Federal Technical and Vocational Training Institute

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Department of Dairy Processing Technology

Assessment of Bee Keeping Practice and Chemical Composition of Honey in Different Agro Ecologies of Dehana district Waghimra Zone Amhara National Regional State Ethiopia.

MSc Thesis for the Partial Fulfillment of Master of Science in Animal Production Technology

By

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July, 2024

Addis Ababa, Ethiopia

Assessment of Bee Keeping Practice and Chemical Composition of Honey in Different Agro Ecologies of Dehana district Waghimra Zone Amhara National Regional State Ethiopia.

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By: Gobeze Gelaw Demeke

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July, 2024

Addis Ababa, Ethiopia

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Assessment of Bee Keeping Practice and Chemical Composition of Honey in Different Agro Ecologies of Dehana District Waghimra Zone Amhara National Regional State Ethiopia.

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LIST OF ABBREVIATION

AC	Ash Content
AEZ	Agro Ecology Zone
ANOVA	Analysis of Variance
ASC	Apparent Sugar Content
CAC	Codex Alimentarius Commission
DWADO	Dehana Woreda Agriculture Development Office
DWLFDO	Dehana Woreda Livestock and Fishery Development Office
EC	Electrical Conductivity
EU	European Union
HMF	Hydroxyl Methyl Furfural
HPLC	High Pressure Liquid Chromatography
IHC	International Honey Commission
KTBH,	Kenya Top Bar Hive
LSD	List Significant Difference
MC	Moisture Content
Meq	Mill equivalent
MRJP	Major Royal Jelly Proteins
NGO	Nongovernment Organization
QSAE	Quality and Standards Authority of Ethiopia
RSC	Reducing Sugar Content
SPSS	Statistical Package for Social Sciences
TTBH	Tanzania Top Bar Hive

ABSTRACT

This research aims to assess the practice of beekeeping and analyze the chemical composition of honey in different agro-ecological zones of in Waghimra zone Dehana District Amhara region. Stratified random sampling technique was used to select the sampling sites. Six representative kebeles were selected randomly from the three agro-ecologies. 133 beekeepres that owned at least two bee colonies were purposely selected and interviewed using semi-structured questionnaire. Then from previously interviewed beekeepers a total of 30 farmers were selected for honey chemical composition samples, the three honey production systems were varied honey yield capacity. The beekeeping systems with an average honey yield of (8.69±3kg), (13.37 ±3.30kg) and 15.05±4.53kg Traditional, Transitional and frame hive respectively per year/hive. The Highland region was the highest average moisture content at 17.82%, The Midland and Lowland regions had lower than highland average moisture contents of 16.61% and 16.14% respectively. Interms of free acidity the lowland honey was the highest free acidity at 27.18 meq/kg, while the Highland and Midland were lower at 23.26 and 22.37 meq/kg respectively. The pH values across all regions are slightly acidic, average from 3.54, 3.74, and 3.82 in the Lowland, midland and Highland respectively. Slightly higher pH in the Highland area. The content of ash in the Lowland honey was the highest ash content at 0.17%, while the Midland was lowest at 0.12%.The Lowland honey was the highest average HMF at 7.95 mg/kg, while the Highland was lowest at 3.58 mg/kg. The average reducing sugar contents were very similar across the regions, ranging from 65.85% in the Midland to 66.76% in the Lowland. The Lowland honey was the highest average conductivity at 0.34 ms/cm, while the Midland was lowest at 0.24 ms/cm. Generally the overall results highlight the predominance of traditional hive beekeeping, with limited adoption of transitional and modern hives. The overall agro ecology honey chemical composition sample were within the acceptable range of world and national standard. The study demonstrated that honey productions in the study area are hampered by several constraints and the bee keeping practice were above 93% traditional system. Moreover, insufficient knowledge and skill transfer about transitional and modern bee-hives,improvement of honey bee hive management, and are paramount important. Furthermore, large scale and comprehensive research on constraints and honey production are highly recommended to set appropriate solution.

Key word: *Agro-Ecology, Assessment, Beekeeping, Dehana district, Honey, Chemical Composition*

1. INTRODUCTION

1.1. Background and Justification

Beekeeping is a long-standing agricultural practice in Ethiopia. Beekeeping is thought to have started between 3500 and 3000 BC, while its exact start date and place are unknown (Getachew, 2020). Ethiopian agriculture has benefited greatly from beekeeping. Ethiopia has produced more beekeepers than any other nation since the third century, while the sector is still in its infancy (Habtamu & Nasir, 2020). The management of honey bee colonies, which are utilized to create honey and other goods in addition to pollinating crops, is known as beekeeping, or apiculture.

This non-farm business initiative benefits the environment and is undertaken by both landless people and farmers in particular and it accounts 1.3% of agricultural GDP of Ethiopia. (Kassa, *et al*, 2017) It also requires less investment, doesn't require cultivated land, and produces financial benefits right away. Beekeeping is a good environmental practice that can help developing countries reduce poverty and protect their natural biodiversity. It has also improved rural households' incomes and Ethiopia's overall economy (Ajabush, 2018). It contributes significantly both directly and indirectly by producing valuable goods including queens, bee colonies, honey and beeswax. Additionally, indirectly, through food production, environmental protection, and financial stability. Additionally, it offers a chance for employment and typically promotes financial security. (Teferi K.2018) numerous issues, such as diseases of bees, parasites, and predators, pesticide poisoning, deforestation, inappropriate harvesting, and others, have contributed to the restricted growth of beekeeping. (Wakshuma, *et al*, 2023.

Honey is a naturally occurring organic substance that has a sweet, delicious liquid consistency and is made from the nectar of flowers by *Apis mellifera*. (Dessie, 2021)Honey is a complex mixture that exhibits wide variations in composition and characteristics. During production, a number of environmental factors, including weather, humidity levels inside the hive, conditions for nectar, and handling of the honey during extraction and storage, can affect the composition and quality of honey (Dessie, 2021; Maled and Addis, 2014).

Over 800 authorized honey supply plants and roughly 10 million bee colonies can be found in Ethiopia (Ajabush, 2018). Ethiopia, with 6,189,329 hives, is the fourth-largest country in the world, behind China, India, and Turkey in bee colony number. Modern frame hives, backyard hives, and transitional hives are examples of contemporary beekeeping practices. Out of all the hives, there are 1.30% transitional, 3.33%, frame and 95.73% traditional hives. (Wakshuma *et*

al., 2023). Ethiopia is among the top 10 honey producers in the world and produces the most honey in Africa. Ethiopia dominated Africa when honey output was ranked ninth (9) globally (Samuel & Getahun, 2016). In terms of production volume, beeswax ranks first in Africa and third (3) globally. (Addis & Maled, 2014) A potential yearly production of 500,000 tons of honey and 50,000 tons of beeswax might be achieved in the country. The amount of honey and beeswax that can still be produced is only 5542 tons and 47,706 tons, respectively.

Honey production occupies the majority of Ethiopia. Although the ability to produce honey varies by region, the most significant regions for producing honey are Oromia (38%), Amhara (26%), SNNPR (18%), and Tigray (7%). (Wakshuma et al., 2023). The amount produced is a meager 0.53 kg/head, far less than the potential when the current considering Ethiopia's population of 120,000,000, stands at 0.53 kg per capita honey consumption (Filmon,2023), indicating no appreciable rise in line with population growth. In contrast (Esthete & Yeshitela, 2018), Despite the country's immense potential for honey and beeswax production, the national annual honey and beeswax yield is very low as compared to the potential of the country (Maled & Addis, 2014).

The study district, Dehana, is located in Wghemra zone. Amhara region the area is suitable for beekeeping practice, because the district is located around Tekezie corridor. Beekeeping practice in the district has been believed to have an important contribution to the rural livelihood. Escalated income generation and important role plays to poverty reduction and livelihood improvement,

1.2. Statement of the Problem:

Beekeeping is a prevalent farming practice and culture in Dehana district, with more than fifteen thousand bee colonies found in the district,(DWLFDO 2023) but the beekeeping practice have many problems that need a lot of research, and beekeeping operations are still based on a traditional system.

There might be a gap in understanding the current beekeeping practices in Dehana District. This could include aspects such as hive management techniques, feeding practices, pest and disease control methods, and overall beekeeping management strategies. And the district had limited knowledge on chemical composition of honey:

There is no significant study report on the Chemical Composition of honey and bee keeping practice based on agro ecology in Dehana district Therefore, the chemical composition of honey in the study areas needs to be verified against based on National and International standards. The research intends to fill this knowledge gap by analyzing and comparing the

chemical composition of honey from different areas within the district, Overall, the research aims to contribute to the understanding of beekeeping practices and the chemical composition of honey in Dehana District, highlighting potential gaps in knowledge and providing valuable insights for beekeepers, farmers, and stakeholders involved in the honey production industry.

1.3. Objectives

1.3.1. General objective

To assess beekeeping practices and evaluate the chemical composition of honey in different agro-ecological zones in the study area.

1.3.2. Specific objective

- To assess the current beekeeping practices in different agro-ecological zones in the study area.
- To evaluate the chemical composition of honey samples collected from various agro-ecological zones.

1.4. Research Questions

This research was aim to answer the following questions:

- What are the beekeeping practices adopted in different agro-ecological zones
- What is the chemical composition of honey produced in different agro-ecological zones?
- How does the agro-ecology impact chemical composition of honey?

1.5. Significance of the Research:

The research aims to evaluate the current beekeeping practices in different agro-ecological zones of Dehana District. This assessment is important to understand the existing methods, challenges, and opportunities in the local beekeeping industry.

By analyzing the chemical composition of honey samples from various agro-ecological zones, the research can provide insights into the quality and characteristics of the honey produced in the region. This information can be valuable for producers, consumers, and potential marketers of the honey.

The findings from this research can help identify specific areas or practices that may require improvement or support to enhance the overall quality and sustainability of the beekeeping industry in the study area.

Understanding the relationship between agro-ecological zones and honey composition can assist in developing more targeted and environmentally-friendly beekeeping practices, contributing to the long-term viability of the industry.

The research findings was provide valuable insights into the strengths and weaknesses of current beekeeping practices in different agro-ecological zones. This information can be used to develop targeted training programs and interventions that enhance beekeeping practices, leading to increased productivity and income for beekeepers.

Generally, this research aims to generate practical and scientific insights that can inform and improve beekeeping practices, honey quality, and the overall sustainability of the beekeeping industry in the study area.

2. LITERATURE REVIEW

2.1. Importance of Beekeeping in Ethiopia

2.1.1. Economic Importance of Beekeeping in Ethiopia

An integral component of Ethiopia's agricultural economy has long been beekeeping. It before the development of alternative farming practices as a custom. An estimated one million farmers maintain bees, making beekeeping a long-standing and deeply ingrained custom in rural areas of the nation. The economy of the country and the smallholder farmers who depend on beekeeping for their livelihood have benefited greatly from beekeeping. (Haftey,*et al,* 2017)

Beekeeping is a significant contributor to both the environment and the economy. This subsector has a great deal of potential to support the creation of jobs, the local and international markets, the improvement of livelihoods, and the financial advantages for Ethiopia's impoverished households, women, and youth. The advancement of beekeeping techniques has the potential to greatly improve food security, crop yield. (Kenesa, 2018)

Many people could benefit from beekeeping by seeing an increase in their income and crop harvests. Beekeeping is a great hobby for those with limited room, money, or land because it requires very little area. (Dugda, 2022) Many smallholders and landless peasants have the opportunity to better their standard of living. They on to state that any food or revenue source that doesn't require land is perhaps significant. Because beehives may be planted on west land and take up very little area, beekeeping is such an effort.

2.1.2. Environmental Importance of Beekeeping in Ethiopia

The advancement of beekeeping techniques has the potential to greatly improve, crop yield, plant diversity preservation, and ecosystem health .and the preservation of biodiversity (Haftey,*et al,*2017) Beekeeping uses natural resources that would not otherwise be utilized to create food; it does not compete with other forms of agriculture for resources. Thanks to honeybees' pollination services, it enhances the ecosystem and promotes plant reproduction. Unlike other animals, bees don't overgraze. (Dugda, 2022)

2.2. Species and Races of Honey bees in Ethiopia

Approximately 46% of Ethiopian honeybee populations have high levels of aggression, which suggests that they become angry easily, become furious, and strike right away. (Amssalu *et al.,* 2023) The most important and extensively spread insect in the world today is the honeybee. In Ethiopia, *Apis mellifera* is the most widely recognized species of honeybee, despite the

existence of other variants. Apart from the main advantage of pollinating plants, this type of bee is excellent and popular for making honey and beeswax. The identification of Ethiopian honeybee races has been studied by several researchers. (Amsalu *et al.*, 2023) Smith claims that the earliest species of honeybee known to exist on the Ethiopian plateau was Apis mellifera monticola, given the names of Ethiopia's five honeybee races. The aforementioned species are spread over the country, with *Apis mellifera jemenitica* being found in lowland areas of eastern Ethiopia, *A. mellifera scutellata*, *Apis mellifera bandasii* in the central mountains. *Apis mellifera monticola* being found in the southeast mountain of Bale-Dinsho, and *Apis mellifera litorea* being found in the southwest lowlands of Ethiopia. Ethiopia's central, western, and southern highlands are home to Apis mellifera abyssinica. (Wakshuma *et al.*, 2023).

2.3. Types of Bee keeping Practices in Ethiopia

According to Teferi (2018), in Ethiopia, beekeeping is one of the oldest forms of agriculture. Since the 3rd century, during the reign of King Ezana, Ethiopia has had a longer beekeeping heritage than any other country in the world. (Habtamu & Nasir, 2020). It plays a significant and essential role in the country's agricultural economy. It makes both direct and indirect contributions to the national economy. While its indirect contributions include increased crop productivity and pollination-induced environmental protection, its direct contributions include the harvesting of honey and hive products like bee wax and bee colonies.

The art of managing bee colonies is called beekeeping. It involves managing a healthy colony of bees in a hive built for the operator and involving supervision, manipulation, and upkeep. Beekeeping can involve a variety of techniques, ranging from straightforward methods utilizing low-tech equipment to intricate processes involving more advanced machinery. In any technological context (Legesse & Wakjira, 2019).

Ethiopia now has three bee product production systems in operation: the traditional (backyard and woodland), the intermediate (transitional), and the modern (frame beehive) systems. (Aman, *et al.*2019) The technologies used and the expected productivity of any production system form the basis of its critical classification. (Legesse & Wakjira, 2019)

2.3.1. Traditional beekeeping

In traditional beekeeping, bees are kept in fixed-comb hives similar to those found in forests, but the bees are given some sort of protection. With a thousand-year history, traditional beekeeping is among Ethiopia's oldest occupations. Nowadays, conventional wooden hives are used for over 90% of beekeeping activities across the nation. (Legesse & Wakjira, 2019)

Traditional beekeeping can be divided into two categories: backyard and forest. Hanging several hives on trees is a common method of forest beekeeping in several regions of the country, particularly in the western and southern regions. However, most of the country has backyard beekeeping, which is more widespread and requires greater management. (Dekebo *et al.*, 2019)

2.3.2. Intermediate (Transitional) beehive beekeeping

Ethiopia was first exposed to the art of transitional beekeeping in 1976. This kind of beekeeping is situated halfway between conventional and cutting-edge techniques (Belie, 2009). When compared to traditional beekeeping methods, this is one of the better ones. Mud-block hives, Kenya Top Bar Hive (KTBH), and Tanzania Top Bar Hive (TTBH) are the three types of hives employed in this activity (Dekebo, *et al*, 2019). The total honey yield from this type of hive, which is 13 kg of honey on average per beehive every season. (Wakshuma, *et al*, 2023)

2.3.3. Moveable frame hive beekeeping

The goal of frame hive beekeeping is to maximize honey yield while minimizing bee damage. It makes use of many frame beehive types that are available in Ethiopia, including Modified Zander, Dadant, Zander, Lang troth, and Foam beehives. The quantity of frames and hive size of these beehives vary. In Ethiopia, Zander type frame beehives are the most widely utilized variety. (Legesse & Wakjira, 2019). If given the right technological tools, honey production in Ethiopia has the potential to help thousands of impoverished farmers escape poverty. Modern beekeeping procedures are required to provide the most honey yield for an extended length of time without putting bees in risk. Accommodating modern moveable-frame hives, tiers of identically sized rectangular box hives are stacked on top of each other. The quantity of bees in the population and the season determine how many boxes are needed.

