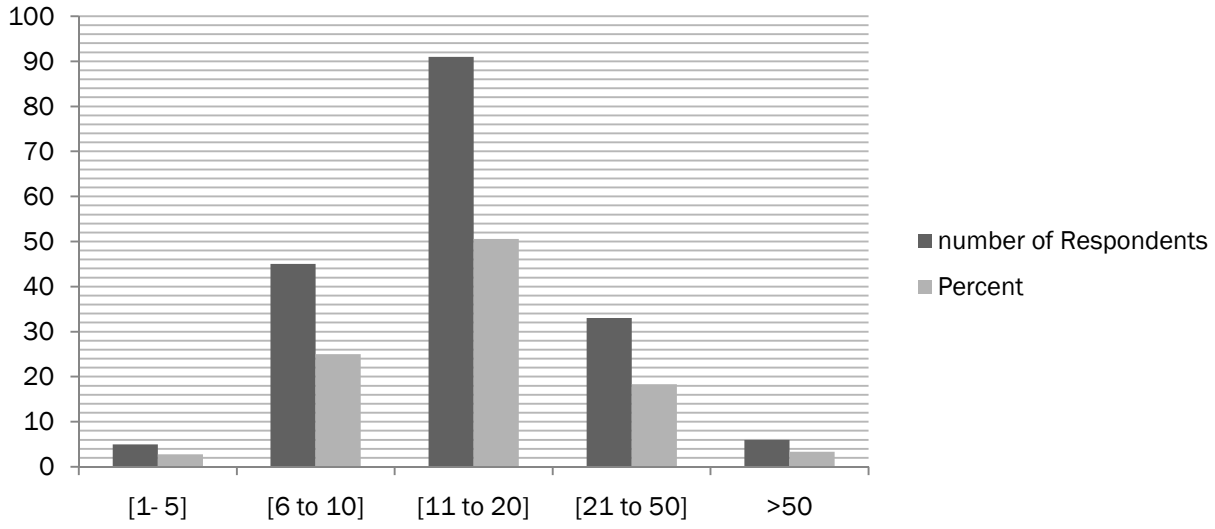

Figure 2. Colony holding of the respondents

4.2. Beekeeping Practices

4.2.1. Beekeeping experiences of the respondents

Despite the availability of conducive environments for honeybees including enough foods, waters and technologies, the output of beekeeping may be unsatisfactory unless accompanied with apt know how and experiences (Chala kinati *et al*, 2012). Beekeeping practices have long been part and parcel of the socio cultural system of South and Southwestern parts of Ethiopia (Tefera Belay, 2005; Yoshimasa, 2014).

According to personal observations during survey, the endogenous skills and knowhow of the individuals regarding the practical aspect of beekeeping such as identifying the nature of honeybees, pest prevention/controlling mechanisms, identifying the seasonal trends of their colonies, etc are significantly varying based on the level of their beekeeping experiences.

The survey result shows about 60% of the respondents have more than 10 years of beekeeping experiences and the overall beekeeping experiences(Mean±SD) of the respondents is 13.21±8.40 years(Figure 3). Similarly, the beekeeping experiences of the area also reported to be 11.89±3.95 and 16.17±6.88 years by Kasa Tarekegne *et al*, 2017 and Awraris Getachew *et al,* 2012 respectively. The result indicates even though beekeeping is undertaken in traditional ways, it is considered to be a long lasting practice in supporting the livelihood of most communities of the areas. The beekeeping experience of the area is comparable with Burie district which is reported to be 14.46±11.25(Tessega Belie, 2009).

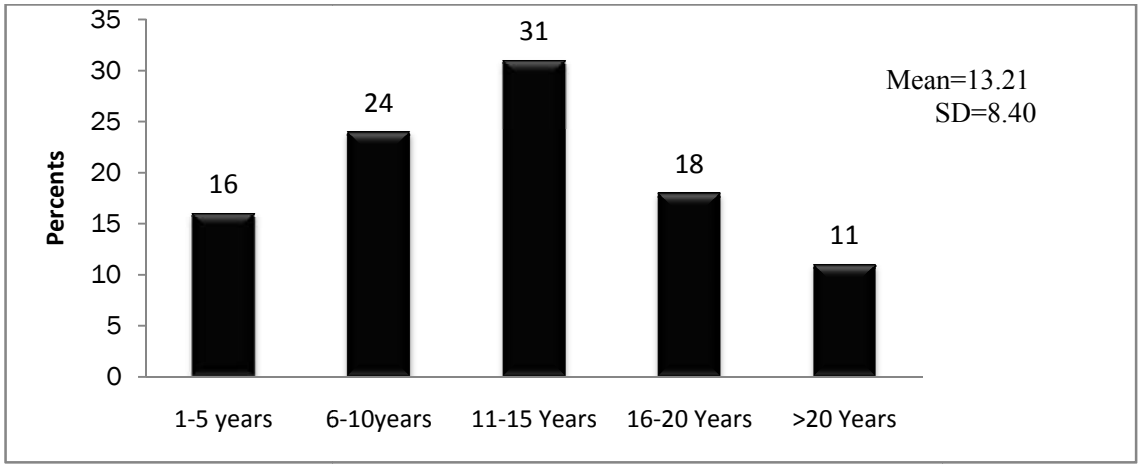

Figure 3. Beekeeping experiences of the respondents

4.2.2. Reasons for engagement in beekeeping

According to the survey result, the need for income sources from the sale of honey product is found to be the primary reason for the engagement of most, 59.41% of respondents in beekeeping activity. whereas, Home consumption, hobby, training and other supports are also considered as the major reasons for the engagement of individuals in beekeeping sharing 19.47%, 15.51% and 5.6% respectively (Table 7).

According to various studies acknowledged that in related to the huge forest resources, beekeeping is primarily aimed with honey production which is used as the major immediate income sources for most communities of the south and south west areas of Ethiopia (Tefera Belay, 2005; Janet and Andrian (2014); Hartmann (2004) and Nuru Adgaba (2007a). Similarly, Awraris Getachew *et al.* (2012) also stated that over 50% of the households' income sources of the area are obtained from beekeeping mainly from the sale of crude honey. During survey, 25(13.67%) individuals are found to be obtaining almost all of their livelihood requirements merely from the sale of honey crops. Hence, beekeeping has paramount roles in supporting the livelihood of most individuals of the areas. According to few, 5.6% beekeepers replied that training and inputs support provided by governmental and nongovernmental Organizations increased their awareness and motivation to be engaged in beekeeping (Table 7).

Table 7. Reasons for engagement in beekeeping

Reasons for engagement	**Ranks**				**Total**	**Index**	**Rank**
	1st	**2nd**	**3rd**	**4th**			
Income	155(76.4)	25(33.78)	-	-	180(59.41)	0.65	1
Hobby	11(5.73)	15(20.27)	21(36)	-	47(15.51)	0.12	3
Home consumption	18(9.38)	28(37.84)	13(52)		59(19.47)	0.17	2
Training & Other supports	8(4.17)	6(8.11)	3(12)	-	17(5.6)	0.05	4
Total	**192**	**74**	**37**	**-**	**303**	**1**	

Index = sum of (3*ranked 1st + 2* ranked 2nd +1* ranked 3rd) for individual reason divided by the sum of (3*ranked 1st + 2* ranked 2nd +1* ranked 3rd) for over all reasons.

4.2.3. Sources of foundation colonies of the study areas

In the study areas, about 45% of the respondents obtained their foundation colonies by catching swarms, 32% by catching swarms and parents gift, 19% from parent gifts and 4% through inheritences (Figure 4). Unlike other areas such as in central and northern parts of the country where a considerable number of beekeepers obtain their foudation colonies from purchases (Tessega Belie, 2009; Guesh Gudfey *et al.,*2015; Addisu Bihonegne *et al,* 2017), sale of honeybee colonies is not common in the study areas. Existence of immense and diverse natural vegetations enables the area to have potential flower resources which are readily abundant year round. This favors for the existence of huge colony numbers which will be easily cought by hanging bait hives in the forests. However, very few individuals such as those who want to obtain more number of colonies in a short period of time will purchase colonies from swarm catchers. The price of a colony is ranging from 100-250 ETB which is by far cheaper than the price of a colony sold in central and north parts of the country. For istance, in Tigray region, a colony may cost from 500 to 1,800 ETB which is considered as one of the main purposes of beekeeping for most individual beekeepers of the areas (Guesh Gudifey *et al,* 2015; Yetimwork Gebremeskel, 2015).

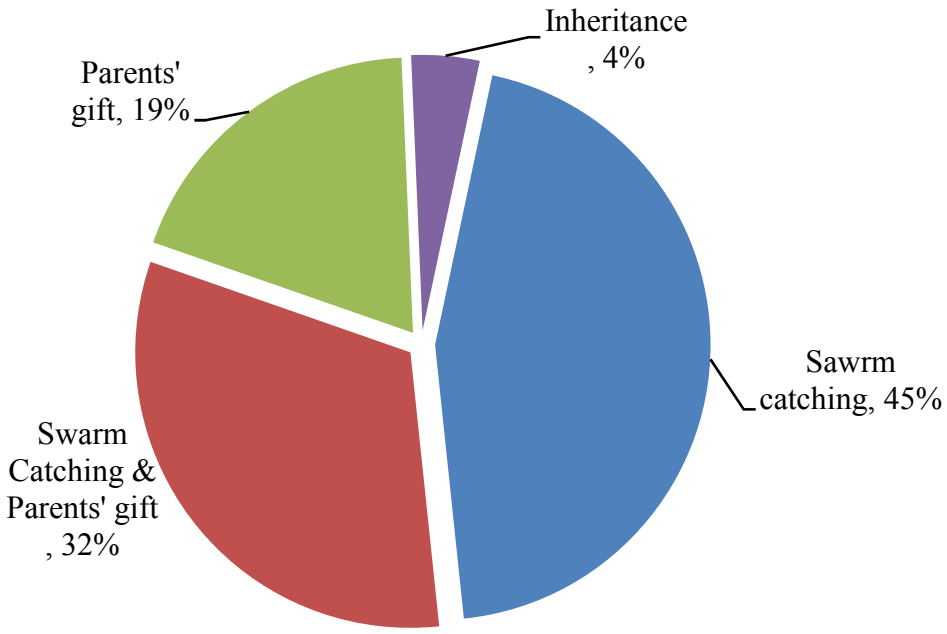

Figure 4. Sources of foundation colonies

4.2.4. Source of colonies for increasing stocks

According to the survey results regarding honeybee colony holding trends over the last five years indicated that 72(40%) of the respondents replied that there is no change in their colony numbers. Where as, 50(28%)of them have an increasing and 58(32%) of them have a decreasing trends. The beekeepers use various mechanisms to increase their colony numbers. Accordingly,156 (86.67%) of them by swarms catching, 12(7%) by using queen rearing and swarm catching, 9(5%) by purchasing and swarm catching and 3(1.67%) by queen rearing (Figure 5). The result revealed that swarm catching is a common practice of most beekepers of the areas for starting beekeeping as well as increasing their stocks and very few individuals are practicing queen rearing methods for increasing as enhancing the productities of their stocks by selecting better colonies from their stocks.

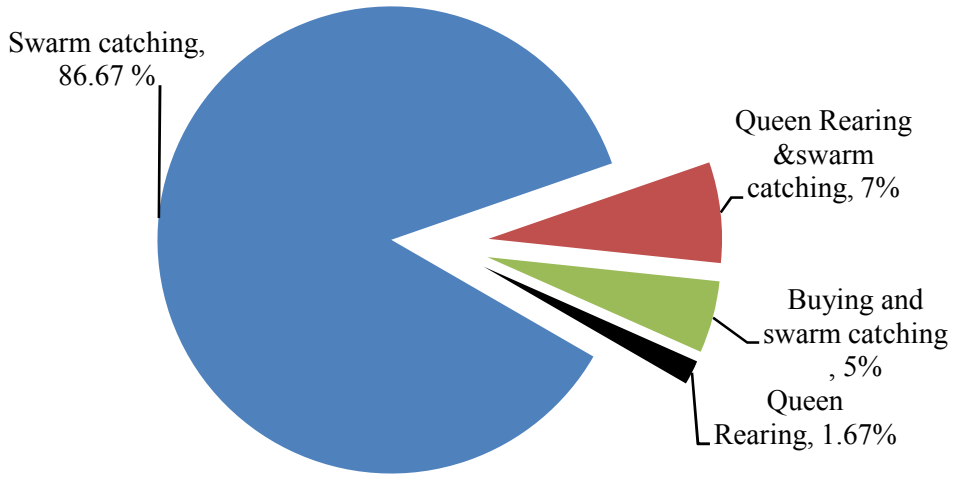

Figure 5. Source of colonies for increasing stocks

4.2.5. Hive types and honey yield

With regard to hive types and its coverage, the greater number, about 73% are locally made traditional hives followed by movable frame/box hives and transitional hives which accounts for 16% and 11% respectively. Equivalent result, over 70% of locally made traditional hive and about 30 % of improved hives were reported by Kasa Tarekegne *et al,* 2017.

