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Beeswax production and marketing in Ethiopia: Challenges in value chain

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Abstract: Beeswax is one of the most valuable and oldest bee products to be used by mankind and still being used in the development of new products in various fields such as cosmetics, foods, pharmaceuticals, engineering and industry. Ethiopia has huge apicultural resources that made it the leading beeswax producer in Africa, and one of the important beeswax exporter to the world market. In Ethiopia apicultural research is being conducted in a coordinated manner under the national agricultural research system. Hence, a lot of information have been gathered on different aspects of the beekeeping. This work is a review of various research results from published and unpublished data over a long period of time in the area of beeswax production, chemical analysis, marketing and value chain studies in Ethiopia. Despite the country's huge potential for production of high quality beeswax, only less than 10% of the beeswax produced is exported. The beeswax production and processing practices use traditional and inefficient techniques that leave significant amount of beeswax resource unutilized. The marketing channel for beeswax in the country is also entangled with challenges related to uneasy traceability and adulteration that are affecting both the local and international trade.

Keywords: Beekeeping, Beeswax, Ethiopia, Marketing, Production

1. Introduction

The term beeswax is often limited to wax produced by honeybees (*Apis* species) and many would specify *Apis mellifera* L. as a source [1]. It is one of the most valuable bee products and it is also one of the oldest items used by mankind [2]. Beeswax, with its unique characteristics, is now being used in the development of new products in various fields such as cosmetics, foods, pharmaceuticals, engineering and industry [3]. Specifically, most of the wax produced nowadays are used in the manufacture of cosmetics, such as hand and face creams, lipsticks and depilatory wax and many other uses. Moreover, the pharmaceutical industry uses the wax in various ointments, for coating pills and suppositories and other miscellaneous industrial products [4].

Beeswax is secreted in small wax platelets form by worker honeybees from four pairs of wax glands on the underside of the abdomens which are functional when the bees are about 9–17 days old after being engorged with honey and resting suspended for 24 hours together [5]. Construction of combs saps the colony's energy supplies, through the costly production of wax from the sugars in collected honey [6], and through thermoregulation of the building site by the surrounding festoon of bees [7]. Honeybees fed with sugar syrup during dearth periods couldn't produce more beeswax emphasizing the need of nectar/honey for beeswax production (Gemechis, Holeta Bee Research Center, Ethiopia, unpublished data). The platelets are scraped off by the bees, masticated several times into pliable pieces with the addition of saliva and a variety of enzymes to form part of the comb of hexagonal cells [8]. Wax is used to cap the ripened honey, and when mixed with some propolis protects the brood from infections and desiccation and also employed for sealing cracks and covering foreign objects in the hive [2]. Worldwide in general and in Ethiopia in particular, a lot of research activities had been conducted and data regarding beeswax production, physical and chemical characterization , processing and value addition and marketing and problems related to marketing are documented. However, in particular in Ethiopia, the progresses in different aspects of research in beeswax have not been reviewed and all the available information are found scattered and in inaccessible situation. Therefore, this review work was executed to review the progress of research in production, value addition and marketing of beeswax mainly in Ethiopia.

2. Production

Assessments indicate that Ethiopia has got potential for production of beeswax because of huge number of honeybee colonies being kept in traditional hives [9]. The migratory behavior of the tropical honeybees also contributes to high beeswax production leaving combs behind every time colonies search for new nests [10]. The beeswax production in traditional beehives is 8–10% of the honey yield [2]. In 2005, Ethiopia produced about 4300 tones of beeswax [11]. This made Ethiopia stand first in Africa and third in the world. In the same year there were about 4.55 million hived colonies [12] which, based on FAO data for national production, is equivalent to 0.95 kg wax per hive per year. However, with the current increase in production of honey that is estimated to be around 54,000 tones [13], the annual beeswax production is expected to be more than 5000 tones. [10] indicated that this can be optimized to 9000 tones.

2.1. Characterization of Beeswax

2.1.1. Beeswax Quality

The composition of beeswax is very complex to identify, but it is relatively constant for beeswax from a single species of honeybee [2]. Pure beeswax from *A. mellifera* consists of at least 284 different compounds [1]. Quantitatively, the major compounds are saturated and unsaturated monoesters, diesters, saturated and unsaturated hydrocarbons, free acids and hydroxy polyesters, each consisting of a series of long carbon-chain compounds [1,2]. There are 21 major compounds, each making up more than 1% and together accounting for 56% of the pure unfractionated wax. The other 44% of diverse minor compounds probably account for beeswax's characteristic plasticity and low melting point [1]. Among the physical and chemical features of beeswax, melting point, relative/ specific density, electrical resistance, thermal conductivity, saponification cloud point, ester and acid values and the ratio of ester to acid values serve in determining the quality of beeswax [1]. Quality standards for beeswax are set in most countries according to their pharmacopoeias [8].