(Dekebo, *et al*, 2019) Although they can produce higher-quality honey and allow for more advanced technology to be used in colony management, movable frame hives are likely to require a significant initial investment and skilled labor. They can also accommodate larger colonies. (Wakshuma, *et al*, 2023)

2.4. Bee Flora and Bee Floral Calendar

2.4.1. Bee Flora

The industry of beekeeping is centered on flowers, and honey bees are totally dependent on blooming plants. About 40,000 of the 250,000 plant species that exist in the world are significant sources of food for honey bees. Approximately 800 plant species are abundant in

pollen and nectar among the 6500–7000 flowering plants that have been documented in Ethiopia (Admassu and Tura, 2019).these flowering plants comprise forest trees, shrubs, weeds and cultivated crops (Tariku & Zerihun, 2019). The amount of bee fodder and the ecological compatibility of the location affect the performance of bee colonies as well as the production of honey, bee wax, and other hive products. But the amount of nectar and pollen that may be acquired from different plant species varies greatly depending on the plant, the season, and the time of day. (Begum,*et al* 2022)

2.4.2. The Bee Floral Calendar

A blooming calendar is a beekeeper's timetable that shows the approximate dates and lengths of the major honey and pollen plants' blossoming periods.(Tura &Admassu, 2018) Understanding the different plant species and their blooming seasons is important for both the sustainable management of bee colonies and a successful honey harvest. (Bhalchandra, A, and Nilesh, 2022) It includes mapping the density, distribution, and honey potential of the local bee flora in addition to the timing and length of honey plant blooming. One of the most helpful instruments for apiculture is the bee foraging calendar. Comprehensive monitoring of a habitat's seasonal variations in floral patterns, bee foraging patterns, and the ways in which honeybee colonies engage with their floral surrounds (Kumar and Bharti, 2015).

2.5. Honey Production and quality:

The variety of the plants used to extract honey as well as the climate and environmental factors all have a major role in the composition of honey. (Melese, 2020)Apis mellifera flowers yield nectar, which is used to make honey, a naturally occurring organic substance with a sweet, delectable liquid consistency. This natural sweetener is one among the most popular ones. It can be defined chemically as a naturally occurring food that consists primarily of sugars and water, with trace amounts of organic acids, minerals, vitamins, amino acids, flavonoids, and other phenolic and aromatic compounds. Depending on where and what kind of plant it comes from, its composition varies wildly (Dessie,2021).

It is a very good source of energy. Honey is made up of over 180 ingredients and has a wide range of applications. Since honey is used to make "Tej," a popular beverage in the area, it is highly sought for One of beekeeping's direct benefits is the production of honey (Haftey,*et al*, 2017). One of the animal products that is sold in Ethiopia is honey, which is exported from the country. It exerts a significant economic impact. The demand for honey production is rising as a result. Ethiopia is the biggest honey producer in Africa and is among the top nine honey-

producing nations in the world, contributing 23.6% and 2.3% of the continent's total honey production, respectively. The nation produced 42,000 tons of honey altogether between 2000 and 2008, an increase of more than 69%. (Kenesa, 2018)

2.6. Factors influencing the Chemical Composition of Honey

According to (Brahmbhatt, 2020) However, other factors can affect the quality of honey, aside from the pasteurization procedure. A multitude of things influence it, such as the use of pesticides and chemicals, pollution, harvesting methods, the surrounding environment, bee health, apiary hygiene, and many more. A few of them are listed below.

Location: Since the bees rely on the local flora to generate honey, the apiaries' location is crucial. Chemicals: Overuse of pesticides or chemicals can kill honeybees and may contaminate the honey as well. Hygiene: Keeping the hives clean and harvesting with hygienic tools are essential to the bees' well-being and, consequently, the honey's quality.

Temperature: When extracting, storing, and transporting honey, it's critical to keep it at the proper temperature to prevent enzyme destruction and the breakdown of the honey's simple sugars. Filtration: In order to preserve the pollen grains, honey may also need to be filtered to remove impurities such as wax particles or brood. Ultrafiltration, on the other hand, should be avoided. Inadequate methods of extraction or filtration can affect the honey's texture and consistency. Harvesting Methods: Using incorrect or unethical harvesting methods can also result in the inclusion of foreign materials in honey, which can negatively impact the flavor or shelf life of the product.

Honey is mostly made up of sugars, with much smaller amounts of organic acids, proteins, amino acids, enzymes, vitamins, minerals, volatile compounds, and polyphenols being present. (Miguel, MD, & ML, 2017)

The primary determinants of honey's chemical composition are the climate, harvesting and storage conditions, as well as the sources of flora. Basic sugars, water, minerals, and nitrogenous compounds make up the majority of the ingredients in honey**.** (Million & Desalegn, 2020)**.** About thirty more complex sugars are present in trace levels in honey's concentrated aqueous solution, which is mostly composed of fructose and glucose.

The high sugar content (80–83%) of honey makes it a wonderful source of energy (304 kcal/100 g). (Alvarez & Jose, 2017) Although seasonal variations, environmental factors, and processing conditions all play a significant role, the composition of honey mostly depends on the source of flowers. (Dessie, 2021)

Although sugars are the main component of honey, it also contains a variety of other elements, including enzymes, aromatic compounds, vitamins, minerals, and carotenoids. One food that is found naturally is honey. Packed with phenolic acids and flavonoids, which have a range of biological effects and act as natural antioxidant, (Priscila,) *et al*, 2016)

2.6.1. Water content of honey

The moisture level of honey has a crucial role in determining its quality, stability, and resistance to deterioration due to yeast fermentation and granulation. (Sharma, *et al*, 2023) The ideal moisture content in honey is about 17.8% and it should be strictly below 19%. Honey is hygroscopic and tends to attract moisture if left in an open container for too long. Incorrect harvesting techniques and storage practices can alter its moisture content, therefore shortening its shelf life (Brahmbhatt, 2020) The water content ranges from 13.2% to 17.6%, with an average of 14.47%.The moisture content of highland (17.43%) honey is higher than that of lowland (14.48%) honey. Nevertheless, there is no difference between the hive types. (Tilahun & Tewodros, 2023). Honey's water content varies depending on a number of factors, including the plant from which the nectar is derived, the climate, the time of year it is harvested, and its maturity level. For example, honeydew honey has a moisture content of 14.4%, while clover honey has an 18.6% moisture content, indicating optimal harvesting techniques and a good level of ripeness. (Ana Pascual-Mate, 2018). According to (Tilahun & Tewodros, 2023) the moisture content was within permissible bounds for quality. Good quality honey has a low moisture level. Conversely, a high moisture content in honey suggests a lower quality and increases the likelihood of fermentation. Moisture content is regarded as the most significant honey quality criterion in the global honey trade.

2.6.2. Reducing Sugar Content

Honey contains a number of reducing sugars, the percentage by mass of which should at least be 65%. Glucose and fructose are major components, while maltose and sucrose are found in relatively less quantities. The fructose/glucose ratio should not be less than 0.95%. (Brahmbhatt, 2020) There are three different types of sugar found in honey instead of just one. The fruit sugar (fructose) has one of the greatest percentages (41%), followed by grape sugar (glucose), which has roughly 34%, and regular sugar (sucrose), which has a percentage between 1 and 2%. The source, such as floral pasture, and the enzyme invertase, which breaks down ordinary sugar in grapes and fruit, have an influence on the ratio of one form of sugar to

another. This enzyme is found both inside the flower that bees get nectar from and inside the bee itself. (Tafere, Dessie Ashagrie, 2021)

2.6.3. Ash content in honey

Ash is usually utilized to evaluate floral provenance because the chemical composition of nectar is what determines the floral origin of honey. Ash makes up a very small portion of honey, up to 0.6% of the total mass. (Brahmbhatt, 2020) The ash content ranged from 0.13% to 0.60 percent on average. The outcome fell between QSAE (0.6 max), EU (≤0.6), and CAC (≤0.6) permissible bounds. According to (Hailu & Dassalegn, 2023) the accepted international limits for the mineral content of honey are within the range of 0.06 to 0.17 g/100 g for the ash content. Thus, the research's conclusion (0.1 ± 0.01 g/100 g) is less than what Ethiopia's Kembata Tambaro (0.25 ± 0.02 g/100 g) reported. (Tigistu et al., 2021), and the Amhara and Tigray regions of Ethiopia (0.21 ± 0.01 g/100 g

2.6.4. PH and Acidity

Free acidity has an impact on honey's quality and is a crucial factor in determining how quickly it deteriorates. The optimal composition for honey is up to 50 milli equivalents of acid free per kilogram. A maximum of 0.20% formic acid percentage (by mass) should be used to express acidity. The honey's inherent acidity rises with age, fermentation, or extraction from honeycombs containing propolis. (Brahmbhatt, 2020) The average value of acidity was 28.22 meq/kg, with a range of 20.85 to 39.14 meq/kg. Compared to the other places, acidity had reached the standard limits defined by QSAE (<0.05) and CAC (≤50 meq/kg), although there was no difference (P>0.05) across the types of hives.
(Tilahun & Tewodros, 2023)

The international guideline for honey's pH ranges from 3.2 to 4.5. The freshness of honey samples is indicated by pH values ranging from 3.4 to 6.1. (Shakoori, *et al*, 2023)

Since honey's natural pH range is between 3.4 and 6.1, it is naturally acidic due to the presence of organic acids that shield it from microbial deterioration. Ph. can affect the honey's shelf life, stability, and texture. (Brahmbhatt, 2020) The average pH was 4.28, falling between the acceptable quality ranges of 3.35 and 4.62. (Tilahun & Tewodros, 2023)

2.6.5. Hydroxyl-methyl-furfural content (HMF)

HMF forms when the fructose present in honey breaks down due to acid and is an indicator of storage and heat changes. It is thus used to determine the purity of honey.

The breakdown of fructose may increase exponentially during prolonged exposure to heat. HMF is naturally present in honey, but the permissible amount of HMF in honey is 40mg per Kg. (Brahmbhatt, 2020) the range of HMF was 22.66 to 65.94 mg/kg, with an average of 48.48 mg/kg. HMF fell between 60 mg/kg and the permitted range of CAC quality criteria. Honey from lowland, midland, and market areas had an HMF value that was higher than that of highland honey. Still, there was no difference in types of hives. (Tilahun & Tewodros, 2023)

2.6.6. Electrical conductivity

Proteins, complex sugars, inorganic salts, organic acids, and mineral content all affect honey's electrical conductivity (EC).EC is used to characterize unifloral honey and distinguish between blossom and honeydew honey. As per Codex Alimentations (2001), honey classified as blossom honey is less than 0.8 mS/cm, while honeydew honey has an EC of >0.8 mS/cm .additionally, color affects conductivity; dark honey has higher conductivity.

The conduction of electrical current is impacted by the mineral elements, amino acids, and organic acids found in bee honey. These compounds produce ions in honey aqueous solutions. The amount of inorganic salts, organic acids, proteins, complex sugars, and minerals in honey all affect its EC. It is said that colonies feed sugar syrup yielded honey with a reduced ash level. Higher the amount of organic acids and ions present, the EC is used to characterize unifloral honey and distinguish between blossom and honeydew honey. Honeydew honey is defined as honey with an EC of greater than 0.8 mS/cm. (Sharma, *et al*, 2023)

2.7. Constraints and Opportunities in Apiculture Sub sector

2.7.1. Constraints of beekeeping (Apiculture Sub sector)

It is crucial to recognize the opportunities and limits that exist in the beekeeping subsector in order to fully use its potential, (Tarkegn et al. 2017) The three main production and marketing-related barriers that have been identified as impeding the growth of the beekeeping subsector According to the (Segni, 2018) the beekeeping industry in Ethiopia is impacted by a variety of factors. These limitations include pests and predators, chemicals that harm bee colonies (Chen, *et al*, 2019) (insecticides), a lack of fodder for the bees, the high cost of contemporary hives and their accessories, and the poor quality of honey produced. a lack of bee food, poisoning chemicals from bee colonies (insecticides), and the expensive cost of modern hives and their accessories. (Elfyps & Abera, 2018, Haftey, *et al*, 2017)

2.7.2. Opportunities of Beekeeping in Ethiopia

Ethiopia is currently on the European Union's list of countries authorized to export honey. The value of the products produced, such as honey, bee wax, and bee colonies, used in cosmetics and medicine, constitute the direct contribution of beekeeping. Honey is becoming more and more in demand from a variety of clients and organizations for both domestic use and export. (Wakshuma, *et al,* 2023) A few examples of these include the presence of a rich beekeeping culture and history, an appropriate habitat with varying agro-ecological conditions, Indigenous knowledge and skills, and farmers' willingness to adapt new technology and make beekeeping their way of life. The government's current focus on introducing various beekeeping technology packages, the establishment of beekeeping associations, and the existence of governmental and non-governmental organizations engaged in beekeeping, (Tarekegn,*et al*, 2017). (Wakshuma, *et al*, 2023)

3. MATERIALS AND METHODS

3.1. Description of the study areas

The study district was one of the seven Districts' and two town administrative districts in the Waghimra zone, Amhara regional stats. According to Dehana district Agriculture office (DWADO 2020), Dehana districts contain the three major agro-ecological zones of high, mid, and lowland at a proportion of 15.5%, 46.6 %, and 37.9%, respectively. The respective altitudinal ranges for highland, midland, and lowland are >2500, 1500–2500, and <1500 m a.s.l., respectively.