The average household colony holding of the areas based on the hive types is found to be 12.19±8.16, 1.83±4.28, and 2.65±5.04 for traditional, transitional and modern/box hives respectively. The result indicates that the predominant numbers of beekeepers of the areas are using traditional hives. According to personal observation during survey, though there are various factors contributing for the minimum adoption levels of improved hives, lack of accessibility to road infrastructure is considered as one of the major determinant factors. To this fact, about more than 80% of the respondents who have improved hives are found in areas approaching to main roads within a distance radius of about three kilometers from the main roads. This might be due to their higher exposures to various supports and information sharing. The honey production estimate of the areas by hive types and districts in the below Table 14, depicts that the annual productivity of the colonies is significantly different at ($p<0.05$) among hive types and study districts. Accordingly, Gesha district has significantly higher yields than Chena and Gimbo districts. However, there is no significant yield variation between Chena and Gimbo districts.

The mean annual honey productivity of hives in the study areas is 8.34±2.33, 15.96±2.62 and 27.27±2.74 for traditional, transitional and moveable frame hives respectively (Table 9). The current result is less than Awraris Getachew, *et al.,* 2012; who reported the productivity of traditional hives was 10.53±5.27, 12.60 ± 4.83, and 16.06± 9.03 for Gimbo, Chena and Gesha districts respectively. The difference might be due to the minimum sample sizes taken during the previous study which is 20, 24 and 26 sample respondents were considered for Gimbo, Chena and Gesha districts respectively.

The current result is greater than the national honey yield report which is estimated to be 5-8 kg, 10-15 kg and 20-25 kg of crude honey per hive for traditional, transitional and movable frame hives respectively (Nuru Adgaba, 2007a). It is also greater than the production obtained from Goma district which is 7.20±0.23kg, 14.70±0.62kg and 23.38±0.73kg from traditional, transitional and movable frame hives respectively as reported by Chala Kinati*, et al,* (2013).

Table 8. Share of honeybee colony holdings based on hive types

Hive types	Districts											
	Chena			Gimbo			Gesha			Overall		
	Total	**%**	**Mean±SD**	**Total**	**%**	**Mean±SD**	**Total**	**%**	**Mean±SD**	**Total**	**%**	**Mean±SD**
Traditional	602	69.68	10.03 ± 5.25^{b}	701	76	11.68 ± 8.49^{b}	892	73.3	14.87 ± 9.50^{a}	2195	73.12	12.19±8.16
Transitional	110	12.73	1.83±5.57	82	9	1.37±2.92	138	11.34	2.3±3.96	330	11	1.83 ± 4.28^{NS}
Movable frame hives	152	19.59	2.53±5.50	138	15	2.3±4.68	187	15.37	3.12±4.94	477	16	2.65 ± 5.04^{NS}
Total	**864**	**100**	**14.40 ± 10.29^{b}**	**921**	**100**	**15.36 ± 11.99^{b}**	**1217**	**100**	**20.28 ± 13.49^{a}**	**3002**	**100**	**16.68±12.21**

*Letters with different superscript across rows indicates significant difference of hive numbers among districts.

Table 9. Honey yield based on hive types and districts

Districts	Hive types										
	Traditional			Transitional			Movable frame			Over all	
	Total hives	Total Yield (Kg)	Yield/a hive (Mean±SD)	Total hives	Total Yield (kg)	Yield/a hive (Mean±SD)	Total hives	Total Yield(kg)	Yield/a hive (Mean±SD)	Total hives	Total yield (Kg)
Chena	602	4732	$7.86\pm 2,16^{b}$	110	1633.5	14.85 ± 1.8^{b}	152	3934	25.88 ± 1.85^{b}	864	10299.5
Gimbo	701	5713	8.15 ± 2.14^{b}	82	1246	15.19 ± 2.78^{b}	138	3635	26.34 ± 2^{b}	921	10594
Gesha	892	8046	9.02 ± 2.53^{a}	138	2436	17.65 ± 2.42^{a}	187	5414	28.95 ± 2.92^{a}	1217	15896
Total	**2195**	**18491**	**8.34±2.33**	**330**	**5315.5**	**15.96± 2.62**	**477**	**12983**	**27.27±2.74**	**3002**	**36789.5**

*Letters with different superscripts within columns indicates significant variation of honey yield among districts

4.2.6. Hive placements

The types of hive placements will vary from place to places and individuals perspective. It is obvious that the management level of colonies will be highly determined by the type of hive placements; which in turn has its own impact on the production status of the colonies.

According to the survey results, hanging on forest trees, placing at back yards, apiaries and putting under eaves are identified as the common hive placement types practiced in the areas.

As shown on Figure 6 and Table 10, of the total 3002 colonies counted during survey, about 2096(70%) are placed on trees found near or far forests from home stead areas. Whereas, few numbers of colonies are also placed at backyards, apiaries and under eaves together accounting for 30% of the total colonies. Similarly, Nuru Adgaba (2002) also stated that even though backyard beekeeping is widely practiced in most parts of the country, in some areas, especially in South and western parts of the country forest beekeeping by hanging a number of hives on trees is widely practiced.

The hive placement share of the study areas is varying from Gamogofa, Hadiya and Silti Zones where the higher portion of beehives are placed at back yards and under the eaves of the houses (Nebiyu Yemane, Messele Taye, 2013; Haftu Kebede, 2014; Alemayehu Kebede, 2016).

In the area, most beekeepers have ownership of trees/forests for hanging hives, locally known as the '*Kobo'* system. Under the '*Kobo*' system one has the right to demark his own forests/trees for the purpose of hanging hives and no one can cut or hanging on trees which has already been demarked by others and the ownership of forests/trees may pass for successive generations. The traditional '*kobo'* system is sometimes considered as potential opportunities for achieving modern natural resource conservations schemes (Tefera Belay, 2005).

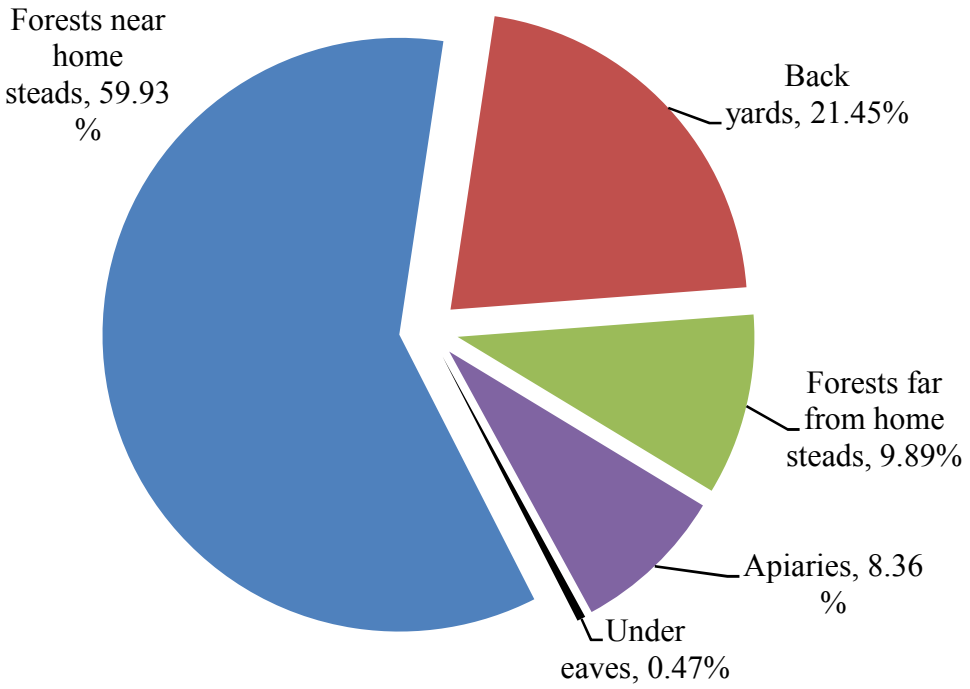

Figure 6. Hive placements

Table 10. Hive placement

Placement sites	**Hives types**	**Districts**			
		Chena	**Gimbo**	**Gesha**	**Total**
Back yard	Traditional	32	22	12	**66**
	Transitional	83	63	102	**248**
	Modern	112	110	108	**330**
	Total	227	195	222	**644**
Apiary sites	Traditional	7	-	17	**24**
	Transitional	25	19	36	**80**
	Modern	40	28	79	**147**
	Total	72	47	132	**251**
Forests near home stead	traditional	456	608	735	**1799**
	Transitional	-	-	-	**-**
	Modern	-	-	-	**-**
	Total	456	608	735	**1799**
Forests far home stead	traditional	104	65	128	**297**
	Transitional	-	-	-	**-**
	Modern	-	-	-	**-**

	Total	104	65	128	**297**
Under the eaves	traditional	-	6	3	**9**
	Transitional	5	-	-	**5**
	Modern	-	-	-	
	Total	5	6	3	**14**
	Overall	**864**	**921**	**1217**	**3002**

4.2.7. Training and other supports

As honeybees are very complex creatures compared to other animal species, the knowhows about honeybees nature and manipulation skills are so important to maintain colonies and obtaining better rewards(Mutsaers, 2005). To this fact, the less adoption levels of new technologies such as improved hives are partly emanating from the misuses of the technologies. Hence, training and regular followups has paramount roles for maximizing the benefits from the sub sector.

The respondents were asked weither they have got any trainings or not, duration of the training, focus areas of the trainings, and the training coordinators. Accordingly, 63(35%) of them replied they have got training on beekeeping (Table 11). Of whom 21(11.7%) of them have got training for more than five days; about general bee managements, bee product handling, transitional/chefeka hive making and queen rearings. Where as the rest 42(66.67%) of them have got training for less than five days about honeybees management and bee products handling and chefeka/ethio ribrab hive making. The total training dates (Mean$\pm$SD) of repondents who have got training is 4.15 $\pm$3.00. This shows the majorities, 117(65%) of the respondents have not got any trainings on beekeeping. The result is similar with Awraris Getachew *et al.*(2012) who reported lack of training and technical supports, shortages of skilled man power in beekeeping are some of the major constraint of beekeepers in the areas.

The zone has various governmental and non governmental stake holders who take part in support of beekeeping subsector. Of which Kafa forest bee products development and marketing cooperative union(KFBPDMU) and Apicec Agro industry PLC are the major ones providing various supports to the beekeepers of the the area such as providing trainings, inputs, credit services and market facilitations. There are also other organisations; such as Aspire, ATA, AGP, World Vission, Nature and Biodiversity conservation union(NABU),

Kafa Biosphere Conservation Union providing beekeepers with various supports in line with conserving the natural forests or biosphere of the areas.

Kafa forest bee products development and marketing cooperative union (KZBPDMCU) is a recently established organization(Since 2016) working in all ten districts of the zone basically aimed with improving the income of beekeepers by enhancing their production, marketing and quality status of honey and beeswax products in the areas. The union collecccts the honey and beeswax products from the cooperatives and sending to central or export markets.

Apinec agro industry is a private limited company working in the areas collecting the crude honey from the beekeepers and from its established apiaries and sending its product (processed honey and beeswax) to central markets. It sales its honey products after refining and packing and the processed beeswax in the form of foundation sheets. It supports the local beekeepers via providing trainings, inputs such as hives, accessories, storage and processing materials, credit services and supplying foundation sheets, market facilitations which inturn beekeepers will supply their honey products to the enterprise. Of the total 180 respondents during survey, 133(74%) of them are registered as members of the cooperatives while the rest 47% are not members.