Ethiopia has set its standards for beeswax after investigating the physical and chemical properties of samples of beeswax collected from different parts of the country at farm gates and at different beeswax processors and exporters' stores [10]. The physical and chemical properties that are relevant to beeswax quality like melting point, saponification cloud point, acid value, ester value and ester to acid ratio were tested based on the protocols of American Beeswax Importers and Refiners Association INC, 1968 as cited in [14]. Generally, the purified beeswax collected from different parts of Ethiopia met the world standards [10]. The saponification cloud point ranged between 57.9 ^{o}C and 65.0^{o}C, while the melting point lied between 61.0 ^{o}C and 63.9 ^{o}C. Acid value of 18.0 to 32.7 and ester value ranging between 66.4 and 98.0 were recorded, while the ratio of ester to acid values was found 4.2 to 4.0 [10].

2.1.2. Adulteration

The quality of beeswax could deteriorate and its natural composition could alter because of adulteration and prolonged overheating [1]. Under local conditions deterioration of beeswax quality due to overheating from processing is highly likely to happen; some of the processing facilities are not suitable to regulate the optimum temperature during processing [10]. Similarly, adulteration of beeswax with cheaper materials like animal fats, plant oils and paraffin has become a problem for beeswax quality and its marketing, especially adulteration of beeswax with paraffin is a major one [1,2, 15]. But in Ethiopia, animal tallow is highly suspected to be the major adulterant to be mixed with beeswax because of availability and cheapness, actually many times cheaper than beeswax [10].

To detect adulteration, a number of tests may have to be conducted. The simplest is to determine the melting point by measuring the temperature at which the first liquid wax appears during very slow heating. It should be between 61 and 66^{o}C or preferably between 62 and 65^{o}C [8]. In addition, determining the saponification cloud point is an officially accepted sensitive method for determining adulteration. The method is limited to detecting quantities greater than 1 % of high melting (80-85^{o}C) paraffin waxes, or more than 6% of low melting (50-55^{o}C) paraffins. The test measures the amount of hydrocarbons which saponify (turn into soap) in a specific amount of ethanol and give a clear solution. If the solution becomes clear at or below 65^{o}C, the wax is probably unadulterated with paraffin. If it is adulterated, the solution will turn clear only at a higher temperature [8].

An investigation conducted following the previously mentioned protocols of American Beeswax Importers and Refiners Association INC, 1968 cited in [14] to look into the melting point and saponification cloud point of mixture of 10 gm of pure beeswax and animal tallow prepared in the proportion of 1%, 2.5%, 5%, 7.5%, 10%, 12.5%, 15%, 17.5%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, and 90% by weight of animal tallow showed that melting point and saponification cloud point could equally serve in detection of as small as 2% animal tallow used in beeswax adulteration [14].

Beeswax samples adulterated with 1% animal tallow melted at slightly lower temperature at an average of 61^{o}C, which was lower by 1^{o}C than the lower limit of most pure beeswax melting point standards. Beeswax samples mixed with 2.5-7.5% animal tallow melted at lower temperature between 60^{o}C-59^{o}C. Above this adulteration level, the melting point was further below 59^{o}C and as the proportion of animal tallow increased the melting point approached to 46^{o}C, which was the melting point for pure animal tallow [14]. For saponification cloud point, the result followed the same trend in which beeswax samples mixed with 1% animal tallow saponified at 60^{o}C and beeswax samples adulterated with 2.5-7.5% animal tallow saponified at lower temperatures between 59^{o}C-58^{o}C. At adulteration of 7.5% the saponification cloud point fell below 58^{o}C and as the proportion of animal tallow increased the saponification cloud point approached to 44^{o}C, which was the saponification cloud point of pure animal tallow [14].