The district is located between 12°10′ and 12°38′ N latitudes and 39°00′ E longitudes. It far from 78km from West Waghimra Administrative Zone and. The district is found in, 240 km North East of Bahir Dar (the capital of the Amhara Region) on the way leading Addis Zemen to Amdwork (Dehana District) and 793 km North of Addis Ababa (the capital city of Ethiopia). This district has an estimated total land area of 164,304.37 hectors classified into 28,693.6 hectors cultivated land, 27,109 hectors grazing land, 61,962.06 hectors, bush land, 3906.5 hectors forest land, 8281.67 hectors settlement and 34,351.9 hectors other lands. Major crop cultivated in Dehana district is barley, teeff, wheat, pea, bean and based on autumn have rain fall to cultivated sorghum and the rainfall is unimodal and erratic that extends not more than three months per year, usually from half of June to the half of September(DWADO 2023)

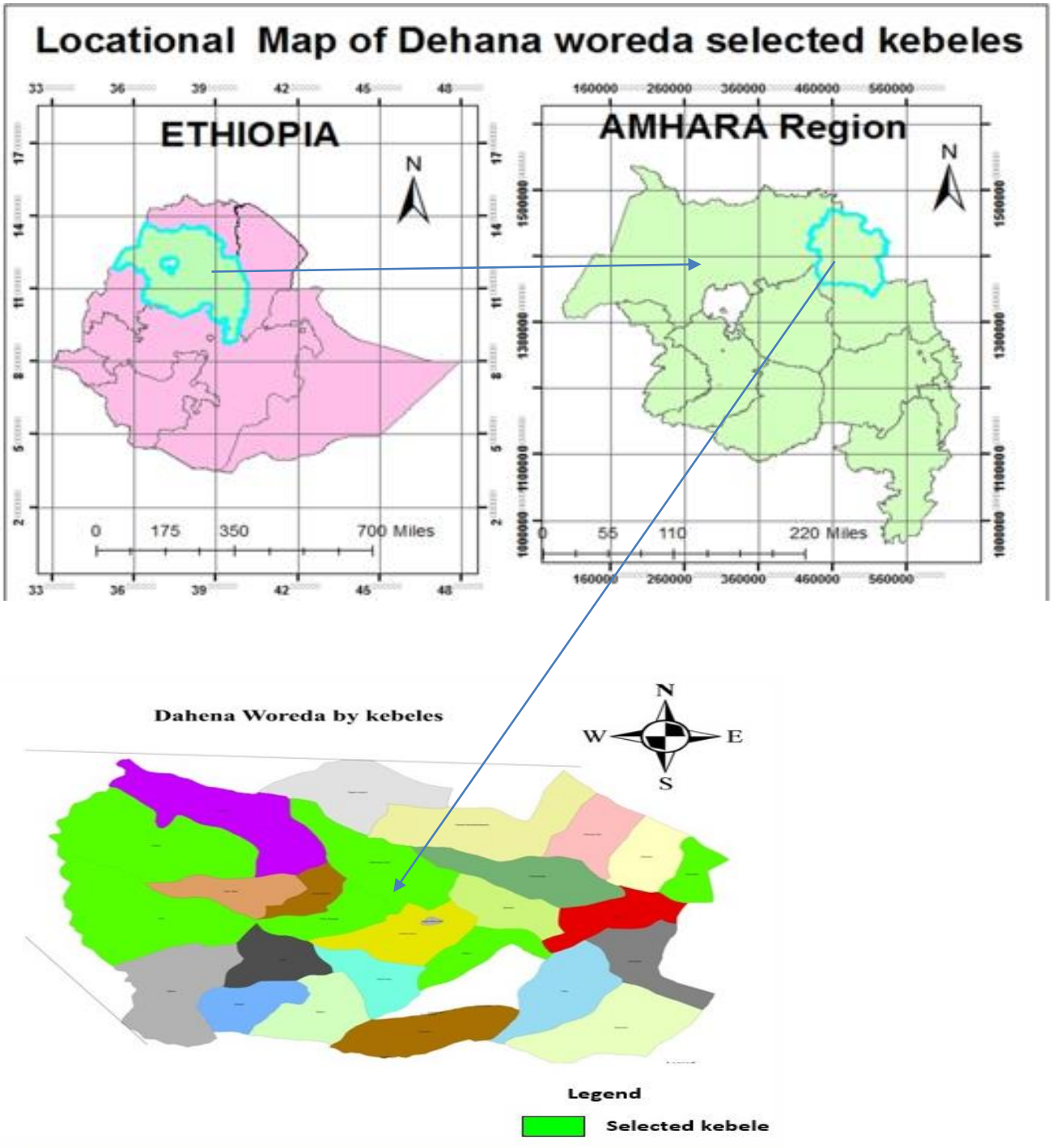


Figure 1. Location map of the study areas

Table 1: Economical and demographic characteristics of the selected districts

1	**Human population**	**148,572**
	Male	76,153
	Female	72,172
2	**Livestock population**	**271,909**
	Cattles	93,027
	Goats	98,745
	Sheep	61,550
	Equines	23,537
	Chickens	93,795
3	**Bee keeping**	**15,464**
	Modern (frame hive)	2470
	Transitional(intermediate)	425
	Traditional	12.569
4	Altitude (m a.s.l.)	1205-3138
5	Annual rain fall range (mm)	700-800
6	Temperature (°C)	18-37
7	Number of Keble's	28

Source (DWLFDO, DWADO, 2023).

3.2. Sampling Techniques and Sample size

3.2.1. Sampling Techniques

The study has two parts. The first has a survey that has done to assess the methods used in the study area for producing honey bees. The second section has laboratory examination to ascertain the chemical Composition of the honey produced in different agro-ecological zone on the research area.

The study area was chosen using a stratified random sampling technique. The Kebeles were stratified according to agro-ecological areas in order to choose the sampling sites, and simple random sampling was used. The district was divided into three Agro ecologies (*Dega, Weyna Dega, and kola*). Six representative kebeles were chosen (two from each Agro ecologies).

3.2.2. Sample size determination

The sample size is using a 95% confidence level, is used to get the sample size. With the entire population of the apiculturist farmers in six kebeles, from every agro-ecology, two kebeles was selected the sample size is determined using McMillan and Schumacher (1997) and Kothari (2004). The significance difference (p=0.05)

$$n = \frac{z^2pqN}{e^2(N-1)+z^2pq} = \frac{(1.96)^2(0.89)(0.11)(1215)}{(0.05)^2(1215-1)+(1.96)^2(0.89)(0.11)} = 133$$

Where: n = the minimum number of sample size within the range of acceptable error margin

N= the total number of households in the six Kebele in district (1215 households)

z = the selected critical value of the desired confidence level (95%) which is 1.96

p = the estimated proportion of an attribute in the population (0.89)

q= estimate of the proportion of population to be sampled (0.11)

e =represents maximum variability or margin of error 5 %(0.05)

1=designates the probability of the event occurring

The study was selected a total of 133 households from six representative kebelies. The sample size for each agro-ecology and kebele was determined proportionally to the population size, using the formula described in the previous equation.

$$nh = \frac{Nh}{N} \times n$$

nh = sample size in Kebelie Nh = kebelie population

N= Total population and n= Total sample sizes

Table 2. Distribution of sample bee keeper households by Keble

Agro-ecology	Sample kebele	Bee keeper Households	Sample households	Total Sample size	Lab Sample size
Highland	Kewzba (024)	125	$\frac{125}{1215} \times 133 = 14$	24	10
	Biwule (015)	95	$\frac{95}{1215} \times 133 = 10$		
Midlands	Minshewa (03)	196	$\frac{196}{1215} \times 133 = 22$	42	10
	Hulaban (04)	185	$\frac{185}{1215} \times 133 = 20$		
Lowlands	Siwura (08)	301	$\frac{301}{1215} \times 133 = 33$	67	10
	Dura (09)	313	$\frac{313}{1215} \times 133 = 34$		
	Total	1215	133	133	30

3.2.2. Types of Data and their Sources

Primary and secondary data were gathered and examined in this Research. Primary data was collected from beekeepers and secondary data collected from livestock and fishery experts in the Dehana district area, as well as previously published research studies, the Internet, reports from the Agriculture and Rural Development Offices, and reports from NGOs operating at various levels of the Dehana district was the key sources of information. Apart from doing a

comprehensive literature study and gathering pertinent secondary data, was employed to obtain primary information. These consist of a household survey, key informant interviews.

3.2.3. Survey Methods

A combination of qualitative and quantitative tools were used to collect data from farm households in the study areas. Semi-structured questionnaires were employed to gather information on various aspects of apiculture: Household characteristics: This included data on demographics (sex, age, family size, and education level), land holdings, livestock, and honeybee colonies. Honey production systems: This covered the number and types of hives owned, sources of bee colonies, beekeeping management practices, honey harvest volumes, production costs, and honey marketing channels and prices. Potential and constraints of apiculture: This assessed factors such as availability of honey plants and flowering times, presence of poisonous plants, water sources, honeybee pests and predators, and use of chemicals.

3.2.4. Sample Collection and Sampling Technique for honey quality

During primary data collection a total of thirty (30) fresh ripe honey samples were collected five honey samples from randomly selected six potential beekeeping kebelies. Honey samples were collected at farm gates from Traditional hive type. The honey samples was harvested in the same period in the year during the second round honey harvesting season (March to May) of the study area from major agro-ecologies. The samples was collected by using tightly closed chemical-free plastic containers and were cleared of extraneous materials like as insects, dead bees, detritus, brood, and comb fragments.

3.3. Chemical Composition of Honey analysis

The parameters were determined using the procedures for honey chemical composition standards in the laboratory. From traditional hive thirty (30) harvested honey samples was examined for chemical composition like (moisture content, total reducing sugar, pH, acidity, HMF and Ash (mineral contents) were tested in Sekota dry land and Agriculture research center Waghimra Ethiopia. Samples of honey were analyzed for different honey chemical composition parameters according to the procedures described by International Honey Commission (2009) for the determination of chemical composition of honey parameters as follows:

3.3.1. Moisture content

According to a previously established connection, the refractive index read from the device was transformed into the honey moisture content (Kuar, 2019). Moisture content (MC): MC was measured using the Abbe Refractometer. The relationship between the refract index and the water content reading at 20 ◦C done using. The MC was determined by reference to a standard table using the honey refractive index. The refractive index reading was fixed to 20 ◦C. The refractive index was converted to moisture content by "(-log10 (Corrected Refractive Index - 1) - 0.2681)/0.002243"

3.3.2. Reducing Sugars Content

Reducing sugar content (RSC): RSC was calculated by Ref. modified process, which involved reducing the Soxlet modificationg of Fehling solutions by titrating at 60 ◦C against a solution for reducing honey sugars using methylene blue as an internal indicator. The result was calculated as: C = (25/W) × (1000/Y);

Where, C = gram of invert sugar per 100 g honey,

W = weight of honey sample, and

Y = volume of diluted honey solution consumed.

3.3.3. Ash Content of the Honey

Ash content (AC): Methods were used to compute AC. To the ash dish, five grams of honey (M2) was added. Add two drops of olive oil to the dish, then place it in a preheated furnace and heat it for 1.5 hours at 600 ◦C. The process of ashing persisted until a stable weight was reached (M1). The following formula was used to get the ash (%):$\text{Ash} = \frac{\text{M1}-\text{M2}}{\text{MO}} \times 100$

Where M1 is the weight of the crucible and ash, Mo is the mass of the sample that are taken, and M2 is the weight of the empty crucible. (Tewodros &, Tilahun, 2023)

3.3.4. Ph. and Free Acidity

The honey sample and distilled water was combined in a scientific manner to create a solution for the following step. The Titroline instrument was used to measure the pH and free acidity of 10 g of honey dissolved in 75 mL of distilled water. Titrating with 0.1 M sodium hydroxide solution to pH 8.30 allowed for the determination of free acidity, which was measured in solution. After utilizing the following formula to do the computation, the findings were

expressed in mill equivalents/kg of honey using the following formula: Free acidity = mL of 0.1 M NaOH × 10 (Ciursa & Oroian, 2021):

3.3.5. Electrical Conductivity

Electrical resistance is measured in order to determine electrical conductivity, of which electrical conductivity is the reciprocal (IHC, 2009). The conductivity meter and conductivity cell was connected: - A thermometer and the cells was submerged in a potassium chloride solution after the cells have been completely cleaned with it.

Once the temperature has stabilized at 20 °C, the electrical conductance of the solution was measured in mS/cm, or mill Siemen per cent meter. Using the following formula, the electrical conductivity of the honey solution was determined: SH is equal to K - G. Where K is the cell constant in cm-1, G is the conductance in mS, and SH is the electrical conductivity of the honey solution in mS.cm-1. K = 11.691∗1/G, where 11.691 is the sum of the electrical conductivity of a 0.1M potassium chloride solution and the electrical conductivity of freshly distilled water in mS per cm (mill Siemen per cent meter) (Bogdanov, 2009).

3.3.6. Hydroxyl Methyl Furfural (HMF)

According to (Ciursa &Oroian, 2021, Tilahun &Tewodros, 2023). (HMF) the hydroxymethyl furfural content was determined by the spectrophotometric method. An amount of 5 g of honey was dissolved in 25 mL of ultrapure water. The solution are transferred to a 50 mL volumetric flask, over which 0.5 mL of Carrez I solution was added and mixed. Then, 0.5 mL of Carrez II solution was added and made up with ultrapure water. The solution obtained was filtered and the first 10 mL were rejected. In two tubes, 5 mL of filtrate were introduced over which 5 mL of ultrapure water (in the first test tube) and 5 mL of 0.2% sodium bisulphite were added (in the second test tube representing the reference solution). The absorbance of the sample solution against the reference solution at 284 and 336 was read using a UV-3600 spectrophotometer (Schimadzu Corporation, Japan). The HMF content are calculated using the following formula, the result being expressed in mg/kg: HMF (A284 − A336) × 149.7 × 5 × D/W,

Where: A284—absorbance at 284 nm, A336—absorbance at 336 nm, D—dilution factor, W—weight of the honey sample (g)

3.4. Statistical Model Analysis

Data processing which includes manual editing, coding, data entry, data cleaning and consistency checking was made before undertaking analysis. Descriptive statistical tools was

used to analyze the collected data including frequency, percentages, mean and, standard deviation using SPSS software (version 20). Moreover the chemical property data was analyzed by one-way ANOVA using SPSS software (version 20).

$$Yij = \mu + \alpha i + eij$$

Where, Yij = honey quality parameters

μ = the overall (grand) mean

αi = the i^{th} effect of agro-ecology (i = Highland, Midland and lowland)

eij = random error

4. Result and Discussion

4.1. Household Socio-Economic Characteristics

4.1.1. Characteristics of the respondents

The study found that 90.5% of the sampled households were male-headed, while only 9.5% were female-headed. This indicates that the majority of beekeepers in the study area were male, despite beekeeping being an activity that can be performed regardless of sex. This aligns with a previous study by (Alemu 2015), which reported that 91.1% of were male, and only 8.9% female beekeepers in the Amhara region of Ethiopia.

The survey data reveals that the majority of the interviewed households were married, accounting for 89.6% of the total. In contrast, the proportions of single, widowed, and divorced individuals were 2%, 7.4%, and 1.8%, respectively (Table 3). This suggests that married participants are significantly more engaged in beekeeping compared to those with other marital statuses. This finding could indicate that beekeeping requires a certain level of stability, and married couples may be more inclined to use beekeeping as a means of asset building. Additionally, the survey data shows that 100% of the interviewed participants identified as being of the Christian (Orthodox) religion (Table 3).

The current study showed that the average family size per household was 4.94±1.67 individuals, with a maximum of 9 and a low of 3. However, the statistical analysis revealed that there was no significant variation in family size among the participating beekeepers. In terms of average beekeeping experience, the results revealed that sample respondents had 11.37 years of continuous involvement (experience) in beekeeping (with a range of 3 to 29 years) (Table 3). This result disagrees with the findings of (Addisu, 2017) who reported that (31.85%) of the beekeepers had more than 15 years of beekeeping experienced beekeepers in South Wollo zones Amhara regions.

Furthermore, we discovered that women (wife), young boys, and girls in the family participate in various beekeeping tasks to assist the head of the household. Interestingly, respondents stated that young boys and girls who gained beekeeping experience with their families eventually became independent beekeepers when they were given the opportunity to own a colony.