Table 11. Training

Parameters	**Variables**	**freq.**	**%**
Have you got any training on beekeeping ?	Yes	63	35
	No	117	65
	Organizer/host	**freq**	**%**
Who trained you(Organizer)?	BoA/BoLivestock and fishery dev't	19	15.57
	KFBPDMU	7	5.74
	AGP	30	24.59
	Aspire	13	10.66
	HBRC	3	2.46
	Apinec	12	9.84
	Unknown	38	31.15

4.2.8. Colony declines

Even though the area is blessed with a huge colony population compared to other most parts of the country, most, (93%) or respondents agreed that there is an overall declining trend of colonies from time to time. According to their responses, before certain years, a colony may be captured even within a week times after hanging the hive in forests. However, nowadays, it needs longer times to capture a colony after hanging hives and currently, almost half of their hives are free of colonies.

According to ranking done based on the priority scores of reasons for colony declines listed by the respondents; Pests, Predators, Absconding, poor managements, Swarming, Dearth, agro chemicals, poisonous plants, seasonal variations, Deaths of honeybees due to unknown reasons are listed as the major causes for colony declines in the areas in order of their importance (Table 12).

Similarly, various researchers (Gallmann and Thomas, 2012; Chala Kinati *et al.*, 2013) also reported that Prevalence of pests mainly ants, wax moths, beetles and varroa mites and predators mainly honey badgers are reported to be the major bottle necks of beekeeping in south and south western parts of the country. According to Awraris Getachew *et al.*(2012); Gallmann and Thomas (2012) and Tolera Kumsa (2014), poor seasonal colony management is also considered as the major causes for colony declines in the areas by aggravating them for higher infestations by various pests and diseases. In the area, the care taken for colonies during honey harvesting is very poor in which the fortune of colonies is not taken into account.

Existence of some poisonous plant species such as *Croton microstachys, Helinus mystacinus, 'Gachi' (local name)* have great impacts on honeybees deaths in the area. As most respondents declared that *Croton microstachys* results for a great devastation of honeybees by massively killing the adult bees and their broods especially through June to July when typical blooming of *croton microstachys* occurring. According to Chacha (2013) reports, even though plants are very decisive for the existence of honeybees, there are some plant types which will intoxicating the bees as well as their products resulting for noticeable symptoms even on

human beings such as dizziness, weakness, excessive perspiration, nausea, and vomiting, low blood pressure, shocks, heart rhythm irregularities, and convulsions, even some times may result for deaths up on consuming their product. Existence of poisonous plants is also reported as one of the constraints of beekeeping in Ethiopia (Nuru Adagba and Hepburn, 2001; Hailegebriel Tesfay, 2014).

Agro chemicals such as '*Round up, Glycien and Tilt* which are seasonally sprayed for protecting pests and diseases against coffee plantations, chat (*Catha edulis*), fruits and vegetables are also listed as one of the major threats for honeybees in the areas. According to survey results, none of the respondents have reported disease as the main cause for colony deaths in the areas (Table 12). According to Amssalu Bezabih *et al. (*2012), agrochemicals which are commonly used in the country for protection of various pests and diseases of crops have a significant effect on honeybees' health either directly or indirectly.

Various honeybee diseases such as Nosema, Amoebae and chalk broods were reported to be exist in the country (Desalegne Begna, 2000; Amssalu Bezabih and Desalegne Begna, 2005; Hailegebreil Tesfay, 2014; Desalegne Begna, 2015). However, the current none reports of honeybees' death by diseases and parasites is probably related with its difficulty to identify the disease symptoms of honeybees by the beekeepers. A considerable number of individuals have reported that there is also a declining or dwindling of colonies due to unknown reasons which needs further investigations whether it is resulted from diseases or other causes.

Table 12. Reasons for colony declines

Variables									**freq.**				**%**
Is there colony decline in your areas?									Yes				93
									No				7
Reasons	**Rank**												**Over all Rank**
	1st	2nd	3rd	4th	5th	6	7th	8th	9th	10th	11th	Index	
Pests	135	30	3	0	0	0	0	0	0	0	0	0.274	1
Predators	3	44	37	36	40	8	0	0	0	0	0	0.215	2
Diseases	0	0	0	0	0	0	0	0	0	0	0	0	11
Absconding	6	25	32	15	10	7	2	5	0	0	0	0.131	3
Swarming	9	11	3	8	12	10	4	7	17	0	0	0.082	5
seasonal variation	0	0	0	2	12	0	0	0	0	2	3	0.016	9
Agro chemicals	7	23	3	6	5	0	0	0	0	0	0	0.063	7
Poisonous plants	0	0	5	23	15	0	0	0	0	0	0	0.0.051	8
Dearth	3	10	11	7	2	12	6	9	15	0	0	0.073	6
Poor management	5	14	17	13	8	6	2	3	4	0	0	0.088	4
Unknown reasons	0	0	0	0	0	0	0	0	12	0	0	0.005	10
Total	**168**	**157**	**111**	**110**	**104**	**43**	**14**	**24**	**48**	**2**	**3**	**1**	

Index = sum of (11*ranked 1st+ 10* ranked 2nd+9* ranked 3rd+8* ranked 4th+7* ranked 5th+6* ranked 6th+5* ranked7th+4*ranked 8th +3*ranked 9th+2*ranked10+1*ranked11) for individual pests divided by the sum of (11*ranked 1st+ 10* ranked 2nd+9* ranked 3rd+8* ranked 4th+7* ranked 5th+6* ranked 6th+5* ranked7th+4*ranked 8th +3*ranked 9th+2*ranked10+1*ranked11) for over all reasons.

4.2.9. Absconding and swarming

Absconding is the total desertion of honeybee colonies from their abodes. Honeybees may abandon their hives at any time of the year due to so many reasons. Shortages of feeds, disturbance by pests and predators, inability to maintain the hive temperature due to over cooling or heating, rain entering the hive and the likes are listed as the most common triggering factors (Judith and Bruce, 2008; Pradeepa, 2012) for absconding. However, it is a common phenomenon particularly in case of poor managements and ill inspections. Moreover, due to the presence of ample forage resources during most seasons, tropical honeybee races have higher abandoning tendencies than the temperate races which are encountering with extended harsh environments during most of the seasons enforcing them to stay home longer (Bradbear, 2009).

According to the study, most, 173(96%) of the respondents agreed that absconding is a common problem for beekeeping in the area. Pest, predators, poor managements, dearth/feed shortages, unknown reasons, agrochemicals are listed as the major causes for absconding sharing 35.68%, 22%, 18.8%, 14.74%, 5.13% respectively(Table 13). In related with high prevalence of pest and predators (especially ants, wax moth, small hive beetles, Honey badger) accompanied with poor management practices of most beekeepers aggravating the high absconding rates of colonies in the areas.

According to most beekeepers responses, intense absconding rates of colonies occurs in time of feed shortages mainly during peak rainy seasons (July-August) and dry seasons (January-February). A considerable amount of colonies absconding due to unknown reasons is probably emanated from the high absconding tendency of honeybee races in the areas. Similar reports by Amssalu Bezabih (2004) and Gallmann and Thomas (2012) indicated that honeybee species found in the south and south west parts of the country (*A.m.Scutellata L.*) has high tendency of absconding due to their distinctive wild characteristics.

The comparison on absconding rates of colonies based on the hive types indicated that transitional and movable frame hives have higher absconding rates accounting for 53% and 36.99%, respectively. Whereas, 12(6.94%) of the respondents replied that absconding rates does not vary based on hive types and 5(2.89%) of the respondents replied higher absconding

rate occurs in traditional hive than improved ones (Table 13). According to Awraris Getachew *et al.* (2012), evaluation done on beehive types revealed that honeybees have better performance and yields in transitional/Ethio ribrab hives next to movable frame hives. In contrast; the current result shows that the higher absconding rate of colonies occurring from improved hives basically from transitional hives. This might be resulted from lack of appropriate seasonal colony management practices under taken by most beekeepers of the areas.

Table 13. Absconding of honeybee colonies in the areas

Is there absconding of colonies in your areas?		Yes	173	96%
		No	7	4%
Reasons for absconding	Freq.	%		Rank
Pests	167	35.68		1
Predators	103	22		2
Dearth/feed shortages	69	14.74		4
Poor management	88	18.8		3
Agrochemicals	17	3.63		6
Unknown reasons	24	5.13		5
Total	468	100		
From which types of hives frequent absconding occurs?	Freq.	%		Rank
Traditional	5	2.89		4
Transitional	92	53.18		1
Movable hives	64	36.99		2
All types of hives	12	6.94		3
Total	173	100		
How can you prevent/control absconding?	Freq	%		Rank
Regular follow ups/inspection	150	34.01		1
Cleaning the hive areas regularly	46	10.43		3
Ash dusting	33	7.48		4
Using physical pest prevention mechanisms	130	29.48		2
Using chemicals (flits)	13	2.95		7
Using biological prevention mechanisms	28	6.35		6
Seasonal feeding and watering	12	2.72		8
Removing old combs	29	6.58		5
Total	441	100		-

Swarming is an instinctive part of the annual life cycle of honeybees(Solomon Legesse and Seid Guyo,2015) that an old queen and some parts of the worker bees and drones departing

from their former nest and seeking for a new home to form an independent colony for reproducing themselves (Sara *et al.,* 2012)

The swarming tendency of honeybees will vary based on the type of species of bees, management levels and seasonal variation which is related with feed availability, especially pollen sources (Bradbear, 2009; Pradeepa, 2012).

Honeybees with high Swarming tendencies are sometimes considered as a golden opportunity in case of colony scarcities and optimizing pollination services. However, have adverse economic impacts when aimed for honey production (MAAREC, 2005).

According to the study, 177(98.33%) of the respondents agreed that swarming is one of the major problems for beekeeping activity in the area. Accordingly, the higher swarming rate of honeybees occurs from traditional hives followed by modern hive sharing 83(46.89%) and 54(30.51%) respectively. While, 27(15.25%) of the respondents replied swarming rates does not vary based on hive types and 13(7.34%) of whom agreed transitional hives have higher swarming rates (Table 14).

According to (Table 14), the higher number of colonies swarm once a year; followed by once in two years, once in 2-4 years, unknown times, and twice a year sharing 38.42%, 24.86%, 19.21%, 10.17% and 7.34% respectively. Similarly, higher swarming rates of *A.m.Scutellata L*. species; 49.4% once a year and 41.6% once in two years was reported by Solomon Legesse and Seid Guyo (2015).With regard to the season of swarming, most, 157(87%) respondents replied that swarming occurs only during October to November. However, few, 13 replied that it also occurs during June to July.

The beekeepers apply various mechanisms to prevent/control swarming. Such as; using large size hives, adding space, shading, Catching the swarm and returning to hives, cutting brood combs, removing the emerging queen cell, and splitting the colony sharing 31.90%, 22.38%, 13.33%, 12.38%,8.57%, 8.10%, 3.33% respectively(Table 14).

Table 14. Swarming of colonies in the areas

Parameters	Variables	Freq	%
Is there swarming in your areas?	Yes	177	98.33
	No	3	1.67
From which type of hive	Traditional	83	46.89(1)
	Transitional	13	7.34(4)
	Movable frame	54	30.51(2)
	All types of hives	27	15.25(3)
	Total	177	100
Frequency of swarming	Once a year	68	38.42(1)
	Twice a year	13	7.34(5)
	Once in two years	44	24.86(2)
	Once in 2-4 years	34	19.21(3)
	Unknown	18	10.17(4)
	Total	177	100
Swarm Prevention/controlling mechanisms	Removal of queen cells	17	8.10(6)
	Shading	28	13.33(3)
	Catching the swarm and returning to hives	26	12.38(4)
	Adding space/ supering	47	22.38(2)
	Using large volume hive	67	31.90(1)
	Cutting brood combs	18	8.57(5)
	Splitting the colony	7	3.33(7)
	Total	210	100

( ) denotes order of ranking

4.2.10. Major honeybee pests and predators

Even though the area is very potential for beekeeping practices, there are various pests and predators which will hinder the proficiency of the sub sector. These are Black ant, Honey badger, Wax moths, Beetles, Varroa mites, Bee eater birds and spiders according to their importance level (Table 15). Among all pests and predators, black safari ant (*Dorrylus spp)* is the major one resulting for the huge economic losses by consuming the pollen, the brood and even the adult bees. Due to its attacking mechanisms (invading during night times and

high climbing efficiency), its enormous number of foragers per a colony, it can damage a number of colonies even over a night. Similarly, Desalegne Begna, 2007; Awraris Getachew *et al*, 2012; Teklu Gebretsadik, 2016 reported that this pest is widely distributed in most parts of the country especially in moist areas and considered as the most troublesome to honeybees and beekeeping subsector.