2.2. Beeswax Processing

In many parts of the world much of the beeswax produced by bees that could be harvested by beekeepers is wasted. The beeswax is left or thrown away because beekeepers do not bother to collect and render it into marketable blocks. As a result only a limited proportion, may be at most one-half, of the world's production of beeswax comes on to the market, the rest being thrown away or lost [2]. From the total amount of beeswax produced annually in Ethiopia, only less than 10% of it is used for export [11,16,17]. The remaining large proportion of it is believed to be wasted at different levels. In Ethiopia, there are so many factors attributing to this wastage of beeswax including consumption of honey in crude form and discarding the crude beeswax at every crude honey consuming points and "*tej*" (local wine made from honey) makers [18]. The majority of beekeepers in Ethiopia practice beekeeping using dominantly traditional beehives and hence huge amount of beeswax is produced [10]. Observations indicate that these beekeepers do not know the use of beeswax, the rendering techniques or the existence of market for this product [19].

The sources of crude beeswax for rendering could be from cappings removed during honey extraction, which produces a very high quality, light colored wax. Light colored broken combs provide the next quality of wax, whereas old black brood combs yield the smallest proportion and lowest quality of wax. Dark combs contain propolis resin, coccon and pollen packs that lower the quality of the beeswax [2]. In areas with traditional and top bar hive beekeeping, different qualities of wax can be produced by separating new white honey combs from darker ones or from those with portions of brood [8]. In Ethiopia, the majority of the crude beeswax is collected by the local *tej* makers in the form of the beverage byproduct called "*sefef*". *Sefef* is produced in a straw form and sometimes difficult to assume it as a source of beeswax because of its impurities and discoloration. Beeswax blocks produced from this material are of low quality (in its sensory properties) and the color is not as light as beeswax sourced from crude honey due to many ingredients used in *tej*, like the leaves of plant called "*Gesho*" (*Rhamnus prinoides*), and the fermentation process.

To begin any processing of beeswax, the first step is to separate the honey from beeswax. In the case of box frame hives extracting honey leaves the empty combs attached to the frames. Therefore, the combs can be directly taken to prepare purified blocks of beeswax by scraping all the combs from the frame and boiling in water. However, crude honey from traditional hives has more non honey and non beeswax foreign materials due to poor harvesting practices [10]. After the crude honey is strained, the beeswax is left with many types of impurities of pollen packs, cocoon sheath, propolis, dead bodies and parts of honeybees and hive bodies [2]. As expected, the proportion of these impurities in the beeswax greatly affects the amount of pure beeswax recovered during rendering [2, 18].

The amount of pure beeswax produced from crude beeswax is dependent on both the quality of source material and the techniques used in processing. An amount of crude beeswax ranging from 5% to 65.6%, with mean of 27.5%, can be recovered from crude honey produced in traditional hives and collected from beekeepers; while the average percentage of pure beeswax obtained from crude beeswax deriving from the aforementioned source was 73.6% [18]. Recently, (2012)separate study at Holeta Bee Research Center (HBRC), Ethiopia, unpublished data) revealed that the average pure beeswax yield using three extracting methods (manual sack extraction method, submerged and solar extraction) was the highest (67.7%) for crude beeswax sourced from crude honey. The average recovery rate of pure beeswax using these three techniques was 26.8% for old and dark combs and 25.9% for *sefef*. However, the techniques by themselves significantly affected the amount of pure beeswax recovered from crude beeswax of the three sources (crude honey, old combs and *sefef*) as manual and submerged methods yielded 44.2% and 49.6%, respectively compared to solar method that gave only 26.4% pure beeswax. This reveals the high and wide variations inefficiency in the existing wax rendering techniques specially for small scale producers and processors.

Several methods of rendering wax are possible and may be adapted to various circumstances. Wax can be separated in solar wax melters, by boiling in water then filtering, or by using steam or boiling water and special presses [2]. However, for small and medium scale producers and processors the existing inefficient beeswax extraction technologies are believed to be one of the factors for the wastage of beeswax in Ethiopia [18]. The manual sack pressing method could recover about 34.2% of the crude beeswax content sourced from crude honey which is far less than 64.7%, the percentage of the pure beeswax recovered from the same material by simple machines applying mechanical and hydraulic pressure developed at HBRC [18]. Similarly, the average pure beeswax recovered from *sefef* by the manual sack method was about 25%, while mechanical and hydraulic pressure applying simple machines could increase this efficiency by 50% more than that of manual pressing [18].

3. Marketing

In Ethiopia, beeswax is one of the important exportable agricultural commodities [20]. Currently, the annual production of beeswax is expected to be more than 5000 tones. [10] indicated that this is around one tenth of the world annual beeswax production that is estimated to be around 50,000 tones. Because of its pliability, yellow coloration and other physical properties, the Ethiopian beeswax has been highly demanded and mostly used to blend beeswaxes from other sources. It is dominantly yellow in color though white beeswax is produced in southeast and southwest parts of the country. Yellow coloration is mainly due to the pollen stored in combs and propolis polishing [10].