The average age of respondents in the research area was 44.55±9.72 years, ranging from 27 to 60 years. This could explain why beekeeping is an activity that can be done at any age, and in most situations, people of both young and old ages are actively involved in beekeeping. (Table3). In terms of education level from the total respondents, about 60.1% of them were

illiterate with 37.9% being literate. 5% attended primary education, 24.3% of them can read and write; 6.8% beekeepers attended junior education and the rest only 1.8% of beekeepers attended secondary education. It vary from the findings of (Aregawi, *et al*, 2018) who reported that only 51.5 % were illiterate whereas 48.5% of them were literate. Demographic characteristics of the respondents at Waghimra Zone. Based on the study's findings, beekeepers who are literate and understand most training materials and advice are the ones who practice beekeeping, as evidenced by the production of their colonies and their ability to manage them.

Table 3. Characteristics of the respondents.

Descriptive		Agro-ecology			
		Highland (n=24)	Midland (n= 42)	Lowland (n = 67)	Overall (N =133)
		percentage			
Gender	Male	91.7	85.7	94.0	90.5
	Female	8.2	14.3	6.0	9.5
Educational status	Illiterate	70.8	61.9	53.7	62.1
	Basic edu/n	20.8	23.8	28.4	24.3
	Grade 1-4	4.2	4.8	6.0	5.0
	Grade 5-8	4.2	7.1	9.0	6.8
	Grade 9-12	0	2.3	3.0	1.8
Marital status	Married	87.5	85.7	92.5)	89.6
	Single	0	4.7	1(1.5	2.0
	Widowed	8.3	9.5	4.5	7.4
	Divorced	4.1	0	1.4	1.8
		Mean±SD			
Description	Minimum	Maximum	Mean	±SD	P-Value
Family size in No	3	9	4.94	1.67	0.43
bee/k Experience	3	29	11.37	6.62	0.629
Age of respondents	27	60	44.55	9.72	0.87

N= number of observation, SD= standard deviation

4.1.2. Land holdings

The average land holding per family in the agro-ecology was not significantlly different except forest land use (P>0.05). The highland (1.52±0.42) was greater than the Midland (1.28±0.52) and Lowland (1.27±0.48) in the research region.(Table4) shows that the average household landholding in the research area was 1.32±0.49 hectares, ranging from 0.00 to 2.5 hectares. This average land size is line with the national average of 1.37 hectares per household (CSA 2013). Furthermore, the findings reveal that a considerable proportion of respondents owned landless that was mostly used for agriculture production.(Table 4). This result was differe from the finding of (Abebe, 2017) who reported that The average land holding was about 0.6 hectares

(with a range from 0 to 1.38 hectares) in Tehulederie District of South Wollo Zone, Amhara Region, Ethiopia and also (Alemu, 2015)The average land holding of the sample respondents during the study period was 0.99 hectares in waghimra and south wollo zones of amhara regionThese findings imply that beekeeping could be a feasible choice for persons involved in mixed agricultural systems, even if they only have tiny plots of land available. The relatively small landholdings in the research area provide an opportunity to include beekeeping as a complementary activity into these households' existing farming methods.

Table 4. Land use system in hectares

Land use in Hectare	Agro-ecology				
	Highland (n=24)	Midland (n= 42)	Lowland (n=67)	Overall (N=133	p-value
	Mean ±SD				
Farmland	1.16±0.32	1.06±0. 47	1.11±0.38	1.11±0.40	0.60
Forest land	0.19 ±0.19[b]	0.08±0.13[a]	0.04±0.09[a]	0.08±0.14	0.00
Grazing land	0.31±0.16	0.15±0.17	0.12±0.19	0.13± 0.18	0.64
Total L/ holding	1.52±0.42	1.28±0.52	1.27±0.48	1.32±0.49	0.08

[a, b] Means followed by different superscript letters within a raw are different at P<0.05,and the same letters within the row indicate Ns (non-significant difference)

4.1.3. Major crops grown and crop production problems in the study area

Respondents' reported that cereals are the most commonly grown crops in the study area. More specifically, Sorghum (bicolor.) 26.8% followed by Teeff (Eragrostis) 16.1% Wheat (Triiticum).10.7% and Barley (Hordeum vulgare L) 9.7%, are the most commonly grown crops. (Table 5). Respondents also indicated that cereal crops are the major sources of pollen and nectar for honey bees during flowering season. Thus, season of crop production is one of the major determinant factors for honey production in the study district.

All three of the agro-ecological zones regularly see sorghum as a major crop, with the Midland having the largest proportion. Teeff is grown in all zones, though in different proportions; the Midland has the highest percentage. In the Midlands and the Highlands, scarcely noteworthy, but nonexistent in the Lowlands. In the High Land, wheat is clearly present. Across the many agro-ecological zones, the main crops generally show variable consistency; certain crops are more preferred in particular zones, while others are more widely distributed.

Table 5. Major crops in the study area.

Description (%)			Agro-ecology			
			High land (n=24)	Mid land (n= 42)	Low land (n = 67)	overall (N=133)
	Local name	Scientific name	percentage			
Major crops Grown in the study area	Teeff	*Teeff ergoistatis*	8.2	23.8	16.4	16.13
	Mashla	*Sorghum bicolor*	12.5	26.2	41.8	26.8
	Gibes	*Hordeum vulgare*	12.5	16.7	0	9.7
	Sendie	*Triticum aestivum*	25.0	4.7	0	10.7
	Miser	*Lentils*	8.3	2.4	0	3.5
	Baqila	*Vicia faba*	12.5	4.8	0	5.85
	Atere	*Pisum sativa*	16.7	7.1	0	7.9
	Shimbra	*Cicer artietinum*	4.2	4.8	0	3
	Adenguarie	Not identify	0	0	14.9	4.96
	selite	*Sesame indicum*	0	0	13.4	4.46
	teleba	*Linum vsitatissiumum*	0	0	3.0	1
	masho	Not identify	0	0	10.4	3.46

As the result indicated that the major constraints of crop production in the three different agro ecologies are. Shortage of farm land, Soil fertility loss, drought (erratic rain fall).Inputs (seed, fertilizer) shortage, Insects and Diseases are the major problems that faces repeatedly and affects the crop production in the study area. The decline of soil fertility and the scarcity of farmland are the more urgent issues in the highland and midland regions (Table 6). In the lowland and midland regions, drought is the main obstacle. In the highland area, the scarcity of inputs (fertilizer, seed) and oxen is a more serious problem. Diseases and insects are comparatively more of an issue in the lowland area.in order to address the unique crop production restrictions in each agro-ecological zone within the Dehana district, these findings can assist guide focused interventions and resource allocation

Table 6. Major crop production constraints in Dehana district.

Variables	Rank (% of respondent) top 6								
	1st	2nd	3rd	4th	5th	6th	Score	Index	Rank
	Highland								
farm land Shortage	41.7	20.8	25.0	12.5	0	0	516.2	0.249	1
Soil fertility loss	8.3	33.3	25.0	16.7	4.2	12.5	387.3	0.187	2
Drought	33.3	20.8	8.3	12.5	16.7	8.3	336.2	0.162	3
Inputs shortage	16.7	4.2	33.3	16.7	29.2	0	362.9	0.175	4
Insects and Diseases	8.3	16.7	4.2	25.0	16.7	29.2	285.9	0.138	5
Shortage of oxen	0	8.3	0	8.3	33.3	50.0	183	0.088	6
	Midland								
Soil fertility loss	7.1	45.2	26.2	19.0	2.4	0	749.6	0.32	1
Drought	47.6	14.3	23.8	0	11.9	2.4	478.5	0.20	2
farm land Shortag	31.0	21.4	26.2	16.7	0	4.8	330	0.14	3
Inputs shortage	11.9	0	19.0	23.8	35.7	9.5	299.7	0.13	4
Insects and Diseases	2.4	11.9	7.1	21.4	28.6	28.6	252.3	0.11	5
Shortage of oxen	0	4.8	0	19.0	21.4	54.8	178.6	0.07	6
	Lowland								
Drought	41.8	14.9	28.4	1.5	10.4	3.0	467.2	0.23	1
farm land Shortage	31.3	25.4	20.9	16.4	0	6.0	453.6	0.22	2
Soil fertility loss	14.9	41.8	26.9	14.9	1.5	0	453.7	0.22	2
Insects and Diseases	3.0	10.4	4.5	19.4	29.9	32.8	238.8	0.11	3
Inputs shortage	10.4	0	20.9	19.4	34.3	14.9	204.5	O.10	4
Shortage of oxen	0	6.0	0	28.4	22.4	43.3	203.3	0.10	4

Index = sum of (6*ranked 1st + 5* ranked 2nd +4* ranked 3rd +3* ranked 4th +2* ranked 5th +1* ranked 6th+). For individual reasons divided by the sum of (6*ranked 1st + 5* ranked 2nd +4* ranked 3rd +3* ranked 4th +2* ranked 5th +1* ranked 6th) for overall reasons

4.1.4. Major livestock production constraints

In terms of livestock production constraints, respondents reported that lack of animal feeds, Shortage of grazing land, lack of drinking water and parasites and diseases was the major livestock production constraints presented in table 8. Among those constraints, lack of animal

feeds was the primary factor for all agro-ecologies that ranked first have an index value 0.31, 0.35 and 0.33 for highland, midland and lowland respectively. Followed by Shortage of grazing land was the second constraints for each agro-ecologies that ranked second with an index value 0.27, 0.34 and 0.32 for highland, mid land and low land areas respectively. However, the third most important constraint for highland was parasites and diseases have index value 0.24, and for both mid and low land was lack of drinking water index value 0.20. An improved private grazing property with little productivity and communal off-farm areas in the district have an average size of 0.2± 0.32 hectares, making them suitable for animal feed production (table7).

Table 7. Major constraints of Livestock production in the study area

Livestock production Constraints	Rank (% of respondent) top 4						
	1st	2nd	3rd	4th	Score	Index	Rank
Highland							
Shortage of feed	66.7	20.8	8.3	4.2	350	0.31	1
Shortage of grazing land	29.2	54.2	4.2	12.5	300.3	0.27	2
Parasites. &Diseases	4.2	16.7	25.0	0	268.1	0.24	3
Lack of drinking water	0	8.3	62.5	29.2	179.1	0.16	4
Midland							
Shortage of feed	57.1	31.0	9.5	2.4	342.8	0.35	1
Shortage of grazing land	31.0	64.3	4.8	0	326.5	0.34	2
Lack of drinking water	2.4	9.5	69.0	19.0	195.1	0.20	3
Parasites. &Diseases	4.8	0	19.0	76.2	133.4	0.13	4
Lowland							
Shortage of feed	53.7	28.4	10.4	7.5	328.3	0.33	1
Shortage of grazing land	34.3	58.2	6.0	1.5	325.3	0.32	2
Lack of drinking water	4.5	13.4	64.2	17.9	204.5	0.20	3
Parasites.&Diseases	3.0	1.5	22.4	73.1	134.4	0.13	4

Index = sum of (4*ranked 1st + 3* ranked 2nd +2* ranked 3rd +1* ranked 4th)/ for individual constraint divided by the sum of (4*ranked 1st + 3* ranked 2nd +2* ranked 3rd +1* ranked 4th) for overall reasons

4.2. Beekeeping practices and honey ‘crop’ production system

4.2.1. Source of bee colonies

These findings of the study indicate that the main sources of bee colonies were indicated by respondents Catching swarms bee colonies is the most common foundation source of bee colonies in the study area, accounting for 38% of the colonies. Buying bee colonies is the second most common foundation source, making up 37.7% of the colonies. Bee Colonies obtained from parents account for the smallest proportion at 24.3 %.(table 8) This result was

contradicted with the finding of (Addisu, 2017) who reported that Different sources of starter bee colonies in south Wollo zone, Amhara region 45.19% , 17% and 17 swarm caching ,from parent and buying respectably and also (Guesh, *et al* , 2018) who reported that The result indicated that majority of the beekeepers obtained their establishing colonies by purchasing (61.7%) gift from parent (22.4%) and through catching swarms (15.9%)

In general , the majority of bee colonies in the study area are established through acquiring swarms or purchasing colonies, rather than inheriting them from parents. This suggests that beekeepers in the study area rely heavily on external sources to build up and maintain their bee colonies, rather than relying on colony reproduction within their own apiaries

The majority of respondents (38%) claimed that their transitional and frame hive colonies were formed via collecting swarms during the swarming season (Table 8). It indicates that swarming of bees remains a source of foundation stock and starter for the majority of beekeepers.

Table 8. Sources of bee colony

Variables (%)		Agro-ecology			
		Highland (n=24)	Midland (n = 42)	Lowland (n = 67)	Overall (N=133)
		percentage			
sources of colony in study area	From parents	29.2	21.40	22.4	24.3
	Catching swarms	29.7	142.9	41.8	38
	Buying	41.7	35.7	35.8	37.7

4.2.2. Beekeeping practices and number of colonies

The survey result shows that depending on the technological advancement, beekeeping in the study area had taking place in three different production practices. Those are the traditional hive beekeeping practice owned by 133 participants with 6.72±3.12 colonies in traditional or local hive, the second transitional hive beekeeping practice which is owned by 15 participants with 0.27±0.50 colonies of top bar hives and the third frame hive beekeeping practice that owned by 13 participants with 0.29±0.48 frame hived (box hive) colonies.

In the highland region, there are an average of 4.62 traditional hive colonies, 0.62 transitional hive colonies, and 0.75 frame hive colonies. In the midland region, there are an average of 7.21 traditional hive colonies, 0.21 transitional hive colonies, and 0.14 frame hive colonies. In the lowland region, there are an average of 8.35 traditional hive colonies, no transitional and frame hive colonies (Table 9) Overall, taking all regions into account, there is an average of 6.72 traditional hive colonies, 0.27 transitional hive colonies, and 0.29 frame hive colonies.

These numbers indicate the current distribution and prevalence of different hive types in the respective ecological regions, providing insights into the beekeeping practices in each region. It indicate that there are significant differences in the number of traditional, transitional, and frame (modern hive) hive colonies. Between the Highland region and the other two regions. The Midland region also shows significant differences in the counts of traditional hives, transitional hives, and frame hives compared to the Lowland region. ($P < 0.05$).

Table 9. Number of colonies owned in different agro-ecology

Type of bee hive	Agro-ecology				
	Highland (n=24	Midland (n = 42)	Lowland (n=67)	Overall (N =133)	P-Value
	Mean ±SD				
Traditional hive	4.62±1.76[b]	7.21± 3.71[a]	8.35±3.90[a]	6.72±3.12	0.000
transitional hive	0.62±0.87[a]	0.21± 0.64[b]	0.00±0.00[b]	0.27±0.50	0.000
modern hive	0.75±0.98[a]	0.14±0.47[b]	0.00±0.00[b]	0.29±0.48	0.000

[a, b] Means followed by different superscript letters within a raw are different at $P<0.05$,and the same letters within the row indicate NS (non-significant difference)

4.2.3. Traditional hive construction material

Across all three agro-ecological zones, mud was the first rank used for traditional hive construction material. (Table 10).This suggests that mud was the preferred and most widely adopted material for traditional beehive construction in the study region.

Bamboo was used as the second rank for hive construction material in all agro ecology zone. Compared to mud and also bark tree was the last rank or index in all three agro ecology.

Table 10. Traditional hive construction Materials.