Honey badger (*Mellivora capensi*) is prioritized as the second important enemies of honeybees. In related with higher forest coverage of the areas, it is widely distributed and has great devastation to the local beekeepers especially on traditional hives which are hanged in forests.

Wax moth is another important pest that can result for huge economic losses of beekeeping listed as one of the major causes for absconding of colonies in the areas. Similarly, Amssalu Bezabih and Desalegne Begna, 2007 reported that the wax moth which is of two types, the greater (*Galleria mellonella* L.) and the lesser wax moths (*Achroia grisella E.)* are widely distributed in all over the country and consequence for high absconding cases of colonies especially in hot areas. According to the same study, in East and West Shoa zones, 56-75% of the infected colonies will be prone for absconding. The Small hive beetles (both greater and lesser) are very common in the areas and its infestation level is getting higher specially during high nectar flow seasons, it also resulting for absconding of colonies when they are weak to resist. The prevalence of hive beetles (both larger and smaller) was reported to be getting higher in maize and sorghum growing areas (Amssalu Bezabih and Dessalegne Begna, 2001) including South and South western parts of the country.

As shown in Table 16, locally beekeepers apply various physical, chemicals and biological methods to prevent and/or control the attacks of pests and predators in the areas.

Table 15. Major Honeybee pests and predators

Pests and predators	**Relative degree of importance**								
	1st	**2nd**	**3rd**	**4th**	**5th**	**6th**	**7th**	Index	Rank
Ant	180	-	-	-	-	-	-	0.375	1
wax moth	-	60	30	17	15	-	-	0.185	3

Beetles	-	19	32	63	22	-	-	0.176	4
Honey badger	-	120	23	-	-	-	-	0.248	2
Birds	-	-	-	-	-	7	2	0.005	6
varroa mites	-	4	1	-	-	-	-	0.009	5
spiders	-	-	-	-	-	3	3	0.003	7

Index = sum of (7*ranked 1st+ 6* ranked 2nd+5* ranked 3rd+4* ranked 4th+3* ranked 5th+2* ranked 6th+1* ranked 7th) for individual pests divided by the sum of (7*ranked 1st+ 6* ranked 2nd+5* ranked 3rd+4* ranked 4th+3* ranked 5th+2* ranked 6th+1* ranked 7th) for over all pests and predators.

Table 16. Some of the local prevention mechanisms of pests and predators

Pests and predators	**Local prevention methods**
Ant	Cleaning the areas, dusting ashes around the hive stands, smearing the hive stand with used engine oil, tying "*teff*" straw on the hive stands or stems of trees where the hives hanged on, spraying flits, surrounding the hive areas with water canals, killing the queen and distracting its nests, hanging hives over long trees (traditional hives), tying pieces of hangover on the stems, hanging hives on trees containing '*Crimatogaster chiarinii'* ant nest or adapting it to their apiaries/ back yards which is used as biological protection mechanisms, using hot water, attaching plastics or metal sheets on top of hive stands, using single hive stands to reduce its opportunities to climb(Appendix picture 6).
Wax moths	Removing old combs from apiary areas and from the hives, keeping colony strength, spraying green paper/'*berberie'* on the infected comb, reprocessing the old combs and replacing with new foundations.
Beetles	Using screen on the entrances of hives (for large beetles), but there is no protection mechanisms for small hive beetle except strengthening the colonies.
Honey badger	Attaching iron sheets on the stems, using pets for chasing it, suspending the hives on top of trees not to be reached by the predator.
Birds	chasing with stones, putting a human like object in front of hives,
Varroa mites	Smoking tobacco leaves, removing the drone brood when the pest is occurred,
Spiders	Cleaning the hive areas, regular follow ups,

4.3. Honey Production and Management

4.3.1. Honey production

Due to the existence of diverse floral resources and successive flowering seasons, there is multiple harvesting seasons in the areas. The plant type and composition will vary based on the agro ecological variation; mostly the mid and highland areas have nearly uniform plant types and composition than low lands areas. As a result, the typical harvesting seasons and productivity will also varying based on agro ecological differences.

The major harvesting seasons for mid and high land areas will occur through April to May. However, it is considered as minor season for low land areas whose major harvesting season occurs from November to December which in contrast considered as the minor season for mid and high land areas. There are also other minor harvesting seasons, occurring during July, and January-February.

The major botanical origin for each harvesting seasons are *Schefflera abyssynica (April-May)*; *Croton microstachys (July)*; *Guizotia scabra* (Nov. - Dec.), *Vernonia species, Olea abyssinica, and Coffee arabica* (through January to February). As the majorities of beekeepers in the areas are using traditional log hives which is hung over long trees, it is not conducive for undertaking appropriate inspections and harvesting will takes place merely by splitting the hive (logs) into two parts after bringing the hive down to the ground using ropes. During harvesting, most of the beekeepers will remove the whole resources including honey, pollen, and broods by drawing the bees using smokes and storing the empty hives at a prepared place until next season will come. During which the hives will be prepared and hanged again mainly during February to March. However, some beekeepers will prepare or hanging empty hives adjacent/near areas before commencing to harvesting in order to make colonies entering into it after being drawn from old hives during harvesting.

With regard to harvesting frequencies, majorities, 133(74%) of the respondents will harvest once a year while 36(20%) of them harvest twice and 11(6%) trice and more (Figure 7).
As most parts of the country, the main purpose of beekeeping in the study areas is obtaining honey product which is used as an immediate income sources. However, they also keep

some amount of honey for home consumption which they use it as food, as medicinal purposes, as a gift to their relatives/families, for making local drinks, and for ritual ceremonies sharing 45%, 27%, 13.38%, 8.1%, and 5.63% respectively(Table 17). According to Takele Geta (2014), a considerable amount of honey will be stored for consuming during fasting as luxury food after fasting 12 hours during Ramadan as '*Fetira*', for consuming with other foods like bread as breakfast, consuming by diluting with water or other liquids, for consuming with local drugs for some specific diseases.

The result shows on average the beekeepers may keep 7.045kg of honey for consumption purposes. However, the amount will vary from 3 to 20 kg based on the amount of honey produced and the wealthy status of individual beekeepers (Table 17).

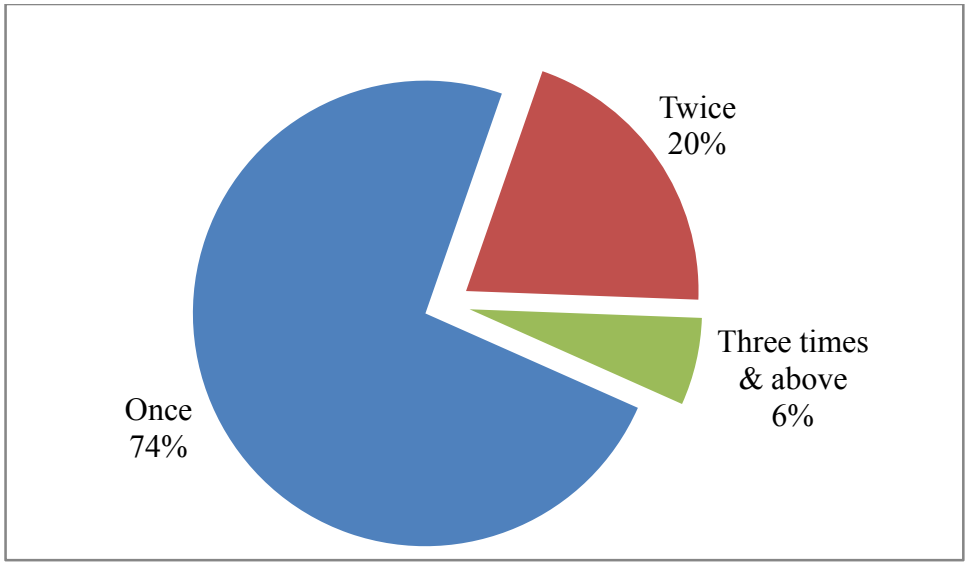

Figure 7. Honey harvesting frequencies

Table 17. Honey consumption in the study area

Parameters	**Variable**	**Frequency**	**%**
Do you consume honey	Yes	180	100
	No	-	-
How much you consume annually	Unknown	14	7.78
	≤5 kg	71	39.44
	>5-10kg	80	44.44
	>10-15 kg	9	5.00
	>15-20	6	3.33

	Mean±SD	Min	Max
	7.045±3.05 kg	3	20
Uses of Honey	As food	128	45.07
	As medicine	79	27.82
	As gifts	38	13.38
	For making local drinks (*'Tej', 'Birth','borde'*)	23	8.10
	For Ritual Ceremonies	16	5.63
Honey beyond consumption	Sale	171	95(1)
	Store	2	1.11(3)
	Both sale and store	7	3.89(2)

( ) denotes order of ranks

4.3.2. Honey processing

Processing of honey product is imperative to maximize the benefits incurred from beekeeping by obtaining additional incomes both from honey and beeswax. In the areas, about 93% of beekeepers sale their honey in crude form without any processing.

Of the total 477 zander model box hives counted during the survey, 293 or about more than 60% are constructed by local carpentries. Under such types of hives beekeepers do not use hive frames instead they use top bars and harvesting will takes place in the same manner as that of transitional hives. During the survey, a total of 49 individual beekeepers have been counted having a total of 184 modern/movable frame hives. However, only 7(14%) of whom can extract their honey product using honey extractor and the rest 42(86%) of them sell their honey in crude forms. Beekeepers strain their honey for the purpose of home consumption, selling and as gifts for their families accounting for 48%, 36% and 16% respectively. This indicates, the processing of honey at beekeepers level is not commonly practiced in the areas. lack of awareness (31.47%), considering as it will reduce the amount of honey (25%), lack of processing materials (22.94%), small production(13.24%) and consumers preferences(7.35%) are listed to be the major reasons for not processing their honey products (Table 18).

According to Birhanu Tesema (2016), lack of straining materials and skill (49%), Lack of knowledge as how to strain (36%), Consumers preference (23%) were reported to be the

major constraints for processing of honey at Guji Zone. On the other study by Addisu Bihonegne *et al.*(2017), lack of awareness (66.67%), lack of materials(51.85%), consumers' preference (24.44%), small production (1.48%) and considering as it will reduce the amount of honey yield (0.74%) are reported to be the major reasons for not processing honey products in South Wollo Zone. Similarly, study by Biressaw Serda *et al.* (2015) also indicated that considering as it will reduce the amount of honey (55%), Lack of materials (24.5) and lack of knowledge 20.5 % were listed as the core reasons for not straining honey in Haramaya District.

Table 18. Honey processing

Parameters	**Variable**	**Freq.**	**%**
Do you strain honey from traditional and transitional /frameless box hives?	Yes	12	6.67
	No	168	93.33
Purposes of straining honey?			
For home consumption		12	48
For sale		9	36
For family gifts		4	16
Materials used for straining			
	Honey presser	10	83%
	Sieves	2	7%
Reasons for not straining	Lack of awareness	107	31.47(1)
	Lack of materials	78	22.94(3)
	Consumers preference	25	7.35(5)
	Reduces the amount of honey	85	25.00(2)
	Small production	45	13.24(4)
Do you use honey extractor for movable frame hives?	Yes	7	14.29
	No	42	85.71
Total respondents who have moveable frame hives		49	100

( ) denotes ranks of reasons for not straining honey

4.3.3. Honey storage and marketing

The majorities, 122(67.78%) of producers sale their honey products within a short period of times which is less than three months. Whereas 58(32.12%) of them practice storing their honey. Of whom, 43(23.89%) storing for 3-6 moths, 13(7.22%) for 6 months to 1 year and 2(1.11%) for 1 to 2 years. According to Chala Kinati *et al.* (2012), about 75% of beekeepers in Goma district will sale their honey product with in 1 to 6 months and only 1.7% of them

will store for more than two years. Similarly, Yetimwork Gebremeskel and Desalegne Begna (2015) reported that 51% of beekeepers in Eastern Tigray practice storing their honey. Of whom, 14.7% will store for 3 months; 15.4% for 4 to 6 months and 21.2% for 4-6 months. On the other study by Addisu Bihonegne *et al.*(2017), a total of 35.34% beekeepers store honey with storing time of three months, (9.02%) for 3-6 months, (19.55%) for 9 months to one year, and (6.77%) for 1 to 2 years were reported in South Wollo Zone. This indicates storing honey for extended time is not common in the country and it is mostly used as immediate income sources for most beekeepers.