The smallholding beekeepers are the primary sources of beeswax in Ethiopia who sell the majority of crude honey to the *tej* brewers, hence most of marketable crude beeswax comes from them as a byproduct of the beverage [19]. After the beverage production, the *tej* makers collect the crude beeswax and store it as it is in the crude form of "*sefef*" or partially strained form of "*keskes*" [10]. The *sefef* or the partially processed *keskes* is collected from the *tej* makers [19]. Traditional beeswax extractors are also the other intermediate sources who process the *sefef* partially to rough beeswax blocks. Recently, many private firms collect *sefef* and *keskes*, process and export beeswax [20]. The channel of crude beeswax collection, processing and marketing in Ethiopia is very complex and the issue of traceability is a big concern. This is one of the major challenges that is attributing to the increasing adulteration of beeswax with cheap materials like animal fat in addition to the ever increasing price that draws attention of the people involved in the mischief.

Beeswax has good domestic market in Ethiopia. The traditional religious practice of the Ethiopian Orthodox Church followers to burn candle sticks called "*tuaf*" made from pure beeswax is believed to consume a significant amount of the beeswax produced locally even though not quantified so far. Moreover, the intensity of the improved beekeeping extension in the main beekeeping potential areas of the country launched by government and NGOs has created a huge demand of beeswax for foundation making for frame box hives. Currently, a kilogram of purified blocks of beeswax cost about 250-300 ETB (25-30 USD) in the local markets. Generally, the beeswax price at the domestic market is mostly higher than the international beeswax price which makes beeswax export less profitable in Ethiopia.

Most of the world beeswax is supplied by the developing countries. China is the leading producer and exporter [10]. The EU is the major market for beeswax in the world, accounting for more than half of global imports [21]. The price of beeswax exported to EU is also on continuous rise since 2003. For instance, the price of beeswax exported from Ethiopia had risen from 2430 €/ton in 2003 to 3200 €/ton in 2009, with the highest 3630 €/ton in 2006, in main European ports [22]. In EU, most of the beeswax refining and re-exporting is done as the importers in EU are in a better position to enjoy the competitive advantage through advanced technological and market reputation they have already established. They don't actually encourage their suppliers in the developing countries to refine their beeswax.

Exports of beeswax from Ethiopia have increased spectacularly and reached 402 tones of beeswax (1.2% share in world market), destined to different countries (USA, Japan, Greece, Great Britain and Netherlands etc.), generating USD 936 thousands in 2003 [11]. After 2003, the export volume is not far from 400 tones annually [16,17]. However, similar to the local beeswax market, the export of Ethiopian beeswax has threats as adulteration with cheaper materials has become a challenge for its quality and marketing. Exporters complain that significant proportion of the exported beeswax is refused by recipient companies because of compromised quality mainly due to adulteration with cheap materials (personal communication, Ethiopian honey and beeswax processors and exporters association, 2013).

4. Conclusions

The Ethiopian beekeeping is characterized by traditional production system that created an opportunity for high beeswax production potential. However, even the total production expected each year is not properly collected, processed and marketed. In fact, little is known about the beeswax produced but utilized in other applications except used for export market. Challenges at the beekeepers' level that in some potential areas they don't have awareness of the importance of beeswax, skill to collect, process and market beeswax are among many. Moreover, the existing beeswax processing technologies are very limited and traditional of very low efficiency.

The market demand for beeswax both in the domestic and international trade is very high. Beeswax from Ethiopia has higher demand and also earns higher price in EU, that is mainly used for blending low quality beeswax from different sources. The local beeswax market is always short of supply even for the expanding improved beekeeping. Hence, prices have always been rising continuously. This, along with many others is a driving factor for adulteration of beeswax with other cheap materials like animal fats. The *tej* making process from which *sefef* is collected and supplied in the beeswax value chain is one of the important factor in deteriorating the quality of beeswax even though *tej* makers are still the major source of crude beeswax. In addition, the informal and complex nature of beeswax market channel in the country is another serious problem in the production and marketing of the product for both domestic and international trades. This has contributed for the prevailing adulteration practices of beeswax as traceability is hardly possible.

Generally, increasing the production level of beeswax through improved processing technologies of higher efficiency is important step to be taken. Moreover, formalizing the market system and establishing clear path of the products' movements in the market from producers to the consumers will increase the traceability and hence minimizes the problem of adulteration.

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