Variables	Rank (% of respondent) top 3					
	1st	2nd	3rd	Score	Index	Rank
	Highland					
barck tree	4.2	0	95.8	108.4	0.17	3
Mud with straw	83.3	12.5	4.2	280.6	0.43	1
Bambo with mud	53.3	42.5	4.2	249.1	0.39	2
	Midland					
barck tree	7.1	9.5	83.3	123.6	0.20	3
Mud with straw	90.5	4.8	4.8	285.9	0.47	1
Bambo with mud	0	88.1	11.9	188.1	0.31	2
	Lowland					
barck tree	0	14.9	85.1	114.9	0.18	3
Mud with straw	98.5	1.5	0	198.5	0.30	2
Bambo with mud	1.5	85.1	13.4	228.4	0.35	1

4.2.4. Honey yield per year and bee colony price

As the study revealed that the average honey yield for three types of hives (traditional, transitional, and framed) was 8.69±3, 13.37±3.30, and 15.05±4.5 kilograms per year (Table 11). The current result is higher than the result reported by (Addisu, 2017) the amount of honey produced from traditional, transitional, and frame hive were 5.99±18.2, 7.86±13.24, and 14.47±69.88 kg per hive respectively at Dessie Zuria and Kalu South Wollo Zone. However, the current results agree with (Wakshuma *et al.*, 2023) who reported honey production from traditional and transitional hive is 8kg/hive and 13kg/beehive respectively,

The maximum amount of honey harvested from traditional, top bar, and frame hives were 14, 17 kg and 22 kg, respectively, while the minimum were 3 kg, 5.5 kg, and 8 kg.

The mean honey production in the Highland (6.91 kg) is significantly lower than both the Midland (10.33 kg) and Lowland (8.83 kg) regions ($p < 0.05$). but There were no significant difference between the Midland and Lowland regions in terms of traditional hive honey production.in Transitional hive honey production there is no significant difference between the Highland (10.62 kg) and Midland (10.79 kg) regions and the mean honey production in the Lowland region (13.37 kg) is significantly higher than both the Highland and Midland regions ($p < 0.05$).Regarding the Modern (frame) hive honey production, there is no significant difference in mean honey production between the three regions (Highland, Midland, and Lowland).The mean current price of bee colonies is highest in the highland region (1866.7 ± 572.30), followed by the midland region (1830.95 ± 415.25) and the lowland region (1726.86 ± 338.70). There is no statistically significant difference in the current bee colonies price between the three regions (Highland, Midland, and Lowland)

Table 11. Honey yield per year and colonies price in Dehana district

Variables	Agro-ecology				
	Highland (n=24)	Midland (n = 42)	Lowland (n = 67)	Overall N=133	P-Value
	Mean ±SD				
Traditional hive	6.91±2.24[b]	10.33±3.97[a]	8.83±2.79[a]	8.69±3	0.000
Transitional hive	10.62±2.65	12.45±4.00	10.79±3.26	13.37±3.30	0.050
Modern hive	15.66±4.38	15.09±4.58	14.41±4.54	15.05±4.5	0.397
bee colonies price	1867±572.3	1831±415.3	1726.9±338.7	1808±442.1	0.408

[a, b] Means followed by different superscript letters within a raw are different at P<0.05,and the same letters within the row indicate NS (non-significant difference

Although the price of one colony has between the minimum 1033.3 and maximum 2500.birr value, and the mean price of one colony is 1808.17±442.08.Birr (Table11). There is no official market in the district to sell the honey bee colony and people sell their colony only for neighbors who know present colony price to determine only by seller and buyer agreement.

4.2.5. Honey harvesting time and Frequency

The two distinct harvesting seasons in a year are the first major harvesting period during Septum- November 91% and the second harvesting during April - June 9%(Table 12). Based on the respondent's interview results of the study, honey was harvested once or twice due to the chance of availability of the binary rains for bee forages. the finding of this study result contradict with the study of (Addisu) who reported that these major harvesting periods, 11.85%, 77.04% and 11.11% of the respondents harvested once, twice and three times a year respectively south Wollo zone, Amhara region.

Table 12. Honey harvesting time and frequency in study area

Variables		Agro-ecology			
		Highland (n = 24)	Midland (n =42)	Lowland (n = 67)	Overall (N=133)
		percentage			
Honey harvesting frequency per year	1 times per year	75.0	71.4	76.1	74.2
	2 times per year	25.0	28.6	23.9	25.8
	Above 2 times	0	0	0	0
Season of Honey harvesting in the study area	Septum- Novem	83.3	97.6	92.5	91
	April – June	16.7	2.4	7.4	9

4.3. Colony management practices

4.3.1. Site of beekeeping practice

As table13 shows a colony placement at various places within each agroecological zone. The back yard is the most common location across all zones (84.7%). followed by inside the home (6.5%) and under the eaves of the house (4.5%). A tiny number of colonies are located on watershed forest (4.3%) (Table 13).This finding is consistent with (Addisu, 2017), who found customary hive installation in the backyards of Dessie zuria and Kalu.

Table 13. Placement of the bee colony in Dehana district

Variables	Agro ecology			
	Highland (n=24)	Midland (n=42)	Lowland (n = 67)	Over all (N=133)
	percentage			
back yard	70.8	95.2	88.1	84.7
Under the eaves of the house	8.3	2.4	3.0	4.5
Inside the house	12.5	2.4	4.5	6.5
In Water shed forests land	8.3	0	4.5	4.3

4.3.2. Type of honey bee colony inspection and supering

Most of beekeepers frequently externally and internally inspect their colonies (Table 14). Across all agro-ecological zones, (95.0%) beekeepers inspect their colonies, while (4.5%) beekeepers do not inspect.

The practice of, hive supering during July-September was reported at 79.2%, dropping to 20.8% during April-June. Conversely in the Highland region, The Midland area, hive supering tallied 92.9% during July-September and 7.2% during April-June. And also in the Lowland region, hive supering were 91.0% for July-September and 8.9% for April-June. Regarding super reduction practices, during December-February, the Highland region exhibited a rate of 29.2%, the Midland region 64.3%, and the Lowland region 71.6%. For the period of March-May, the percentages changed to 70.8% in the Highland region, 35.7% in the Midland region, and 28.4% in the Lowland region.

Table 14. Bee colony inspection and supering

Descriptions		Agro ecology			
		Highland (n=24)	Midland (n = 42)	Lowland (n = 67)	Overall N=133
		percentage			
Do you inspect your colonies	Inspect	91.6	97.6	97.0	95
	No inspect	8.3	2.3	2.9	4.5
Internal inspection	Frequently	28	27.2	48.2	34.5
	Sometimes	13	10	7	10
	Rarely	9	17.8	9.3	8.5
External inspection	Frequently	21	24.4	19.8	21.7
	Sometimes	9	8	8.5	8.5
	Rarely	11.7	9.5	11.3	32.5
Hive supering	July -September	79.2	92.9	91.0	87.7
	app-June	20.8	7.2	8.9	12.3
Super reduction	Decem-February	29.2	64.3	71.6	55
	mar-may	70.8	35.7	28.4	45

4.3.3. Seasonal activities of bee colony swarming and colony feeding

Swarming Season: In the Highland, Midland and Lowland, swarming mainly occurs from July to September, Overall, 99.5% reported swarming between July and September (Table15). The respondents reported using different methods to increase colony numbers. In all agro-ecologies, the majority of beekeepers practiced swarm catching. In the Highland, (45.8%) respondents used swarm catching, while (54.2%) respondents used simple multiplication. In the Midland, (57.1%) used swarm catching, while (42.9%) bee keepers used simple multiplication.

In the Lowland (62.7%) bee keeper used swarm catching, while (34.3%) used simple multiplication. Only a few respondents reported using grafting as a method of increasing colony numbers (Table 15).

Techniques Used to Capture Swarming Colonies: The table presents various techniques used to capture swarming colonies. These techniques include dispersing dust, spraying water, hanging hive (stands tree), and a combination of all techniques. The combination of all techniques was not reported in the Highland, but it was used (40.5%) respondents in the Midland and (38.8%) respondents in the Lowland.

The majority of respondents practiced swarm control. In the Highland, all respondents (100%) reported practicing swarm control, while in the Midland, all respondents (100%) reported the same. In the Lowland, respondents (92.5%) practiced swarm control. Overall, out of 128 respondents, 97.5% practiced swarm control.

Respondents reported using different methods for swarm control. These methods include increasing the hive size, removing developed queen cells, and splitting the colony. In all agro-ecologies, increasing the hive size and removing developed queen cells were the most common methods used for swarm control. The advantages of swarming reported by respondents include increasing the number of colonies, generating sales and income, and replacing nonproductive bee colonies. The percentages vary across the different agro-ecologies, but overall, increasing the number of colonies and generating sales and income were the most commonly reported advantages.

Table 15. Swarming season and Colony feeding

Variables (%)		Agro-ecology			
		Highland (n=24)	Midland (n = 42)	Lowland (n = 67)	Overall (N=133)
		percentage			
Swarming Season	July –September	100	100)	98.5	99.5
	Octo- December	0	0	1.5	0.5
Method of increase colony number	By swarm catching	45.8	57.1	62.7	55.2
	Simple multiplication	54.2	42.9	34.3	43.8
	By grafting	0	0	3.0	1
Techniques used to capture swarming colony?	By dispersing dust	33.3	19.0	19.4	23.9
	by, spraying water	16.7	7.10	6.0	10
	By, hanging h/s tree	50	33.3	35.8	39.7
	The combination of all	0	40.5	38.8	26.4
Practice of swarm control	Yes	100	100	92.5	97.5
	No	0	0	7.5	2.5
Methods to swarming controls?	Increasing the hive size	41.7	57.1	52.2	50.3
	Removing queen cells	45.8	35.7	38.8	40.2
	Splitting the colony	12.5	7.1	9.0	9.5
Advantages of Swarming	increase colony number	29.2	38.1	35.8	34.4
	sale and income	37.5	35.7	29.9	34.4
	Replace nonproductive colony	0	0	4.5	1.50
feeding practice bee colonies	Yes	20.8	30.9	10.4	20.7
	No	79	69	89.5	79.3

During dearth periods, when there is a scarcity of nectar and pollen in the environment, bee colonies may face challenges in finding enough food to sustain themselves. This can lead to a decline in the health and productivity of the colony. Feeding bees during dearth periods is important for several reasons.

The feeding practices for bee colonies in three different agro-ecological regions: Highland, Midland, and Lowland. From the Highland region, (20.8%) stated that they feed their bee colonies, while the remaining 19 (79%) do not. From the Midland region, (30.9%) feed their bee colonies, while 29 (69%) do not. In the Lowland region, (10.4%) feed their bee colonies, and the majority of (89.5%) do not. out of the total 133 respondents, (20.7%) feed their bee colonies, while the majority of (79.3%) do not (Table 15).

Overall, the percentage of beekeepers who feed their colonies is relatively low, with only 20.7% of respondents engaging in this practice. And also respondents explain the critical time of bee colony feeding at drought season from February to June in the study area.

based on the rankings and scores across all three regions, the types of bee colony feed can be ranked as follows (Table 16).Honey: It has the highest overall score and index, making it the

most preferred bee colony feed across all three regions, Sugar: It has the second-highest overall score and index, making it the second preferred bee colony feed. Shiro: It has the third-highest overall score and index. And Besso It has the lowest overall score and index, ranking as the least preferred bee colony feed. Therefore, the overall preference for the bee colony feeds, considering all three regions, is Honey, followed by Sugar, Shiro, and Besso (Table16).

Table 16. Major bee colony feeds in the study area

Variables	Rank (% of respondent) top 4						
	1st	2nd	3rd	4th	Score	Index	Rank
			Highland				
Honey	16.7	16.7	0	12.5	129.4	0.28	1
Ssyrup	0	8.3	33.3	4.2	94.8	0.20	2
Baso	0	8.3	12.5	25.0	74.9	0.16	3
Sugar	29.2	12.5	0	4.2	157.7	0.03	4
			Midland				
Sugar	16.7	16.7	4.8	0	126.5	0.33	1
Honey	19.0	14.3	0	4.8	123.7	0.32	2
Syrup	2.4	2.4	21.4	11.9	71.5	0.18	3
Baso	0	4.8	11.9	21.4	59.6	0.15	4
			Lowland				
Honey	23.9	11.9	1.5	4.5	138.80	0.30	1
Ssyrup	14.9	16.4	3	7.5	122.3	0.26	2
Shiro	3	6	22.4	10. 4	85.2	0.18	3
Baso	0	7.5	14.9	19.4	71.7	0.15	4

Index = sum of (4*ranked 1st + 3* ranked 2nd +2* ranked 3rd +1* ranked 4th). For individual reasons divided by the sum of (4*ranked 1st + 3* ranked 2nd +2* ranked 3rd +1* ranked 4th) for overall reasons

4.3.4. Honey straining and storage practice

Out of all the respondents, only (8.1%) strained their honey before marketing it. They used both traditional and frame hives to obtain their honey; they strained it using the simple decantation method and sold it locally for a higher price (604.39±61.96.birr). Out Of the total respondents, about 91.9% had to unstrained the honey because they lacked the necessary supplies (20%), didn't know how to strain it (28.8%), and thought that the amount of honey would be reduced (37%) in (Table 17).

Nevertheless, straining honey effectively separates it from bee wax, and both the honey and the wax are sold separately, with the separated honey fetching a higher price than the unstrained honey. It takes effective follow-up and awareness-raising to get manufacturers to consistently use the approaches. The unstrained honey is sold immediately to the local market by all other

respondents, for a minimum of 300 and a maximum of 600 birr per kg (Table 17). A kilogram of honey costs, on average, 386.4±71.44 birr. The price of honey determine by between suppliers and consumers. Because of the district's periodicity in honey production, price fluctuations during different seasons are prevalent.

Table 17. Staining and storage of honey in Dehana District

Variables		Agro-ecology			
		Highland (n=24)	Midland (n=42)	Lowland (n=67)	Over all (N=133)
		percentage			
Do you strain your honey?	Yes	12.5	11.9	0	8.1
	No	87.5	88.1	100	91.9
Materials used For straining?	Honey extractor	0	0	0	0
	Honey presser	12.5	11.9	0	8.1
	Sieve	0	0	0	0
If you don't Strain your honey why?	Lack of materials	33.3	14.3	13.4	20
	Lack of knowledge	54.2	19.0	13.4	28.8
	reduced honey	0	54.8	56.7	37
How long do you Store your honey?	do not store honey	25.0	9.5	10.4	14.9
	1-3months	50	47.6	47.8	48.4
	4-6 months	25.0	33.3	35.8	31.3
	Above 6 month	0	9.5	6.0	5.1
Reasons store honey	Due to price	75.0	90.5	89.6	83.5
Containers used honey collection and Storage?	Plastic container	50	66.7	67.2	61.3
	Clay jar	37.5	19.0	17.9	24.8
	Metallic Container	12.5	14.3	14.9	13.9
		Mean ±SD			
The price of 1kg honey	Strained honey	621.3±14.5	598±87.3	594.1±84.1	604.4±62
	Non strained honey	395±79.61	382.4±69.5	382±65.3	386.4±71.4

Honey is held for a long time to obtain a better price when there is an abundance of honey on the market at harvest season, unless the beekeeper is facing serious financial difficulties. The replies varied in how long they kept their honey. About 14.9% of those surveyed stated they didn't store, that they would sell it right away after harvest or use it while harvesting; the remaining 48.4% stated they stored it for one to three months, the next three to six months (31.3%), and the longest period six months (5.1%) (Table 17).