According to the response of most beekeepers, staying honey for extended times will result for additional income losses as it is difficult to avoid consumption once the honey is in home and they needing it to earn immediate incomes. Similarly, BfD (2006) also declared that as honey is produced by most vulnerable households, about 87% of the beekeepers are basically aimed with fulfilling their instant income needs such as school fees, medicines, family clothes, taxes and other expenses. Putting this into account, the sale of honey crop provides enough incomes to buy about 20% of the annual cereal consumption of a five member household (Worku Abebaw, 2010).

Beekeepers in the study area use various containers for storing and transporting their honey product. The major materials identified during the survey were; fertilizer bag, Plastics, clay pots, stainless steel and barrel sharing 55.15%,36.60%,4.12%,2.58% and 1.55% respectively(Table 19 and Appendix picture 2).

In the areas, honey is marketed at districts, at villages, house gates and Addis Ababa sharing 63.97%, 23.16%, 12.87% and 0.83% respectively (Table 19). The door to door marketing is under taken by honey collectors who will collect honey and supplying for local retailers, local mead houses and whole sellers. The whole sellers are those who conveying honey to big cities like Addis Ababa, Jima and Mizan.

The average distance travelled by beekeepers for marketing is 7.23 km ranging from 0 to 27 km. Even though, honey is marketed throughout the year, the majorities, 158(58.30) of

beekeepers will sale during April to June. Whereas, 53(16.31%), during January March, 47(17.34%) during July to September and 13(3.80%) during October to December.

The price of honey is significantly varying based on districts, its' processing level and seasons. Accordingly, Gesha district has significantly lower honey prices than Chena and Gimbo districts. However, there is no significant price variation between Gimbo and Chena districts. The crude comb honey has significantly higher price than the chopped comb. However, sell of extracted honey is not practiced by most beekeepers of the areas. Due to the shorter time storage practices of honey products by most beekeepers, presumably scarcities will occur during off seasons (July-September and January-February) resulting for noticeable price fluctuations.

The mean annual price for crude honey and processed honey of the area is 46.28±9.37 and 68.33±11.33 respectively. Whereas, the mean is aggregate annual prices for crude and extracted honey is 58.65±15.18, 62.67±16.38 and 50.57±11.38 for Chena, Gimbo and Gesha districts respectively. The overall price of honey in the study areas is 56.88±15.09 ETB (Table 19).

Even though the marketing chains of honey in the study areas seems complex, the major buyers of honey from the producers are retailers, cooperatives, local consumers, *'tej'* houses and Apinec agro industry(PLC) sharing 41.29%, 30.98%, 20.97%, 4.19% and 2.58% respectively.

In the study districts there are two cooperatives found Chena and Gesha districts which were recently established and engaged in collecting the crude honey from its 'member beekeepers, processing and conveying the honey and wax products to the Union (Kafa forest bee products development and marketing Union). The cooperatives will pay to its members based on the amount of honey they supplied and immediate payment will be under taken based on the current market prices of honey. However, they may earn additional incomes from the final sells of honey and beeswax products. The cooperatives will also providing credit services, input facilitation and trainings for its member beekeepers.

Table 19. Honey marketing

Districts	Price for Crude honey (ETB)		Price for Extracted honey (ETB)		Overall	Range
	Mean±SD	range	Mean±SD	range		
Chena	48±10.10[b]	(35-65)	70.22±10.60[b]	(55-90)	58.65±15.18[b]	(35-90)
Gimbo	50±9.06[b]	(40-65)	75.71±11.32[b]	(60-100)	62.67±16.38[b]	(40-100)
Gesha	41.48±6.77[a]	(30-55)	60.40±6.11[a]	(50-70)	50.57±11.38[a]	(30-70)
Total	**46.28±9.37**	**(30-65)**	**68.33±11.33**	**(50-100)**	**56.88±15.09**	**(30-100)**
Distance traveled (Mean±SD) from local markets					**7.23± 8.79**	**0 - 27**

Parameter	**Variables**	**Freq**	**%**
Major buyers	Retailers	128	41.29
	Local consumers	65	20.97
	Apinec	58	18.71
	Cooperatives	46	14.84
	'*Tej'* houses	13	4.19
	Total	310	100
Places of marketing	District towns	118	49.17
	Village markets	85	23.16
	House gates	35	12.87
	Addis Ababa	2	0.83
	Total	240	100
Storage times	less than 3 months	122	67.78
	3-6 months	43	23.89
	6 months-1 year	13	7.22
	1to 2 years	2	1.11
Storing materials	fertilizer bag (food graded)	107	55.15
	Plastics	71	36.60
	Barrel	3	1.55
	Tin-cans	5	2.58
	Clay pots	8	4.12

*Letters with different superscripts with in column indicates significant variation of honey prices among districts.

4.4. Beeswax Production, Quality and Marketing

4.4.1. Uses of beeswax in the study areas

Beeswax has a numerous economic benefits worldwide particularly in industrially developed countries for making various products. However, in developing countries like Ethiopia its benefit is limited to only local purposes (Aravindakshan *et al.,*2010). In the

country, the greater amount of beeswax is used for making traditional '*tuaf'*/candles which has been used for daily ceremonies for Ethiopian Orthodocs churches. In the study areas, beeswax has been used for smoking bait hives, candle/'*tuaf*' making, smearing top bars for making foundation sheets and for baking '*enjera*'/'*masesha'* sharing 58.19, 9.91%, 7.76%, 3.02%, 5.60 respectively (Table 20). A considerable number (about 15.52%) of individuals do not know any values of the beeswax and mostly discarding it as byproducts.

Table 20. Major uses of beeswax in the study areas

Uses of Beeswax	**Freq**	**%**
To smoke bait hives	135	58.19
For making foundation sheets	23	9.91
For making candle or '*Tuaf*'	18	7.76
For baking '*injera'/'Masesha'*	7	3.02
For Smearing top bars	13	5.60
Don't know any values	36	15.52
Total	232	100

4.4.2. Beeswax collection and production

In the areas, of the total 180 respondents, only 24(13.33%) of them are practicing collection of beeswax from absconded, broken and discarded combs, empty combs during harvesting, from honey extraction and left over after consumption of crude honey and from '*tej'* houses sharing 41.38%, 29.31%, 22.41%, 5.17% and 1.72% respectively (Table 21). Lack of awareness, small production, market problems, lack of processing skills, Lack of processing materials, lack of knowhow about its economic benefits and lack of interests are the major constraints for beeswax collection in the study areas sharing 26.35%, 22.25%, 18.14%, 12.53%, 10.15%, 7.78% and 2.81% respectively(Table 21).

The current result is similar to the result of Haftu kebede and Gezu Tadesse (2014), who stated that none of the beekeepers in Hadiya zone collect the crude beeswax due to lack of awareness about the product (39.2%), lack of beeswax market (21.5%), lack of processing skill (20.8%) and processing materials (18.5%).

Similarly, Addisu Bihonegne *et al.* (2017) also reported that lack of awareness (80%), knowledge gap about its economical benefits (59.17%) and market problems (55.83%) are considered as major constraints of beeswax production in South Wollo zone. On the other study by Biressaw Serda *et al.*(2015) indicated that lack of knowhow (77.7%), lack of processing skills(12%), lack of processing materials (9.6%) and lack of markets(5.3%) are reported to be the core problems for the collection of Beeswax in Haramaya District, Eastern Ethiopia.

Table 21. Beeswax collection in the study areas.

Parameters	**Variables**	**Freq**	**%**
Do you collect beeswax	Yes	24	13.33
	No	156	86.67
If yes, from where you collect			
From Absconded colonies		24	41.38
From broken, discarded/old combs		17	29.31
Empty combs during harvesting		13	22.41
leftovers after consuming the honey		3	5.17
Collection from '*tej*' houses		1	1.72
Total		58	100
If No, why?			
Small production		103	22.25(2)
Lack of processing skills		58	12.53(4)
Lack of processing materials		47	10.15(5)
Lack of market		84	18.14(3)
Lack of awareness		122	26.35(1)
Lack of knowhow about its economic value		36	7.78(6)
Lack of interests		13	2.81(7)
Total		463	100

( ) indicates ranking of reasons for not collecting beeswax

4.4.3. Beeswax processing and storage.

The beeswax should be processed as soon as possible after collection and be stored in clean, cool and dry places in wrapping papers, on shelves or in containers made of stainless steels, glasses or plastics for best preservation of its colour and aroma (Bogdanov, 2004b, KEBS, 2013).

From the total of 24 individuals who collect the beeswax in the study areas, only 7(29.17%) of them practicing processing/purifying the beeswax. The rest 17(70.83%), do not undertake

any processing practices and merely using the crude waxes for local purposes mainly for smoking bait hives.

The beekeepers were also asked about what to do with the processed beeswax, accordingly, they use for selling, making foundation sheets and smearing top bars sharing 20%, 30% and 50% respectively(Table 22).

The ways and times of storages for both processing and non processing beekeepers were assessed. Accordingly, the ways of storages is significantly varying between the wax processers and non processers. With this regard, beekeepers those do not process the beeswax do not bother about the ways of its storages as it is only used for local purposes.

However, beekeepers engaged in processing beeswax will bother about its means of storages and times of storages. According to the discussion made with beekeepers regarding the storage mechanisms, they store it for shorter times with curiously before processing and storing longer after processing by forming it in block form.

Beekeepers can apply various storage mechanisms and materials to protect the deterioration of beeswax. Accordingly, 50% of whom keep the beeswax at aerated places without any materials, 29.17% using fertilizer bag, 16.67% storing in any materials and 4.17% using plastics (Table 22).

Wax moths are the major threats for beeswax production by distracting the beeswaxes within a short period of times up on storages. Wax moths can be prevented by immediately melting the raw wax and storing in cool, light and airy places, treating with *Bacillus thuringiensis,* sulphur, acetic acids and formic acids (Bogdnov, 2016a).

According to the survey results, beekeepers in the study areas will reduce the wax moth attacks by placing the wax in aerated places, immediately processing the crude wax and periodically soaking in the water to kill the moths' larvae. Whereas, adding table salt (NaCl) is also practiced by some *'tej'* houses to prevent wax moth attacks.

Table 22. Beeswax processing and storages for beekeepers processors

Beeswax processing methods	Freq	%
Sack extraction	7	29.17
No processing	17	70.83
Total	24	100
What do you do with the processed beeswax?		
Selling	2	20
For making foundation sheets	3	30
For smearing top bars	5	50
Total	10	100
How long you store your beeswax?		
1. For Beekeepers		
Storing up to one week before processing and for up to two years after processing and molded	1	4.17
Storing up to two weeks before processing and for unlimited times if kept in aerated place after processing in block form	3	12.50
More than two months before processing and for unlimited times if placed in aerated places and periodically soaked in water to kill the moth	2	8.33
Storing up to one month before processing and up to 2-3 years after processed /molded/	1	4.17
For more than two years without processing	2	8.33
I don't know	1	4.17
For one year without processing	4	16.67
Immediately using for smoking hives	10	41.67
Total	24	100
2. For processors		
For up to one week before processing and up to 3 months after processing and molded	1	50
From 1 to 2 weeks before processing and 0.5-1 year after processing	1	50
Total	2	100
Materials used for storing beeswax		
1. For Beekeepers		
Fertilizer bag	7	29.17
Keeping at aerated places without containers	12	50.00
Plastics	1	4.17
Any materials	4	16.67
Total	24	100
2. For processors		
Fertilizer bag or sacks	1	25
Putting at aerated and clean rooms	2	50
Wrapping with plastics	1	25
Total	4	100
Source of beeswax for movable frame hives		

Agricultural office	2	4.08
Own sources	4	8.16
Own and agricultural office	1	2.04
No use of wax for frame hives	42	85.71
Total (having frame hives)	49	100

4.4.4. Beeswax adulteration

Adulteration or mixing of beeswax with other foreign materials such as animal tallow, candles, are thought to be a serious and cross cutting issues that deteriorating the quality status of beeswax product in the country (Nuru Adgaba, 2007b; Gemechis Legesse, 2014; Meseret Gemeda and Taye Negera, 2017).