Traditionally beekeepers used different storage containers for different storage duration. 61.3%, 24.8% and 13.9% of the respondent used commonly plastic jar clay pots and metallic container, respectively. (Table 17) According to (Abebe, 2017) plastic container is the ideal storage material for the quality of honey. But the clay pot may pass and absorb the moisture and bad smell from the atmosphere due to the hygroscopic nature of the honey. According to the Ethiopian honey quality standard (ES1202:2005) storage containers made of improper

material shall be coated completely with bees wax or food grade plastic lines to avoid any direct contact between honey and the container.

4.4. Constraints and opportunity of bee keeping practice

4.4.1. Major honey bee plant species and water resources

In explained that beekeepers cultivate a variety of plants that aid in providing nectar and pollen to bees at different times of the year. As a result, during the honey flow season, the primary sources of pollen and nectar are the major field crops grown in the district: sorghum (Sorghum bicolor), maize (Zea mays), teeff (Eragrostic abicinicus), barley (Hordeum vulgare), wheat (Triticum aestivum), oil seeds of nuge (Guitozia abyssinica), Gomenezer (Brassica Spp), bean, pea Shembera (Cicer artietinum), and lentil (Lens culiaris).

Table 18. Major honeybee plant species and flowering time.

Local name	Scientific name	Plant type	Flowering period											
			Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
Wanza	*Cordia africana*	T			■	■	■							
Bisana	*Croton macrostachyus*	T								■	■			
Girar	*Acacia bussei*	T									■	■		
Kulkual	*Euphorbia abyssinica*	T			■	■	■							
Kinchib	*Euphorbia tirucalli*	T							■	■	■			
Eriet	*Aloe Vera*	S		■	■									
Agam	*Carissa spin arum*	T											■	■
Qurqura	*Ziziphus spinachristi*	T											■	■
Zikakibe	*Ocmum basilicum*	H			■	■								
Tenadame	*Ruta chalepensis*	H				■								
Adey abeba	*Biden spp*	H		■	■									
Embuay	*Solanium indicum*	S			■	■	■	■						
Cheba	*Acacia nilotica S*	S		■	■									
Ekima	NI	T	■	■										
Alqaza	NI	T	■	■										
Telba	*Linum vsitatissiumum*	H			■	■								
Kitkita	*Dadonaea viscosa*	T				■	■	■						
Mentesie	*Becium grandiflorum*	S		■	■								■	■
Endod	*Phytolacca dodecandra*	S							■	■	■	■		
Dedeho	*Euclea shimperi*	T				■	■	■						
Quliza	NI	H		■	■									
Key Bahir zaf	*Eucalyptus spp*	T								■	■	■	■	
Embacho	*Rumex nervosu*	S					■	■						

T= tree, S= shrub, H=herb, NI = Not identified

According to the respondents Answer shows that 72.4% of beekeepers stated that water is always available for their honey bees, while 28% stated that water is not available, according to the respondents' answers. Only 41.7% of beekeepers in the lowland region and 87.5% of those in the highland and midland regions, respectively, reported having water available for their colonies. Most beekeepers reported that their honey bees receive 43.5%, 26.4%, and 2.6% of their water from streams, ponds, and reverse ponds, respectively (Table 19).

When asked how they provide water to their colonies, beekeepers who reported that their colonies lack water mostly responded with 58.2% in the highland region, 11.9% in the midland region, and 39% in the lowland region (Table 19). In general, the table indicates that different regions have different water availability for bee colonies; highland and midland regions generally have better access to water than lowland regions; most beekeepers rely on rivers and ponds as their primary sources of water, with a smaller percentage depending on streams; in situations where water is not naturally available, a significance number of beekeepers use artificial water supplies to meet their colonies' water needs.

Table 19. Water accessibility for bee colony in Dehana District

Access of water for bee colony		Agro-ecology			
		Highland (n=24)	Midland (n=42)	Lowland (n=67)	Over all (N=133)
		percentage			
Does water available for your honey bees at all the time	available	87.5	88.1	41.7	72.4
	Not available	12.5	11.9	58.2	28
Source of water	Rivers	45.8	54.8	29.8	43.5
	Ponds	41.7	28.6	8.9	26.4
	Stream	0	4.8	3.0	2.6
how do you provide water to your bee colonies	Artificial water supply	12.5	11.9	58.2	28

4.4.2. Current Opportunity of Bee keeping practice in the study area**.**

The major opportunities in the study area urbanization/human population, good market price, watershed development strategy, expert follow-up and access to native honey bees. Urbanization and population growth are the top-ranked opportunities, followed by good market price in all agro ecologies

Across all zones, urbanization and good market prices are consistently ranked highly, suggesting a strong demand for honey and the potential for urban beekeeping in all agro ecologies. Watershed development strategy is also a significant opportunity, particularly in the Midland zone, highlighting the crucial role of beekeeping in maintaining healthy ecosystems. While access to native honey bees is important, it ranks lower than other opportunities, suggesting a need for further exploration of beekeeping practices that support native populations. Expert follow-up and support are consistently ranked lower, indicating a need for improved access to resources and guidance for beekeepers.

Table 20. Opportunities of bee keeping in Dehana District

bee keeping opportunities	Rank (% of respondent) top 5							
	1st	2nd	3rd	4th	5th	Score	Index	Rank
				Highland				
Urbanization/human population	0	0	8.3	33.3	50	141.1	0.37	1
Good market price	16.7	25.0	25.0	20.8	0	961.7	0.25	2
Watershed development strategy	45.8	25.0	16.7	16.7	0	520.9	0.13	3
Expert follow up and supports	25.0	8.3	50.0	16.7	0	441.6	0.11	4
Access of native honey bee	12.5	41.7	0	12.5	33.3	387.6	0.10	5
				Midland				
Watershed development strategy	45.2	21.4	23.8	7.1	0	497.1	0.20	1
Good market price	31.0	33.3	9.5	14.3	0	445.3	0.19	2
Urbanization/human population	19.0	7.1	40.5	11.9	14.3	704.2	0.18	3
Access of native honey bee	7.1	21.4	7.1	21.4	33.3	318.3	0.13	4
Expert follow up and supports	0	14.3	4.8	42.9	31.0	237.1	0.09	5
				Lowland				
Urbanization/human population	40.3	23.9	22.4	11.9	0	488.1	0.23	1
Watershed development strategy	26.9	23.9	9.0	19.4	0	396	0.19	2
Good market price	16.4	14.9	38.8	10.4	10.4	389.1	0.18	3
Access of native honey bee	17.9	20.9	6.0	17.9	31.3	358.2	0.16	4
Expert follow up and supports	0	14.9	6.0	34.3	37.3	283.5	0.13	5

(5* ranked 2nd +4* ranked 3rd +3* ranked 4th +2* ranked 5th +1* ranked 5th+). For individual reasons divided by the sum of (5*ranked 1st + 4* ranked 2nd +3* ranked 3rd +2* ranked 4th +1* ranked 5th) for overall reason

4.4.3. Major beekeeping constraints

The major constraints affecting beekeeping in three different regions: Highland, Midland, and Lowland. The constraints are ranked based on the percentage of respondents who identified them as significant issues. Agroecological 20%, 13%, 21%, 16%, 20%, and 6% Lack of bee forage, lack of water, Agrochemicals, Drought, paste and predator and bee diseases are the major constraints respectively. This result Comparable with the results of (Addisu, 2017) indicated the causes of absconding and swarming. The constraints faced by beekeepers vary across the different regions. While some constraints, such as lack of bee forage and agrochemicals, are common concerns in all three regions, (Table 21).the severity and ranking of other constraints differ. Understanding these constraints can help beekeepers and relevant stakeholders address the specific challenges faced in each region to support sustainable beekeeping practices. Similarly reported at The Current Constraints and opportunities of Beekeeping in Ethiopia of results indicated prevalence of pests and predators, pesticide

poisoning and declining bee forage are major constraints for beekeeping production respectively (siraj , *et al.*, 2021).

Table 21. Major bee keeping practice constraints

Major constraints	Rank (% of respondent) top 6								
	1st	2nd	3rd	4th	5th	6th	Score	Index	Rank
				Highland					
Lack of bee forage	45.8	25.0	16.7	16.7	0	4.2	520.9	0.13	3
Lack of water	12.5	41.7	0	12.5	33.3	0	387.6	0.10	5
Agrochemicals	16.7	25.0	25.0	20.8	0	12.5	961.7	0.25	2
Drought	25.0	8.3	50.0	16.7	0	0	441.6	0.11	4
Pests and predators	0	0	8.3	33.3	50	8.3	1431.1	0.37	1
Honey bee Diseases	0	0	0	8.3	16.7	75.0	133.3	0.03	6
				Midland					
Lack of bee forage	45.2	21.4	23.8	7.1	0	2.4	497.1	0.20	1
Lack of water	7.1	21.4	7.1	21.4	33.3	9.5	318.3	0.13	3
Agrochemicals	31.0	33.3	9.5	14.3	0	11.9	445.3	0.18	2
Drought	19.0	7.1	40.5	11.9	14.3	7.1	704.2	0.18	2
Pests and predators	0	14.3	4.8	42.9	31.0	7.1	237.1	0.09	4
Honey bee Diseases	0	0	16.7	4.8	19.0	59.5	178.7	0.07	5
				Lowland					
Lack of bee forage	40.3	23.9	22.4	11.9	0	1.5	488.1	0.23	1
Lack of water	17.9	20.9	6.0	17.9	31.3	6.0	358.2	0.16	4
Agrochemicals	26.9	23.9	9.0	19.4	0	20.9	396	0.19	2
Drought	16.4	14.9	38.8	10.4	10.4	9.0	389.1	0.18	3
Pests and predators	0	14.9	6.0	34.3	37.3	7.5	283.5	0.13	5
Honey bee Diseases	0	0	19.4	7.5	19.4	53.7	192.6	0.09	6

Index = sum of (6*ranked 1st + 5* ranked 2nd +4* ranked 3rd +3* ranked 4th +2* ranked 5th +1* ranked 6th) for individual reasons divided by the sum of (6*ranked 1st + 5* ranked 2nd +4* ranked 3rd +3* ranked 4th +2* ranked 5th +1* ranked 6th) for overall reasons

4.4.4. Prevalence of pests and predators

By analyzing the scores, indices, and rankings, we can see the relative significance of each pest or predator within its respective region. Termites and birds consistently rank high across all regions, indicating their importance as threats to beekeeping. Spiders are also a concern, although their impact is generally lower. Hama got/shelemetmat is identified as a significant issue in all regions but is not ranked as the highest threat. The respondents agreed that on the most important enemies of bees around the district are Ants (28%), Birds (26%) Hamagote (shelemetmat) (24%) and Spiders (18%) (Table 22). Ants are most wearisome to honey bees and bee keeping sector.

Table 22. Predator of bee in the District

Pests and predators	Rank (% of respondent) top 4						
	1st	2nd	3rd	4th	Score	Index	Rank
			Highland				
Terbites	41.7	8.3	41.7	8.3	283.4	0.28	1
Birds	16.7	54.2	12.5	16.7	271.1	0.27	2
Hamagot/shelemetmat	33.3	16.7	20.8	29.2	254.1	0.25	3
Spiders	8.3	20.8	25.0	45.8	191.4	0.19	4
			Midland				
Terbites	31.0	28.	35.7	4.8	286	0.28	1
Birds	21.4	47.6	16.7	14.3	276.1	0.27	2
Hamagot/shelemetmat	35.7	9.5	23.8	31.0	249.9	0.24	3
Spiders	14.3	14.3	21.4	50.0	192.9	0.19	4
			Lowland				
Birds	28.4	46.3	14.9	10.4	292.7	0.29	1
Terbites	29.9	31.3	34.3	4.5	286.6	0.28	2
Hamagot/shelemetmat	32.8	10.4	29.9	26.9	249.1	0.24	3
Spiders	10.4	11.9	22.4	55.2	177.3	0.17	4

4.4.5. Major honey bee Disease

Highland locations had a lower prevalence of Abriq (miche) at 28%, whereas midland areas have a higher percentage at 43%.Altitude and the prevalence of Abriq (miche) appear to be positively correlated, with higher prevalence found at lower altitudes.

Highland areas had a higher prevalence of brood disease (72%) than lowland and midland habitats (57%) and 62%, respectively. Higher altitudes appear to have a higher occurrence of Brood disease, suggesting a negative link between altitude and latter.

The overall prevalence of Abriq (miche) is 36.3%, while Brood diseases have an overall prevalence of 63.7%. Brood diseases are more prevalent overall compared to Abriq (miche).

Table 23. Common bee diseases in the study area

Descriptions	Agro ecology			
	Highland n=24	Midland n=42	Lowland n= 67	Over all N=133
	percentage			
Abriq (miche)	28	38	43	36.3
Brood diseases	72	62	57	63.7

4.4.6. Toxic plant species for bees

According to the respondents' responses, all agroecological zones in the research region contain plant species that are hazardous to bees. The specific hazardous plant species that are listed are

"Merez, Dikuan tilla, Kinchib and Kalkalda which are toxic to honey bees and cause toxicity in honey products." It has been claimed that the honey generated from the nectar of these plant species that have a negative effect on honeybees and bee products. Dikuntila and Kalkalda are the most dangerous plants for bees because these plants have sticky glue. Beekeepers identified 2 major tree species, and 2 species of shrubs, as poisoning plant species in their surroundings as indicated in (Table 9). This finding line with the study, (Aregawi, *et al*, 2018) who reported at Honeybee poisoning plants in north- east dry land areas of Amhara National Regional

Table 24. Toxic plant in the study area

Local Name	Scientific name	plant type	Flowering calendar	Effect on	
				Bees	Beehive products
Dikuan tilla	Verbena officinalis	Herbs	July-September	✓	
Kinchib	Euphorbia tirucalli	Tree	Year round	✓	✓
Kalkalda	Euphorbia spp	shrub	Year round	✓	
Merez	Not identified	Tree	September		✓

4.4.7. Chemical poisoning of honey bees and honey Production Purposes

The kebelie animal production expert who responded also mentioned whether or not their hives influence the frequency of chemical poisoning. The various pesticides employed in the district have caused harm to their colonies. This outcome is consistent with the findings of (Addisu, 2017), who discussed the various threats to bees and their products.

The detailed information on the application of agrochemicals in various agroecological zones. With percentages ranging from 91.7% to 92.9% across the zones, the majority of respondents stated that they used agrochemicals in their communities (table 24).48.3% of respondents cited crop pest management as the primary justification for using agrochemicals, while 17% cited weed control. There was variation in the timing of pesticide use; 59% of reports placed the largest percentage in July and August (table 24). A variety of agrochemicals were employed, the most often mentioned being insecticides and herbicides. Without any restrictions, the beekeepers and their neighbors employed insecticides to control weeds, pests, and malaria in 48.3%, 17%, and 26.5% of the areas close to the apiary hives, respectively.

Table 25 .The effect of agro chemical and purpose of honey production in the study area.

Variables (%)		Agro ecology			
		Highland (n=24)	Midland (n=42)	Lowland (n= 67)	Over all (N=133)
		percentage			
Do you apply Agrochemicals?	Yes apply	91.7	92.9	91.0	91.9
	Not apply	8.3	7.1	9.0	8.1
Why do you apply agrochemical/chemicals	Malaria control	0	16.7	62.7	26.5
	Crop pest control	66.7	61.9	16.4	48.3
	Weed control	25.0	14.3	11.9	17
When do you use agro-chemicals (months)?	July –August	50	64.3	62.7	59
	September-October	41.6	26.2	26.9	31.5
	May –June	0	2.4	1.5	1.3
Type of agrochemicals are using?	Herbicides	45.8	23,8	20.9	30.2
	Pesticides	45.8	54.8	14.9	38.5
	Insecticides	0	14.3	55.2	23.2
purpose of honey production	Only sealing	33.3	23.8	56.7	38
	Self-consumption &sealing	66.6	76.2	43.3	62
Where your honey products are selling	Farm gate	0	11.9	19.4	10.5
	Local market	100	88	80.6	89.5
	National market	0	0	0	0

Out of all respondents, 56 individuals (38%) produce honey only for sealing purposes. Self-consumption and sealing: A larger number of respondents, 77 individuals (62%), produce honey for both self-consumption and sealing.

The majority of respondents, 115 individuals (89.5%), was directly sold at local market and some 10.5% of them are sold at their farm gates (Table 24). The majority of respondents engage in honey production for both self-consumption and sealing purposes. The primary market for selling honey products is the local market, while no respondents indicated selling honey in the national market. Farm gate sales are less common, with only a small percentage of respondents opting for this distribution channel. Though the district beekeeping practice is carried out as a sideline activity to other income sources. There are no any market information sources about seasonal price and place of the products to sell. Actually it is very necessary to feed those beekeepers to gain fair price at the correct marketing time.

4.5. Chemical Composition of Honey

4.5.1. Moisture Content of honey

The amount of moisture in honey determines its quality, stability, and resistance to deterioration as well as its ability to withstand granulation and yeast fermentation.

Fermentation during storage results from the extraction of immature and unprocessed honey, as well as from collecting during wet seasons. It is dependent upon the geographic origin during, relative humidity, and temperature. The refractive index can be measured using an oven drying method or a refractive index Refractometer at 20 degrees Celsius.

The moisture content in the highland, midland, and lowland honey sample mean value were 17.82±1.26, 16.61±1.95, and 16.14±0.95 respectively (Table26). The overall mean value moisture content of honey sample were 16.85±1.57 in the Dehana district. The results indicated that honey produced from the highland agro-ecology is comparatively higher moisture content than honey produced from midland, and low land areas. There is significance differences ($p < 0.05$) in moisture contents were observed among honey samples obtained from highland, midland, and lowland area of the study. The average result of Dehana district honey sample moisture content had consistency with the national and international standard limits.

The moisture content of honey in this study ranges from 13.90 to 19.70 with the mean of 16.85±1.57 (Table 26). All of the honey samples in the study had moisture content within the accepted range of both the world as well as the national standard level. The current result is line with (Tlahun, et al, 2023). Who reported at Physico-chemical characteristics of honey produced from northeastern Ethiopia? But the results disagree with a result of (Getachew, 2020) and who reported at the moisture content (%) in the investigated samples ranged from Gura Ferda District, south bench district, and North bench district an overall range between19.33 and 22% with a mean value of 20.80% in bench sheko zone southern Ethiopia.

4.5.2. Free acidity

The other quality criterion of the honey is acidity of the honey. Acidity of the samples honey analyzed for this study range from 22.37±5.73 meq acid/kg in the Midland zone to 27.18 ± 4.68 in the Lowland zone (Table 26). The overall mean free acidity is 24.27 ± 5.76% and the p-value for free acidity is (0.138), which is greater than the significance level of ($p > 0.05$). This suggests that the differences in free acidity among the three agro-ecological zones are not statistically significant. In this result the acidity of honey samples fulfilled within the World and the Ethiopian accepted national standard quality level (less than 40 meq. acid/kg of honey). The results indicated that honey produced from the Lowland agro-ecology is slightly higher acidic nature than honey produced from highland Midland agro-ecology areas. The acidity of honey observed in this study is disagree with the study result of Characterization of Beekeeping System and Evaluation of Honey Quality in Tehulederie District of South Wollo Zone, range from 19.5 to 25.5meq acid/kg with mean of 22.3 meq. Acid/kg (Abebe, 2017) and the current

result lined with (Addis, et al., 2014) who reported at Chemical Analysis of Honey and Major Honey Production Challenges in and Around Gondar, Ethiopia free acidity range with a mean value of 23.9 meq/kg).

4.5.3. Reducing Sugar Content

The overall mean value of reducing sugar contents of the studied honey samples were 66.44±1.53 meq/kg for Dehana district. Positioned with in recommended range 60% to 70% by Codex Almentarious commission, (2001). There is no significance differences ($p > 0.05$) in reducing sugar contents were observed between honey samples obtained from highland, midland, and lowland area of the study (Table 26). The p-value for reducing sugar content is (0.340), which is greater than the significance level of ($p > 0.05$). This study result different with (Tlahun, et al., 2023) who Reported at Physico-chemical characteristics of honey produced from North eastern Ethiopia Physicochemical properties of honey samples collected from Traditional hive types reducing sugar content range from 47.2-60.44 and the overall Mean 52.3±4.5meq/kg.

4.5.4. Hydroxyl methyl furfural (HMF)

HMF, or hydroxyl-methyl-furfural, is one of the most crucial factors in determining the quality of honey. HMF is only found in trace amounts in new honey; as honey is stored and heated for an extended period of time, its concentration rises. The quality of honey decreases with increasing HMF level. An aldehyde called HMF is produced when fructose breaks down in an acidic environment. High amounts of HMF are the result of improper storage, adulteration with sugar additions, or extreme heat treatment; they occur naturally over time in most honeys. HMF levels in freshly extracted honey are less than5 mg/kg (Rohini Sharma, 2023,).Metal containers and sources of honey flowers are important variables that impact HMF levels in addition to storage conditions. A maximum of 40 mg kg-1 of HMF is allowed in honey, according to the Codex Alimentarius Standard Commission.

The HMF mean values of honey obtained in this study were 5.85±3.39 and with range 0.75-14.13 mg/kg. The p-value for HMF is 0.010, which is less than the significance level (Table 26).This indicates that there is a statistically significant difference in the HMF content among the three agro-ecological zones. The overall mean HMF content of honey from the study area is by far lower than the national average (40 mg/kg).The low HMF content of honey produced in the study area indicates its freshness and the good honey handling practice of the area.

4.5.5. Ash Content

Minerals, after burning honey, remain as ash. The ash content of the honey samples obtained from the study area for highland, midland, and lowland area were 0.15±0.03, 0.12±0.04, and 0.17±0.19 respectively. The average content of ash was (0.15±0.11). The result was within the acceptable limits of QSAE (0.6 max), EU (≤0.6) and CAC (≤0.6) standards (Table 26). The content of ash showed difference among the locations ($P < 0.05$) but not between Agro ecology types ($P > 0.05$).The p-value for ash content is 0.56, which is greater than the significance level of (0.05). This suggests that. There is no significance differences in ash contents were observed between honey samples obtained from Dehana districts. This study result more agree with (Hailu, *et al*., 2023) the accepted international limits for the mineral content of honey are within the range of 0.06 to 0.17 g/100 g for the ash content. Hailu *et al*, (2023) *reported* at. Physicochemical and mineral contents of honey from Fitche and Addis Ababa districts in Ethiopia

4.5.6. PH

Honey is naturally acidic No matter where it comes from, honey has an inherent acidic quality because it contains organic acids (especially gluconic, pyruvic, malic, and citric acids), lactones, esters, and certain inorganic ions that give it flavor and stability against microbial deterioration. (Rohini *et al*, 2023,). Variations in pH can result from a variety of factors, including the floristic content and diversity of flowers, bee saliva, enzymatic and fermentative conversion of raw materials, and improper harvesting techniques. Blossom honey is defined as having a pH between 3.5 and 4.5, while honey with a pH above 5 is regarded as being of lower quality. A PH meter is used to measure it.

The mean pH values determined for highland honey samples were 3.82±0.13, midland honey samples were 3.74±0.38, and lowland honey samples were 3.54±0.19. (Table 26) .The overall mean value of PH 3.70±0.27 in Dehana district. The p-value for pH is 0.059, which is slightly greater than the significance level of ($p > 0.05$). This indicates that the differences in pH among the three agro-ecological zones are not statistically significant at the 95% confidence level. This study result agree with (Rohini *et al*, 2023,) and slightly disagree with (Million, *et al*., 2020) Physico-Chemical Analysis of Honey Produced in Bako-Tibe District, Western Showa Zone, Oromia Region, Western Ethiopia.

This result is also within the quality regulation level proposed by Codex (1993) and EU (1974). The pH of honey should be between 3.2 and 4.5 (Bogdanov s., et al., 1997).

4.5.7. Electrical conductivity

The mean electrical conductivity ranges from 0.24 ± 0.08 mS/cm in the Midland zone to 0.34 ± 0.11 mS/cm in the Lowland zone. The overall mean electrical conductivity is 0.28 ± 0.09 mS/cm. and the p-value for electrical conductivity is 0.055, which is slightly greater than the significance level of ($p > 0.05$). This indicates that the differences in electrical conductivity among the three agro-ecological zones are not statistically significant difference (Table26)

Table 26. Chemical Composition of Honey Analysis Result.

Parameter	Agro-ecology				
	Highland n = 10	Midland n= 10	Lowland n = 10	Overall N=30	Test
	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	p.value
MC	17.82±1.26[a]	16.61±1.95[ab]	16.14±0.95[b]	16.85±1.57	0.042
Free acidity	23.26±6.13	22.37±5.73	27.18±4.68	24.27±5.76	0.138
PH	3.82±0.13	3.74±0.38	3.54±0.19	3.70±0.27	0.059
Ash	0.15±0.03	0.12±0.04	0.17±0.19	0.15±0.11	0.566
HMF	3.58±3.00[b]	6.03±2.58[ab]	7.95±3.27[a]	5.85±3.39	0.010
RSC	66.71±1.26	65.85±1.6	66.76±1.69	66.44±1.53	0.340
EC	0.26±0.08	0.24±0.08	0.34±0.11	0.28±0.09	0.055

- [a, b] Means followed by different superscript letters within a raw are different at $P<0.05$,and the same letters within the row indicate Ns (non-significant difference)
- MC= Moisture content EC = Electrical conductivity, HMF = Hydrixymethylfurfural, RSC= Reducing Sugar Content,

4.6. Honey comparison with national and international standards.

The overall analysis suggests that the sample generally meets the established standards for most parameters. However, there are concerns regarding the free acidity and HMF content, which exceed the limits set by EU and QSAE standards 9(Table 27).

Because the honey sample is taken directly from the beehive, so the acidity and HMF levels are low, which indicates that the honey is freshly made.

Table 27. Honey comparison of Dehana district with national and international standards.

Parameters	Overall Range	Overall Mean	Standards		
			CAC	EU	QSAE
Moisture content	13.90-19.70	16.85±1.57	≤21	≤21	21 max.
Free acidity	14.91-34.85	24.27±5.76	≤50	≤40	40 max.
PH	3.20-3.80	3.70±0.27	3.4–6.1	-	-
Ash	02-.65	0.15±0.11	≤0.6g/kg	≤0.6g/k	0.60 max.
HMF	0.75-14.13	5.85±3.39	≤60 mg/kg	≤40 mg/kg	40 max.
RSC	62.46-68.91	66.44±1.53	≥45	≥60	65 min.
EC	0.14-0.52	0.28±0.09	-	-	-

Source: (QSAE) Quality and Standards Authority of Ethiopia (2005) and the study results
CAC = Codex Alimentarius Commission; HMF = Hydrixymethylfurfural; EU = European Union; meq = mill equivalent; QSAE = Quality and Standards Authority of Ethiopia.

4.7. Correlation of honey chemical composition

The study reveals that moisture content in a substance has no strong correlations with other parameters. Free acidity has a weak negative correlation with pH, suggesting that as free acidity increases, pH tends to slightly decrease. Ash has a moderate negative correlation with free acidity, suggesting that as ash content increases, free acidity decreases.

PH has a weak positive correlation with moisture content, suggesting that as pH increases, moisture content slightly increases. Ash has a moderate negative correlation with free acidity, suggesting that as ash content increases, pH tends to decrease.

R. Sugar Content has a weak positive correlation with moisture content, suggesting that as R. Sugar Content increases, moisture content tends to increase. E. Conductivity has a moderate positive correlation with moisture content, free acidity, pH, ash, HMF, and R. Sugar Content.

Table 28. Correlation of honey chemical composition

Parameters	MC	FA	PH	Ash	HMF	RSC	EC
Moisture content	1						
Free acidity	-.032	1					
PH	.072	-.004	1				
Ash	-.060	-.220	-.113	1			
HMF	-.030	.277	-.254	-.021	1		
R. Sugar Content	.298	-.227	.001	.139	-.039	1	
E. Conductivity	.315	-.072	-.120	.128	-.019	.108	1

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusion

Generally the dominance of male respondents (90.5%) suggests beekeeping and related agricultural activities in the study area are largely male-dominated. This gender imbalance may limit the involvement and empowerment of women in these economic activities. The high rate of illiteracy (62.1%) indicates a need for improved access to education and training, which could enhance the respondents' technical and management skills in beekeeping and other agricultural pursuits.

Traditional hives consistently outperform modern and transitional hives in all agro-ecological zones. The highest honey yield for all hive types is observed in the Lowland zone. This suggests that the Lowland zone may be more favorable for honey production.

Traditional hives in the highland areas have the lowest honey yield (6.91±2.24), followed by Lowland (8.83±2.79) and Midland (10.33±3.97). This difference is statistically significant (p-value = 0.000) and transitional hives have the highest yield in the midland areas (12.45±4.00), followed by Lowland (10.79±3.26) and Highland (10.62±2.65). The difference is marginally significant (p-value = 0.050). There is no significant difference in honey yield across the three zones in Modern hives (p-value = 0.397).

The overall results highlight the predominance of traditional hive beekeeping, with limited adoption of transitional and modern hives. The results suggest that there are statistically significant differences in moisture content and HMF content among the three agro-ecological zones, while the differences in the other parameters (free acidity, pH, ash, reducing sugar content, and electrical conductivity) are not statistically significant at the 95% confidence level. Where traditional hives remain the dominant practice In Dehana district. Practically every honey sample in terms of HMF, pH, acidity, reducing sugars, moisture, and ash content. Almost all samples of honey examined over all mean (moisture =16.85±0.95 Ash= 0.15±0.11 sugar reducing =66.76±1.53 Free acidity=24.27± 5.76 acid/kg, HMF= 5.85±3.39mg/kg pH= 3.70±0.27 and electrical conductivity = 0.28±0.09) were within the acceptable range of world and national standard.

According to the study's findings, the majority of beekeepers are unable to receive training in frame hives, transitional bee hive construction, or colony multiplication procedures. The use of materials in the beekeeping system, seasonal colony management techniques, and colony transfer to new, contemporary hives

5.2. Recommendation

- Encourage government and development agencies to prioritize gender-inclusive approaches in their beekeeping extension services and support programs. Because Lowe participation of women in bee keeping practice in the study area.
- The main constraints that hindered beekeeping development should be removed through targeted efforts. Consequently, providing beekeeping equipment and its accessories requires a significant deal of attention because the adoption rate of modern bee hive technology is very low.
- Agrochemical application's impact on honeybees and ways to minimize it should be addressed in order to increase quantity, and quality of honey through better management of traditional hives and the introduction of enhanced (Modern) bee hives.
- It is advisable to investigate bee foraging options such as Planting Drought-Tolerant Bee Forages, Natural Resource Restoration and Providing Accessible Water during drought periods. By implementing a combination of these strategies, beekeepers can enhance the resilience of their honey production systems and mitigate the adverse impacts of drought on bee foraging and honey yields.