According to the discussion made with beekeepers regarding the quality aspects of beeswax in the study areas, 97.22% of the respondents replied they do not heard/encountered with any adulteration of beeswax. However, few 2.78% of them replied that rarely there is a case of adulterated beeswax which is distributed by Agricultural office and at local '*tej*' houses.

According to their responses, rarely some '*tej'* houses will mix beeswax with '*kocho'* (a local food prepared by scraping the stem of *Enset vetricosum plant* by masking in wax blocks to obtain additional incomes by increasing its volume and weights. They mix the '*kocho'* in small amount which is not more than 1 to 4 ratios as it is easily identified by its odor if the amount is more. The beekeepers can easily identify the beeswax obtained from such adulteration by its odor (has pungent smell) and by its uniformity up on checking by breaking the wax blocks. However, mostly they may sale it for traders coming from far areas who may not know the case and checking up. Adulteration of beeswax with '*kocho'* is simply under taken by masking/hiding the '*kocho*' within wax blocks immediately after extraction.

Table 23. Adulteration of beeswax in the study areas.

Is there a wax adulteration practice in your areas?	**Freq**	**%**
Yes	5	2.78
No	175	97.22
Who are adulterators?		

'Tej' houses	2	28.57
Merchants from other areas	5	71.43
Total	7	100
Adulterants used		
'Kocho'/enset (i.e. for '*tej' houses)*	2	28.57
Animal tallow, candles (for merchants)	5	71.43
When adulteration does occur?		
Has no specific times (for '*tej'* houses)	2	100
Some times when wax is bought by agricultural offices, /NGOs from big cities.	5	100
Ways of mixing adulterants		
Mixing the '*kocho'* after extracting the wax (for *tej* houses)	2	100
I don't know (for wax from other sources)	4	80
Melting and mixing (for wax from other sources)	1	20
How do you identify the adulterated wax?		
lacks uniformity, bees do not visit (for '*tej'* houses cases)	2	100
Bees do not visit (for both cases)	5	100
Sticking to wax molding (for wax from other sources)	1	20
Has pungent smell (for '*tej'* houses cases)	2	100

4.4.5. Beeswax marketing

Beeswax is a commodity with prestigious international market value that can be economically beneficial and with pro-poor credentials (BfD, 2006). Of the total 180 respondent beekeepers who are interviewed during the survey, only two individual beekeepers are engaged in processing beeswax for marketing purposes.

They collect the crude beeswax from extracted honey, old combs and empty combs during harvesting, discarded combs from around and from left over after the consumption of crude honey. They regularly processing and depositing the wax and selling after certain months when the required amount is gained.

According to their responses, lack of regular market access is the core problem to be engaged in it and maximizing their production levels. As a result, they sell their processed beeswax by periodically transporting to central markets (Addis Ababa). Annually, they may process from 30-50 kilograms of wax block. This implies the processing and marketing of beeswax product

is not common at beekeepers levels. However, '*tej*' houses are the major sources of crude beeswaxes /'*sefef*''and marketing takes place.

According to various researchers declared that '*tej'* houses are the only major sources of beeswax in the country where the product is readily available almost throughout the years (Hartman, 2004; Johannis Agonafir, 2005; Ayalew Kasaye, 2008; Aravindakshan *et al*, 2010).

According to the discussion with '*tej'* houses, there is no formal marketing for beeswax/'*sefef*". However, there are peoples who are coming from other areas and collecting the crude/'*sefef*' and semi processed beeswax from '*tej'* houses in the areas and trading to central markets. They do not have strong market customary linkages with wax collectors and they do not have specific times for collections. The prices for one kilogram of wax is ranging from 25 to 40 ETB for crude wax/'*sefef*" and 70-100 ETB for extracted wax which is in block form. Unlike the honey, the price for beeswax does not have significant variations based on seasons and study districts. Cooperatives are the other actors who are engaged in processing and marketing of beeswax in the study areas.

Apinec agro industry is a private limited company which collects the crude honey from the producers of the areas including from Sheka zone and its own apiaries; extracting and selling the purified beeswax in form of blocks or by preparing foundation sheets. Unlike other processors taking part in production, processing and marketing of bee products, Apinec has better potentialities having modern processing machines using for extracting wax and preparing foundation sheets and has its own mini laboratory to check the qualities of honey products which is going to be packed and sent for central/export markets.

The cooperatives which are established at each district will provide the processed beeswax and crude honey to the union (Kafa Forest Honey Development and Marketing Union) whose seat is at zone level and compiling honey and beeswax from the cooperatives and conveying to central and export markets.

4.4.6. Challenges and opportunities of beeswax production and marketing.

The area has huge untapped potentiality for beeswax production. The dominant traditional ways of beekeeping (using traditional hives), existence of honey and beeswax marketing union which has long term planning to establish cooperatives at each district and existence of private limited processing industries (Apinec agro industry) are considered as the golden opportunities for the production and marketing of beeswax. However, the current production and marketing status of beeswax is very limited compared to the potentials of the areas. Lack of regular buyers (24.38 %), knowledge gaps about its economic values (19.38%), Lack of market information (18.13%), lack of trainings and technical supports (11.88%) skill and Knowledge gaps about product handling (12.5%) and low prices (10.33%) are considered as the core constraints of beeswax production and marketing at beekeepers level (Table 24).

Whereas, shortages of supplies, sustainable market accesses, shortages of processing materials and storage facilities are identified as the core constraints of beeswax production and marketing at processors levels.

McGill (2016) also stated that despite the efforts done by government and other entities in trying to incentivize beeswax production in the country, lack of market accesses is one of the most striking constraints for those who engaged in production.

According to the responses of processors (cooperatives and Apinec), most of the beekeepers have more willingness to be registered as a member of enterprises basically in search of various supports. However, there is a great awareness problem in providing their products to the enterprises.

Table 24. Major challenges of beeswax production and marketing in the study areas

Major challenges of beeswax marketing	**Freq**	**Percentage**	**Ranks**
Lack of regular buyers	78	24.38	1
Lack of market information	58	18.13	3
Knowledge gaps about its economic values	62	19.38	2
Skill and knowledge gaps about product handling	40	12.5	6
Low prices	38	10.33	7
Lack of training and other supports	44	11.88	5
Total	320	100	

4.5. Laboratory Analysis of Beeswax

The physico-chemical quality analysis including melting points, refractive index, Ash contents, total volatile matter, acid values, ester values, saponification values, paraffin and other waxes, fats and fatty acids was under taken collecting the wax samples from '*tej'* houses, fresh combs, old combs and processors in the study areas.

4.5.1. Melting point

The melting point is one of the most important quality parameters used to detect the adulteration of beeswax. The melting point of beeswax is the temperature record at which the first drop of beeswax appears up on heating. The overall melting point of beeswax (Mean±SD) in the study area is measured to be 62.35±0.76, which is ranging from 61 to 64 ^{o}C. It is found within an acceptable range of national standards (61-66^{o}C) as well as Kenyan, Tanzanian and European standards (Table 28). The melting point of the beeswax in the study areas does not have significant variation among the study districts as well as its sources at $P<0.05$(Table 26 and Table 27).

4.5.2. Refractive Index, at 75^{o}C

The refractive index of a substance is the ration of velocity of light in the air to that of an object/substance. It is measured by an apparatus called Refractometer. The refractive index of the beeswax in the study areas is found to be 1.4416±0.0005, ranging from 1.4409 to 1.4427. It satisfies the national standard which is in between 1.4400 to 1.4450.the refractive index of the wax in the study areas does not have significant variation based on the study districts (Table 26). However, there is a significant variation based on its sources at $P<0.05$ (Table 27). Accordingly, significantly higher refractive index value was recorded on beeswax sourced from '*tej*' houses. This might be due to the some impurities found in waxes from '*tej*' houses due to contaminations with dusts or other impurities (Appendix picture 1).

4.5.3. The ash content, % by mass, max.

The ash is a mineral content of the product measured by weighing the residue after ignition in muffle furnace at 550 to 650 ^{o}c. The ash content is used to determine either the wax product is contaminated with soils and other impurities or not. The ash content of beeswax produced in the current study areas in found to be 0.0857±0.0744, ranging from 0.0115 to 0.2354(Table 25). It is within a range of acceptable national standards (0.2 %). The ash content of the wax in the study area is significantly varying based on its sources at $p<0.05$. Accordingly, the wax sample from '*tej'* houses has significantly higher ash contents than wax sourced from fresh combs, processors and old combs (Table 27). This might be due to the fact that waxes in *'tej'* house are highly prone for contamination with soils or other impurities during storages and processing. Similarly, higher ash contents, 0.051was recorded from wax samples collected from *tej* houses found at different regions of the country (Oromia, Amhara, Tigray and SNNPR)(Yeshitela Eshete *et al.,* 2018). The current result is somehow greater than the ash content report from South Wollo zone which is reported to be 0.0345(Addisu Bihonegne *et al.*, 2017). The higher ash content might be resulted from the addition of table salt on beeswax at '*tej'* houses as a preservation mechanism from wax moth attacks and the difference in management of beeswax.

4.5.4. Total volatile matter, % by mass, max.

The total volatile matter in beeswax includes all substance other than moisture which is lost in the form of vapor during combustion in dry oven. The maximum limit for acceptable total volatile matter of beeswax in Ethiopian Standard is 0.75. The total volatile matter for beeswax in the current study is found to be 0.4156±0.1924 ranging from 0.1919 to 0.8721(Table 25).

The current result revealed that the total volatile matter of beeswax in the study areas is within an acceptable range of national standard. Similar results 0.3335 and 0.5491were obtained by Bekele Tesfaye *et al.* (2016) and Addisu Bihonegne *et al.* (2017) respectively. The total volatile matter of the beeswax has no significant variations among districts (Table 26). However, there is significant variation between sources. Accordingly, the beeswax

sampled from '*tej'* houses has significantly higher value (0.6265) of total volatile matters than other sources (Table 27). Similarly, higher total volatile matter 0.8077 and 1.5 were obtained from '*tej*' houses by Addisu Bihonegne *et al* (2017) and Yeshitela Eshete *et al.* (2018) respectively. The higher total volatile matter at '*tej'* houses might be due to its mishandling or exposing for prolonged sun lights during storages.

4.5.5. Acid value, max.

The acid value in beeswax is determined by measuring the amount of KOH consumed to neutralize the free acids in 1gram of wax sample. The acid value (Maen±SD) of the beeswaxes in the study area is 22.689±1.857 which ranges from 18.894 to 26.361(Table 25). The obtained result shows it falls within the acceptable national and international ranges (Table 30). Similar acceptable range of acid values 21.66±2.26, 22.33±0.39 and 18.92±2.7735 were reported by Nuru Adgaba (2007b); Bekele Tesfaye *et al.*(2016) and Addisu Bihonegne *et al* (2017) respectively. The acid value does not have significant variation based on the source and study districts, at $P < 0.05$ significance levels (Table 25 and 26). According to Nuru Adgaba (2007b), of the total 75 beeswax samples collected from various actors, 8 of which were failed to meet the required standards. Of which, 3 of them were from intermediary collector and the rest 5 were from final processors and exporters.

4.5.6. Saponification cloud point, min, (mg KOH/g)

The Saponification cloud point is the amount of Potassium Hydroxide (KOH) needed to hydrolyze a 1g of sample beeswax. It is one of the simple and best parameters used to detect the adulteration of beeswax. However, the method is limited to detecting quantities greater than 1 % of high melting point (80-85°C) paraffin waxes, or more than 4-5 % of low melting (50-55 °C) paraffin (Bonvehi and Bermejo, 2012). The mean saponification cloud point of the wax in the study areas is 94.7540±4.2214 mg KOH/gm; ranging from 82.1233 to 102.1266 mgKOH/g (Table 25). Similar acceptable results; 98.04±0.86, 91.19±22.3015 and 93.6 were reported by Bekele Tesfaye *et al* (2016) and Addisu

Bihonegne *et al* (2017) and Yeshitila Eshete *al.*(2018). It is found to be non significant variations among districts and sources of samples (Table 26 and 27).