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7. Appendix

Appendix 1. Research Questionnaire

Part 1. House hold characteristics (personal information)

. Name of respondent _____kebele_____

1. Gender of the respondent 1.Male 2. Female

2. Age of the respondent A. (20-30) B. (31- 40) C. (41-50) D. (51 and above)

3. Educational status of the respondent

A. Illiterate B. Basic education C. Grade 1-4 D. Grade 5-8 E. Grade 9-12. F- (Higher level)

4. Religion of the respondent

A. (Orthodox) B. (Muslim) C. (Catholic) D. (Protestant) E. (Other)

5. Marital status of the respondent: A. (Married) B. (Single) C. (Widowed) D. (Divorced)

6. Family size set in number

1. Male …….. 2. Female…… 3 total……..

Part 2 Agricultural activity of the respondent

1. Landholding In hectare (h/r)

1. Farmland ……. 2. Forest land…… 3. Grazing land…… 4. Total land holding…….

2. Major crops grown in the study area

No.	Crop type	Area (ha)
1		
2		
3		
4		
5		
6		
7		

3. What are the major crop production problems found in the area? List in order of importance

No	major crop production problems	Rank
1	Shortage of farm land	
2	Drought	
3	Soil fertility loss	
4	Inputs (seed, sfertilizer) shortage	
5	Insects and Diseases:	
6	Shortage of oxen;	

4. What are the major livestock production constraints in the area? List in order of importance

No	major livestock production constraints (problems)	Rank
1	Shortage of feed;	
2	Shortage of grazing land	
3	Lack of drinking water	
4	Parasites. &Diseases;	

Part 3. Beekeeping practices and honey 'crop' production

1. Do you keep honey bees? A. Yes B. No

2. If yes for how many Years in bee keeping experience?

3. How you start beekeeping? A. From parents B. Catching swarms C. Buying

4. If the answer for question 3. Is buying, is there a sale of bee colony in your locality?

A. Yes B. No

5. If yes what is the price of one bee colony? .....ETB.

6. Currently how many honey bee colonies (hives) you owned in number?

A, Traditional…… B. Transitional…… C. Moveable-frame……..

7. What are the major materials used for traditional hive construction in the study area?

A. from bark of tree B. From clay C. From mud D. From straw made E. Others

8. Do you inspect your colonies? A. Yes B. No

9. If yes how inspect your bee Colonies?

A. Frequently B. Sometimes C. Rarely

10. When the following major activities occur in your locality? Mark Like this (√) in the table

No	Activities	Season(s)			
		Aug-Oct	Nov-Jan	Feb-App	May-Jul
1	Hive supering				
2	Super reduction				
3	Honey harvesting				
4	Swarming				

11. Do you feed honey bee colonies? A. Yes B. No

12. What kind of feed you offer to your bees?

No	Type of feed	Ranks
1	Besso	
2	Shiro	
3	Sugar	
4	Honey	
5	Other (Specify)	

13. How much Kg of honey do you harvest from one hive per year?

No	Hive type	Honey production in Kg		
		Max	Min	Average
1	Traditional			
2	Transitional			
3	Modern			

14. How many times do you harvest honey per year

A) 1; B) 2 C) 3 D) 4

15. Where did you keep your colonies?

A. back yard B. Under the eaves of the house C. Inside the house D. Water shed forests land

16. How could you increase your colony number?

A) By swarm catching; B) By simple multiplication techniques; C) by grafting; D) others..

17. What type of techniques is used to capture swarming colony?

A. By, dispersing dust onto swarming colony B.by, spraying water onto swarming colony

C. By, hanging hives on branches of a tree D. Others (specify)……

18. Do you practice swarm control /prevention/? A) Yes B) No

19. If the answer is yes, what methods you used?

A. Increasing the hive size; B. Removing developed queen cells C. Splitting the colony

20. Is swarming advantageous to you? A. Yes B. No

21. If yes what is the reason(s)

A. To increase my number of colony B. To sale and income C. To replace non- productive bee colonies D. others (Specify)

22. Do you strain your honey? A. Yes B. No

23. If yes, what materials do you use for straining?

A. Honey extractor B. Honey presser C. Cloth D. Sieve E. Decantation F. Using hand

24. If you strain, what is the price of 1 kg strained honey? -------- ETB

25. If you don't strain your honey why? (Circle one or more).

A. Lack of materials B. Lack of knowledge how to strain C. Consumer do not prefer strained honey D. The amount of honey will be reduced if strained E. Others specify: ___

26. If you do not strain, what is the price of 1 kg non strained honey? -------- ETB

27. For how long do you store your honey? ……

A. I do not store the honey B. 1-3 months C. 4-6 months D. 7-9 months E. above one year

28. for what reason do you store honey?

A. Due to price B. To increase medicinal value C. Others (explain) ----------

29. What types of containers are used for honey collection and storage?

A. Plastic barrel/jar B. clay jar C. metallic container D. other specify…

30. How to improve your honey quality?

A.to harvest ripe honey B. to use modern honey materials C.by avoiding over smoking on the honey combs D. by cleaning bee hives E. proper honey harvesting time F. the comparison of over all

31. How do you rate the quality of your Honey? A. by color B. smelling C. by its odor D. by testing E. by its thickness f. other (specify)

32. What is the purpose of honey production?

A. For sealing B. For self-consumption C. Other

33. Where your honey products are selling

A. Farm gate B. Local markets C. Cooperatives D. National markets

34. What type of other bee products do you produce? A. Honey and Bees wax B. only honey C. royal jelly D. Bee venom E. pollen F. Bee brood

Part 4. Potential and constraints of apiculture in the area

1. Currently what is the opportunity of bee keeping practice in your locality?

A. Watershed development strategy B. expert follow up and supports

C. Market access and high demands D. Access of native honey bee

E. Government green legacy

2. If there is an increase in trend in the number of bee colonies and honey yield over the years, what are the reasons?

A) Good market price; B. added more bee colonies; C. Use of new technologies; D. Others (specify) _____

3. If there is a decrease in trend in the number of bee colonies and honey yields over the year, What are the causes and Season of occurrence List in order of importance?

No	Causes	Rank	Season of occurrence
1	Lack of bee forage		
2	Lack of water		
3	Drought (lack of rainfall)		
4	Pests and predators		
5	Diseases		

4. What is the major honey Bee plant species (Trees, Shrubs and Herb species), and there flowering time

No	Local name	Scientific name	Plant type	Flowering period					
				Jul - Aug	Sep-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun
1									
2									
3									
4									
5									

T= (Tree) S= (Shrubs) H= (herbs)

5. Is there any plant species which are toxic for bees in the study area? a. Yes b. No

6. If yes mention some of them Scientific Name and Local Name ----------

No	Scientific Name	Local Name	Flowering time
1			
2			
3			

7. Does water available for your honey bees at all the time? 1. Yes 2. No

8. If yes, where do your honey bees get water? (Circle one or more)

A. stream B. rivers c. lakes D. ponds E. water harvesting F. others

9. If your response is No, how do you provide water to your bee colonies? ----------

A. water access around the hive by different dish materials B. supply of water by using human labor C. the combination of all

10. If there is any bee diseases in the study area List in order of importance?

1 ---------- 2……. 3……

11. What are the major pests & predators found in the area that threat your colonies? List in order of importance

No	Pest/predator	Rank	Local control methods
1	Ants		
2	Bee lice		
3	Spiders		
4	Birds		
5	Hama got/shelemetmat		

12. Do you use agrochemicals/chemicals in your locality? A. Yes B. No

13. IF yes, why do you apply agrochemical/chemicals?

A. crop pest control B. weeds control C. malaria control D. tsetse fly control E. others….

14. When do you use agrochemicals/chemicals (months)?

A. Jul –Aug B. Sep- Oct C. Nov- Dec D. Jan- Feb E. Mar- Apr F. May- Jun

15. What type of agrochemicals/chemicals are you using order in ranking?

1. ---------- 2. ---------- 3. ----------

15. Do agrochemicals/chemicals affect your honey bees? A. Yes B. No

16. What is the estimated honey you lose due to the application of agrochemicals/chemicals?

By percent A. 30-50% B. 51- 70% C. 71-90% D. above 90%

17. Have you received any formal training or education in beekeeping? A. Yes B. No

18. If yes, please specify the type of training or education you have received.

1- ---------- 2. ---------- 3. ----------

Compiler Name ----------signature---------- Date----------Time----------

Duration: Starting time ----------Ending time----------

Appendix 2 Table

Table: 1 Relationship of water content of honey to refractive index

Refractive index (20^oc)	Moisture Content (%)	Refractive index (20^oc)	Moisture content (%	Refractive index (20^oc)	Moisture content (%
1.5044	13.0	1.4935	17.2	1.4830	21.4
1.5038	13.2	1.4930	17.4	1.4825	21.6
1.5033	13.4	1.4925	17.6	1.4820	21.8
1.5028	13.6	1.4920	17.8	1.4815	22.0
1.5023	13.8	1.4915	18.0	1.4810	22.2
1.5018	14.0	1.4910	18.2	1.4805	22.4
1.5012	14.2	1.4905	18.4	1.4800	22.6
1.5007	14.4	1.4900	18.6	1.4795	22.8
1.5002	14.6	1.4895	18.8	1.4790	23.0
1.4997	14.8	1.4890	19.0	1.4785	23.2
1.4992	15.0	1.4885	19.2	1.4780	23.4
1.4987	15.2	1.4880	19.4	1.4775	23.6
1.4982	15.4	1.4875	19.6	1.4770	23.8
1.4976	15.6	1.4870	19.8	1.4765	24.0
1.4971	15.8	1.4865	20.0	1.4760	24.2
1.4966	16.0	1.4860	20.2	1.4755	24.4
1.4961	16.2	1.4855	20.4	1.4750	24.6
1.4956	16.4	1.4850	20.6	1.4745	25.0
1.4951	16.6	1.4845	20.8	1.4740	25.8
1.4946	16.8	1.4840	21.0	…..	….
1.4940	17.0	1.4835	21.2	…..	…..

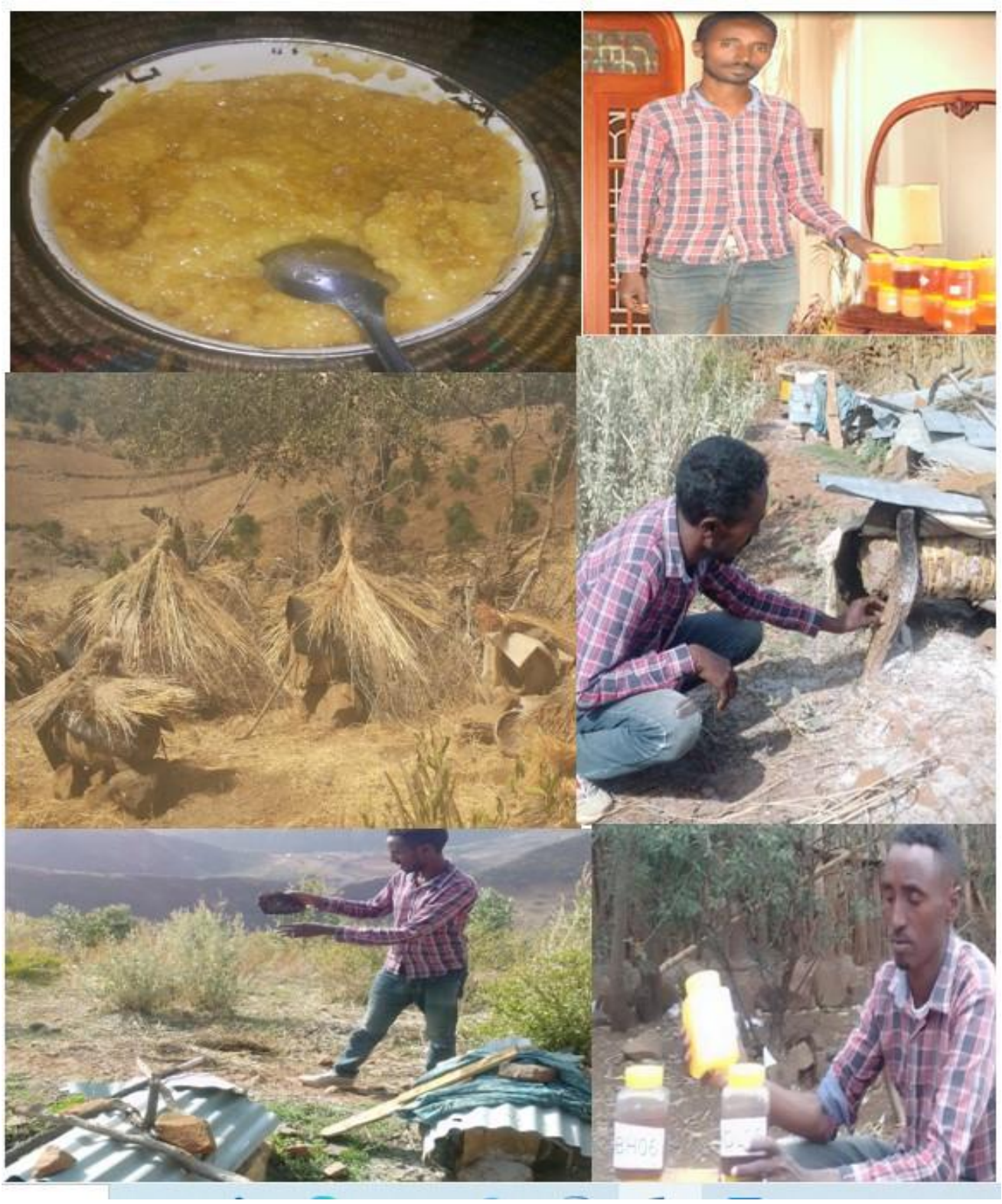
Table: 2 Ethiopian Honey quality standard ES 1202:2005

No	Characteristics	Requirements
1	Reducing sugar % by mass min.	65
2	Water contents % by mass max.	21
3	Mineral content (ash), % by mass max.	0.6
4	Acidity mill equivalents acid per kg	40
5	PH	3.4–6.1
6	Hydroxymethyl furfural content mg/kg	40

Table 3. Honey chemical composition ANOVA Table

Parameters		Sum of Squares	df	Mean Square	F	Sig
Moisture content	Between Groups	15.025	2	7.512	3.582	.042
	Within Groups	56.629	27	2.097		
	Total	71.654	29			
Free acidity	Between Groups	131.486	2	65.743	2.135	.138
	Within Groups	831.313	27	30.789		
	Total	962.799	29			
PH	Between Groups	.416	2	.208	3.148	.059
	Within Groups	1.784	27	.066		
	Total	2.200	29			
Ash	Between Groups	.015	2	.007	.580	.566
	Within Groups	.341	27	.013		
	Total	.356	29			
HMF	Between Groups	95.774	2	47.887	5.450	.010
	Within Groups	237.221	27	8.786		
	Total	332.995	29			
Sugar content	Between Groups	5.257	2	2.629	1.123	.340
	Within Groups	63.194	27	2.341		
	Total	68.451	29			
Electrical Con/y	Between Groups	.053	2	.027	3.245	.055
	Within Groups	.221	27	.008		
	Total	.275	29			

Appendix 3 Figure



The Picture show that different activities at study area.

Honey chemical composition analysis Laboratory Sample



Honey *chemical composition sample*



At beekeepers interview



Traditional bee keeping system in study area



Poor Management practice in Modern hive in the study district.