4.5.7. Ester value, (mg KOH/gm)

Ester value is a measure of Potassium Hydroxide (KOH) required to saponify the ester in 1g of wax sample and also determined by calculating the difference between saponification value and acid value. The variation in ester value of beeswax would be resulted from the extent of prolonged heat exposures of the wax (Nuru Adgaba, 2007b).

The mean ester value of wax samples of the study areas is 72.065±4.273 ranging from 67.9702 to 83.233(Table 25). Similar results which are within acceptable ranges (70-79) were recorded by Addisu Bihonegne *et al* (2017); Bekele Tesfaye *et al.* (2016) and Nuru Adgaba (2007b).

The mean ester value of the beeswax of the area does not significantly varying among study districts at $p<0.05$. However, the ester value of beeswax sourced from '*tej'* houses has significantly lower values than fresh combs, old combs and processors. The result obtained from current study satisfies both the national and international standards.

4.5.8. Ester to acid ratio

The ester to acid ration is a value obtained when the ester value is divided by its acid value. It indicates that whether the wax is stayed for longer or not; as the storage time is increased, the ester value will be decreasing gradually (Tulloch, 1980). It is not taken as a major quality parameter in Ethiopia and has no acceptable quality ranges. However, according to Kenyan standards, an acceptable ester to acid ratio should be 3 to 4.3(KBS, 2013). According to the current result, the ester to acid ratio of the study areas is 3.201 ranging from 2.493-4.405(Table 25). Equivalent results 3.38 and 3.7995 obtained by Bekele Tesfaye, 2016 and Addisu Bihonegne, 2017 respectively. The beeswax sampled from '*tej*' houses has significantly lower values of ester to acid ratio at $p<0.05$ than fresh combs, processors and old comb sources. This might be resulted from the prolonged stays of crude beeswax at '*tej'* houses with less management. Sometimes it is purposively exposed to

sunlight in order to reduce wax moth attacks. However, there is no significant variation of ester to acid values among districts (Table 26).

4.5.9. Paraffin and other waxes

The paraffin and other waxes indicate the contamination or adulteration of natural beeswax with other waxes sources. According to the test result for paraffin and other waxes, all the samples collected in the study areas have passed the test that the liquid become cloudy at a temperature lower than 61^0C.

Table 25. Physico chemical quality characteristic of beeswax in the study areas

	Sample (N = 24)	
parameters	**Range**	**Mean ±SD**
Melting point (^{0}c)	61.00 – 64.00	62.35±0.76
Refractive Index	1.4409-1.4427	1.4416±0.0005
Ash content (% by mass)	0.0115-0.2354	0.0857±0.0744
Total volatile Matter (% by mass)	0.1919-0.8721	0.4156±0.1924
Acid value	18.894-26.361	22.689±1.857
Saponification value (^{0}c)	82.1233-102.1266	94.7540±4.2214
Ester value	67.9702-83.233	72.065±4.273
Ester to Acid ratio	2.4930-4.405	3.201±0.376
Fats and Fatty acid	-	Passed
Paraffin and other waxes	-	Passed

Table 26. Mean comparison of physicochemical qualities of beeswax by districts

Parameters	Districts (Mean±SD)			
	Chena (N= 9)	Gimbo (N=8)	Gesha (N=7)	Overall (N=24)
Melting point	62.17±0.75	62.63±0.69	62.29±0.86	62.35±0.76^{NS}
Refractive Index	1.4416±0.0006	1.4415±0.0004	1.4417±0.0005	1.4416±0.0005^{NS}
Saponification Value	95.397±2.00	93.939±5.712	94.858±4. 837	94.754±4.221^{NS}
Acid Value	23.034±1.597	22.515±2.236	22.443±1.921	22.689±1.857^{NS}
Ester value	72.363±2.333	71.425±4.227	72.414±6.408	72.065±4.273^{NS}
Easter to Acid Ratios	3.158±0.282	3.192±0.278	3.268±0.581	3.201±0.376^{NS}
Total Volatile matter	0.4080±0.1905	0.4288±0.2293	0.4156±0.1783	0.4156±0.192^{NS}
Ash Content	0.0809±0.0734	0.0811±0.0631	0.0970±0.0969	0.0857±0.0758^{NS}

Table 27. Mean comparison of physicochemical properties of beeswax by sources

Parameters	Sources (Mean±SD)				
	Fresh combs; N=9	'*Tej*' houses ; N=8	Processors; N=2	Old combs; N=5	Overall
Melting point	62.33±0.61	62.38±1.03	62.75±1.06	62.2±0.57	62.35±0.76^{NS}
Refractive Index	1.4413±0.0003^{b}	1.4421±0.0003^{a}	1.4413±0.0002^{b}	1.4415±0.0005^{b}	1.4416±0.0005
Saponification Value	96.7403±3.4423	91.3960±4.7406	95.6710±1.8776	96.1847±2.0365	94.7540±4.2214^{NS}
Acid Value	21.869±1.732	23.199±2.153	21.868±0.897	23.067±1.383	22.689±1.857^{NS}
Ester value	74.872±3.946^{a}	68.197±3.574^{b}	73.803±0.981^{ab}	72.508±1.358^{ab}	72.065±4.273
Easter to Acid Ratios	3.451±0.4242 ^{a}	2.958±0.261 ^{b}	3.377±0.094 ^{ab}	3.071±0.193 ^{ab}	3.201±0.376
Total Volatile matter	0.3334±0.0733^{b}	0.6265±0.1917^{a}	0.3168±0.0058^{b}	0.2658±0.2556^{b}	0.4156±0.1924
Ash Content	0.0224±0.0068^{b}	0.1450±0.0533^{a}	0.0133±0.0025^{b}	0.1335±0.0744^{ab}	0.0857±0.0744

Notice: - Letters with different superscripts within a row are significantly difference among sources (P<0.05), N= Number of sample, SD= Standard Deviation, NN=Non significant

Table 28. The mean comparison of wax quality of the study areas with national and international standards

Characteristics/Specification	**Current study result (Mean ±SD)**	**Ethiopian Standard** (ET 1203/2005)*	**Kenyan Standard** (CD /05-1279:2013) **	**Tanzanian Standard** (TBS/ AFDC 17/4049)***	**European Pharmacopeias** (ET 1203/2005) *
Melting point, ^{o}C	62.35±0.76	61 – 66	62 - 65	62 - 65	61 - 65
Refractive index, at 75^{o}C	1.4416±0.0005	1.4400-1.4450	1.4398 -1.4455	1.4398 – 1.4455	1.440-1.4450
Ash, % by mass, max.	0.0857±0.0744	0.20	0.6	0.6	-
Tot. Volatile matter, max	0.4156±0.1924	0.75	-	1	-
Acid value, max	22.689±1.857	17-24	17-24	17-24	18-23
Saponification value, min.	94.754±4.2214	85-105	-	87-104	87-104
Ester value	72.065±4.273	70-80	70-79	70-79	70-80
Ester to Acid ratio	3.201±0.376	-	3.0 - 4.3	-	-
Fats and Fatty acids	Passed	To pass test	To pass test	To pass test	-
Paraffin and other waxes	Passed	To pass test	To pass test	To pass test	Absent

Notice: - N=Number of sample, SD= Standard Deviation, - = not available; Source:- * (QSAE, 2005), ** (KBS, 2013), *** (TBS, 2010)

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

5.1. Conclusions

- In the areas, four types of beekeeping systems (traditional forest, traditional back yards, transitional and improved /modern system) identified.
- In related to the abundance of huge natural resources, beekeeping is widely practiced by most rural inhabitants of the areas serving as a major income sources for most small scale individuals. However, majorities of the colonies are managed in traditional forest beekeeping system resulting for minimum number of females enrolled in the beekeeping.
- Swarm catching is a common practice for both obtaining foundation colonies as well as increasing the stock numbers.
- The local retailers, whole sellers, *'tej'* houses, cooperatives, local collectors, Private Companies, are identified to be the major honey and beeswax market chain actors in the areas. However, '*tej* 'houses and cooperatives are identified to be the major actors taking part in processing and marketing of beeswaxes product.
- Irrespective of the hive types used, honey harvesting is commonly undertaken by cutting the combs from the hives or frames and about 93% of the beekeepers sell their honey in crude forms due to lack of awareness, considering as it will reduce the amount of honey yield, lack of processing materials and small production. Moreover, straining of honey from the movable frame hives and use of foundation sheet is practiced only by few beekeepers (i.e. about 15% of those who have moveable frame hives).
- About 68% of the respondents sell their honey products immediately after harvesting less than three months of stays.
- Of the total respondents, only about 13% of them are engaged in collection of beeswax from old combs, broken combs, '*tej'* houses and leftovers after the consumption of crude honey and the rest 87% of them will waste it as a byproduct due to lack of awareness, small production, lack of markets, lack of processing skills, lack of processing materials, lack of knowhow about its economic benefits and lack of interests.
- According to the laboratory results, all the beeswax samples in the area taken from different sources('*tej'* houses, honey combs, old combs and processors) have fulfilling

the acceptable range of both national and international standards in all parameters which indicates the beeswax product in the study areas is very natural.

5.2. Recommendations

According to the present study findings, the following points can be forwarded and recommended:

- Awareness creation on the economic benefits of beeswax, training on the production, processing and handling of bee products is crucial.
- Even though the area is endowed with huge colony numbers, there is a huge economic loss due to the highly absconding and swarming nature of honeybees in the areas. However, it could be enhanced through selection and rearing of queens with desirable productive traits.
- Establishing and capacitating the cooperatives at local level is very important to handle wastages of the product as well as maximizing their profits through minimizing the market dominance by middle men.
- Encouraging agents or investors to intensively participate in production, processing and trading of beeswax is warranted so as to exploit the huge potentialities of the area.
- Introducing and demonstrating of some robust beeswax processing technologies.
- The majority of the beekeepers in the area are harvesting only once a year. However, existence of huge and diverse floral species flowering at different seasons are considered as a golden opportunity to have multiple harvesting seasons by under taking apt colony managements.
- The ways of managing beeswax in general and '*tej*' houses in particular is very poor which is prone for contaminations and some intentionally added wax preservatives (*NaCl*) might have also its own impacts resulting for some deviations in some parameters from natural qualities. Hence, awareness creation and follow-ups on appropriate management aspects of beeswax products should be given for '*tej'* house owners' indeed.
- The inclusion rates of preservatives (NaCl) on the quality of beeswax need further investigation.

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APPENDIXES

LISTS OF APPENDIX TABLES

Appendix tables 1. Laboratory results of beeswax samples for each parameter (mean value)

		Parameters							
Districts	**Sources**	**MPt**	**RI**	**SV**	**AV**	**EV**	**TVM**	**Ash**	**E/A**
Chena	HC	62	1.4409	94.4532	22.34	72.1132	0.1919	0.0163	3.2279
Gimbo	HC	62.5	1.4412	96.2536	21.002	75.2516	0.4567	0.0198	3.5831
Gesha	HC	61	1.4414	102.1266	18.894	83.2326	0.2669	0.0330	4.4052
Gimbo	HC	63	1.4415	92.4523	20.044	72.4083	0.3425	0.0324	3.6125
Chena	TH	62	1.4421	93.2356	22.321	70.9146	0.7589	0.2012	3.1770
Chena	OC	61.5	1.4413	97.4780	24.003	73.475	0.3325	0.0916	3.0611
Chena	OC	62	1.4423	93.7011	23.441	70.2601	0.2832	0.1895	2.9973
Chena	HC	62.5	1.4416	97.2378	23.501	73.7368	0.3876	0.0150	3.1376
Gimbo	TH	62	1.4418	89.9812	22.011	67.9702	0.8721	0.1463	3.0880
Gimbo	TH	62	1.4421	95.4532	24.304	71.1492	0.6717	0.0845	2.9275
Gesha	HC	62	1.4412	91.5543	22.430	69.1243	0.3522	0.0234	3.0818
Gesha	OC	62.5	1.4417	94.2764	21.430	72.8464	0.2967	0.2354	3.3993
Gimbo	HC	62.5	1.4416	99.7866	24.013	75.7736	0.3324	0.0255	3.1555
Chena	Pr	62	1.4411	94.3433	21.234	73.1093	0.3209	0.0150	3.4430
Chena	TH	61	1.4422	96.5413	26.361	70.1803	0.6727	0.0870	2.6623
Gimbo	OC	62	1.4413	98.1256	24.504	73.6216	0.3026	0.0832	3.0044
Gimbo	TH	64	1.4422	82.1233	19.234	62.8893	0.2735	0.07389	3.2697
Chena	TH	63.5	1.4423	93.2345	23.010	70.2245	0.4532	0.0920	3.0519
Gesha	HC	62.5	1.4414	98.4523	23.503	74.9493	0.3354	0.0162	3.1889
Gesha	TH	63	1.4427	93.2345	23.341	69.8935	0.7523	0.1875	2.9945
Chena	HC	63	1.4410	98.3456	21.091	77.2546	0.3354	0.0200	3.6629
Gimbo	OC	63	1.4409	97.3425	25.004	72.3385	0.2344	0.0678	2.8931
Gesha	TH	61.5	1.4419	87.3645	25.011	62.3535	0.5576	0.1723	2.4930
Gesha	Pr	63.5	1.4414	96.9987	22.502	74.4967	0.3126	0.0115	3.3107

NB: Source-HC-Honey comb/fresh comb; TH-Tej houses; OC-old combs; Pr- Processors; Parameters- MPt-melting points; RE- refractive index; SV-Saponification value ; AV-Acid Value; EV- Ester value; TVM-Total Volatile matter; E/A – Ester to Acid ratio.

Appendix table 2.Survey questionnaires

Bahir Dar University, College of Agriculture and Environmental Sciences, Department of Animal Production and Technology, Apiculture program.

Questionnaire for "Beeswax Production, Marketing and Quality Status In Selected Districts of Kafa Zone, Southern Nations Nationalities and Peoples Region, Ethiopia''.

Zone Kafa District _____ PA _____ Date _____

I. PERSONAL INFORMATION OF HOUSEHOLD HEAD

1. Name of the respondent _____
2. Sex: 1/ Male 2/ Female
3. Age : _____(years)
4. Educational status 1/ Illiterate 2/ Basic educ/n 3/ Grade 1-4 4/ Grade 5-8 5/Grade 9 & above

II. BEEKEEPING SITUATION

5. Do you keep honeybees 1/Yes 2/ No
6. If yes, for how long do you keep? 1/ 1-5 years 2/ 6– 10 Years 3/ 11– 15 years 4/ 16–20 Years 5/ More than 20 years
7. How do you get colony to start beekeeping? 1/Parent gift 2/ Catching swarms 3/ Purchasing colonies 4/ GOs and/or NGOs 5/ Other (specify)_____
8. Does honeybee colony selling common in your areas? 1/ Yes 2/ No
9. If yes, what is the price range for a colony? _____ETB
10. What are the driving forces to be engaged in beekeeping practices? 1/ Income 2/ Home consumption 3/ Hobby 5/ others (specify) _____
11. No of colonies owned, honey & beeswax yield per year of the last 3 years

Hive type	**2007 E.C**				**2008 E.C**				**2009 E.C**			
	Colony	Honey		Wax	Col.	Honey		Wax	Col.	Honey		Wax
		Pure	Crude			Pure	Crude			Pure	Crude	
Traditional												
Transitional												
Movable frame												

12. Where do you place your beehives? Use √ sign

Placement of Keeping Hives	Number of hives with respect to type of hives		
	Traditional	Transitional	Movable frame
Back yard			
Apiary site			
Under the eaves of the house			
Inside the house			
Hanging on trees near homestead			
Hanging on trees in forests			
Other (specify)			

13. What is the trend of your colony numbers for the last five years? 1/ Increasing 2/ Decreasing 3/ No changes
14. How do you increase your number of colonies? 1/Catching swarms 2/ Buying colonies 3/ Splitting colonies 4/ Overcrowding 5/ Other (specify)_____
15. Is there colony decline in your areas compared to last certain years back? 1/ Yes 2/ No
16. If yes, what are the reasons? Rank them in order of importance.

No	Reasons/threats	Rank	Season of occurrence
1	Absconding		
2	Swarming		
3	Diseases		
4	Pests		
5	Predators		
6	Agro chemicals		
7	Drought		
8	Lack of bee forages		
9	Lack of water		
10	poor management		
11	Unknown reason		
12	Poisonous plants		
13	Other (specify)		

17. Is there absconding of colonies in your areas? 1/ Yes 2/ No
18. How many colonies absconded during the last three years?
19. What are the reasons for absconding? ----------.
20. From which types of beehives frequent absconding occurs? (put"√" 1/Traditional _____2/ Transitional _____ 3/ Movable frame hives___4/ does not vary by hive types
21. What are the prevention/controlling mechanisms you practice for absconding? ----
22. Is there swarming of colonies in your areas? 1/ Yes 2/ No
23. If yes, from which type of hives does intense swarming occurs? (Put '√' sign)

    1/ Traditional_____2/ Transitional _____ 3/ Movable frame hive _____
24. What is the frequency of swarming? 1/ Once a year 2/ Twice a year 3/ Once in two years 4/ Once in 2-3 years 4./ Once in 3-4 years 5/ Other (specify)
25. How do you control swarming of your colonies? (put '√')

Swarm control	Yes	No
Removal of queen cells		
Shading		
Harvest or cut brood combs		
Catching the swarm and returning back to hives		
Supering/adding space		
Using large volume hive		
Splitting the colony		
Others, specify:----------		

26. What are the major pests and predators found in the area treating your colonies? (List in order of their importance).

No	Pest /Predators	Rank	Local control measures	No	Pest /Predators	Rank	Local control measures
1	Ants			9	Toads		
2	Wax moths			10	Lizard		
3	Bee lice			11	Snake		
4	Beetles			12	Monkey		
5	Spiders			13	Birds		
6	Wasps			14	Honey badger		
7	Prey mantis			15	Others (----------)		
8	Varroa mites						

III. HONEY AND BEESWAX RELATED

27. Do you consume your honey? 1. Yes 2. No
    If yes how much of it? _____
28. If you use for home consumption, List purposes of honey in home consumption? 1/ As a food 2/ As a medicine 3/ For beverages (' *'Tej'* ' and 'Birth') making 4/ For cultural and ritual ceremonies 5.Others (specify)_____
29. How do you harvest honey from the hives? (Procedure)_____
30. How many times do you harvest honey per year, and the season of harvest?

No	Frequency of harvest/yr	Months of harvest	Remarks
1	1 time		
2	2 times		
3	3 times		
4	4 times		

31. Do you strain honey from traditional and transitional hive? 1/ Yes 2/ No
32. If yes, what are the materials used ? 1/ Honey presser 2/ Strainer 3/ Sieve 4/ Other (specify) _____
33. If not, why? 1/ Lack of awareness 2/ Lack of materials 3/ Straining reduce honey amount 4/ Consumers preferences 5/. Other (specify)_____
34. Do you use honey extractor for movable frame hive's honey? 1/ Yes 2/ No

35. If your answer is N**o,** how do you harvest honey from movable frame hives? 1/ Cut and use/sell as crude 2/ Use honey presser 3/ Use sieve 4/ Use no material
36. How do you process honey? (Separation procedure).___
37. What do you do with the rest of your honey beyond consumption? 1/ Sell 2/ Store 3/Both4/Others ____
38. What is the price of honey in (ETB)? Crude honey/kg _____; Extracted honey/kg _._____Birr
    Strained honey/kg _____Birr
39. When do you sell your honey? Month(s)_
40. Where do you sell your honey and distance travelled? 1)_____2)_____,_____
41. Who are the buyers for your honey? 1/Local Consumers 2/ Local collectors 3/ Traders 4/Processors 5/ *'Tej'* brewers 6/ Cooperatives 7/ Others (specify)_
42. How long do you store your honey?_
43. What are the materials you use to store your honey? _____
44. What are the major uses of beeswax in your area? (In order of importance)*

    * *This question implies only for the local use of beeswax by the beekeepers or respondents.*

No	Use	Rank
1	Candle (*'tuaf')* making	
2	Income (selling)	
3	Foundation sheet making	
4	For cultural and ritual ceremonies	
5	Medicine	
6	As cosmetics	
7	Other (specify)	

45. Do you collect beeswax at home? 1/. yes 2/ No
46. If yes, how do you collect /harvest/ your beeswax? 1/ from crude honey extraction 2/ Discarded, old and broken combs 3/Empty combs during harvesting 4/Collection after honey utilization 5/ Uncapping and spout beeswax 6/ Others (specify)
47. If the answer is No, what is the reason? 1/ Lack of awareness 2/ Lack of processing skills 3/ Lack of market 4/ Lack of processing materials 5/ Don't know the use and economic value 6/ Others specify:____
48. How do you process beeswax? (Procedure)____
49. What are the materials used during processing?__
50. What did you do with your processed beeswax? 1/Sell 2/ store 3/ both 4/others (specify)_____
51. Where do you sell your beeswax? _
52. Who are the buyers of your beeswax? 1/ Direct users 2/ Local collectors 3/ Traders 4/ Processors 5/ Churches 6/ Cooperatives 7/ Others (specify)

53. Who will determine the price of beeswax? 1/Seller 2/ Buyer 3/ Direct negotiation 4/ Cooperatives 5/ Government
54. Is there seasonal price fluctuation? 1/Yes 2/ No
55. If yes, when is the lowest price? When is the highest price?
56. What is the reason for seasonal fluctuation?
57. What is the price of? Crude beeswax/kg _____Birr; Extracted beeswax/kg _____Birr
58. What is the annual income from sale of beeswax?_____(Birr)
59. When do you sell your beeswax (Season)?
60. Why you choose this season? _____
61. Where do you get beeswax for your movable frame hives foundation sheet making? 1/ Own source 2/from Gov't 3/ from NGOs 4/ Buying from market 5/ From cooperatives 6/ use no wax for frame hives
62. What are the major challenges of beeswax marketing?___
63. How long do you store your wax?
64. What materials do you use to store beeswax? __
65. Is there any wax adulteration practice in the area? 1/ Yes 2/ No
66. If yes, what is the extent of adulteration? 1/ High 2/ Medium 3/ Low
67. What are the reasons for adulteration of beeswax?
68. Who are responsible for adulteration of beeswax? __
69. When do you think adulteration occurs? --------
70. Do you know what adulterant materials used? 1/ Yes 2/ No
71. If yes, what are the materials/ adulterants used?__
72. How do the adulterants mixed to beeswax?__
73. How do you differentiate adulterated beeswax from pure one? _____
74. Is there price difference between adulterated and pure wax? 1/ Yes 2/ No
75. If Yes what is the price for pure wax _____; for adulterated one_____
76. Have you encountered a problem due to wax adulteration? 1/ Yes 2/ No
77. Have you got any training on beekeeping? 1/ Yes 2/ No
78. If your response for the above question is yes,

No	Places of training	Focus of training	Duration	Organized by
1				
2				
3				

79. What issues to add concerning beeswax production, quality and market?_____

LIST OF APPENDIX PICTURES

Appendix picture 1. Wax Production/processing

a) Beeswax production at '*tej*' houses (Chena district)

b) Beeswax produced by beekeepers (A-Chena district; B- Gimbo district)

A)

B)

c) bees wax produces by processors(Chena district)

Appendix picture 2: Some of Honey processing and storage materials used by beekeepers

a) Sieves

b) Stainless steel container

Plastic honey container

Honey presser

e) Barrel

f) Fertilizer bag

a/ Waxes from honey combs/fresh comb

b/ wax from old combs

c/ Wax samples from '*tej'* houses

Appendix Picture 3. Wax Sample preparation

BIBILIOGRAPHICAL SKETCH

The Author was born in 1986 from his father Mr. Shegaw Yimer and his Mother Mrs. Adamit Belayneh in Dello Mena district of Bale Zone, Oromia Regional State. He followed his primary and secondary schools at Dello Mena and finished his secondary schools at, Batu Terara Preparatory school, Bale Goba. Then after passing the Ethiopian School leaving exam, He joined Ambo University in 2007 and has got his Bachelor (BSc) Degree in Animal Production in 2009. After his graduation, He has served in various Disciplines of animal science expert under Bureau of Livestock and Fisheries Resource Development at Bale zone for a total of 4 years. In 2015, he has employed in South Agricultural Research Institute (SARI) as Junior Apiculture researcher and has served for two years up to his stay of starting his Degree of Masters Program in Apiculture at Bahir Dar University College Agriculture and Environmental Sciences.