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Botanical origin, colour, granulation, and sensory properties of the Harenna forest honey, Bale, Ethiopia

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ABSTRACT

In this study, the Harenna forest honey samples were investigated with respect to their botanical origin, granulation, colour and sensory properties. Sixteen honey samples were collected from two representative sites (Chiri, C, and Wabero, W) using random sampling techniques. Botanical origin was investigated using qualitative pollen analysis by counting 500 pollen grains using harmonised methods of melissopalynology. Granulation, colour, and sensory properties of honey were determined by visual observation, using Pfund grader, acceptability and preference tests, respectively. Honey samples were also tested for tetracycline. Honey obtained from Wabero is originated dominantly from *Syzygium guineense* while Chiri was multifloral. The colour of honey ranged from 34 to 85 with light amber and extra light amber colours. The honey samples were free from tetracycline residue and form coarse granules slowly. Significant variation ($p > 0.05$) in sensory preference and acceptability tests not observed due to hive types and locations.

1. Introduction

The Harenna forest is delineated in Bale zone, Ethiopia, mainly in the districts of Dello Mena, Harenna Buluk, Goba and Nensebo. This forest is one of the few remaining rainforest patches in the southeastern part of Ethiopia (Senbeta & Denich, 2006) and constitutes the largest part of Bale mountains national park. It differs from the southwestern rainforests in terms of dominant canopy tree species, and supports many vascular plant species (over 300 species) and endemic plant species than other rainforests (Senbeta, 2006). Some of the unique floristic composition and common climber species of the Harenna forest are reported elsewhere (Gole & Senbeta, 2008; Senbeta, 2006).

Honey is one of the well-traded product and important sources of livelihoods in the Harenna forest. The most dominate spp., which have apicultural value are *Oncinotis tenuiloba*, *Polyscias fulva*, *Vernonia amygdalina*, *Vernonia auriculifera*, *Cordia africana*, *Ehretia cymosa*, *Diospyros abyssinica*, *Croton macrostachyus*, *Shirakiopsis elliptica*, *Ocotea kenyensis*, *Syzygium guineense*, *Olea welwitschii*, *Margaritaria discoidea*, *Gouania longispicata*, *Vepris dainellii* and *Pouteria adolfi-friederici* (Senbeta, Gole, Denich, & Kellbessa, 2013). These species, other trees, shrubs and climbers provide nectar and pollen for honey bees (Genene, 2006).

The total number of beehives in Ethiopia is 5,207,300 (95.96% traditional and 2.98% frame hives) (Central Statistical Agency., 2013). Bamboo, timber, bark, climber, mud, animal dung, grass, gourd, barrel, and clay pot are used to make traditional hives; and frame hives are made from timber, plywood, and chip-wood. In the Harenna forest the most common type of traditional hive is a hollow, cylindrical hive made from *C. africana*, which has a length of ~1 m and a diameter of ~25 cm. The bees fill the space with honeycombs from the top to down wards. The traditional hives hang on a long tree in the forest. The frame hives are Zander type, which is largely made from *C. africana*. The hive has mainly two rooms. The bottom box is used for brood rearing and the super box for honey storage. These hives were kept in the back yard.

The advantages of traditional hives include construction with locally available materials by the beekeepers; no need of skilled labour; hives help to trap colonies; and higher yield of beeswax than frame hives. The drawbacks of traditional beekeeping

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practices are production of lower quantity of honey than frame hive, no possibility of inspecting colony. In the case of frame hives, beekeeper has little fear of comb damage, the comb is fixed firmly to the four sides of the frame and thus facilitates easy harvesting, transportation easier, bees save time and energy to construct a replacement comb, easier to remove the honey without damaging the comb and easy of inspection. The disadvantages of frame hives are expensive to construct; a high degree of craftsmanship is required; beekeeper has to install a wired comb foundation; and requires importing centrifugal honey extractor, wax molder and other equipment.

The apicultural value of the Bale zone largely depends on the Harenna forest. According to Central Statistical Agency (2013), the Bale zone produces 1,349,801 kg honey per year from 139,306 bee hives. This volume is ~3% of the total honey production in Ethiopia, 45,095,201 kg. The Bale zone ranked 7th out of 63 zones of Ethiopia in volume of honey production.

Pollen is very important for honeybee nutrition. Honeybees collect pollen grains from plants to obtain protein for their survival and reproduction (Barth, Munhoz, & Luz, 2009; Escuredo, Míguez, Fernández-González, & Carmen Seijo, 2013). The bees frequently collect a wide variety of pollen types, but they generally concentrate on a few species (Bauma, Rubink, Coulson, & Bryant, 2011). Botanical origin of honey can be verified by qualitative and quantitative microscopic pollen analyses based on the relative frequencies of the pollen types of nectariferous species.

Colour in liquid honey varies from clear and colourless to dark amber or black. The most important aspect of honey colour lies in its value for marketing and determination of its end use. Next to general quality determinations, colour is the single most important factor determining import and wholesale prices of honey (Krell, 1996). In many countries with a large honey market, consumer preferences are determined by the colour of honey. Honey colour is frequently given in millimeters on a Pfund scale or according to the U.S. Department of Agriculture classifications (White, 1975 and Crane, 1980). The Pfund scale has water white, extra white, white, extra light amber, light amber, amber and dark amber colour levels (Krell, 1996).

The colour of honey is characteristic of its floral source. Exposure to heat and the length of time that the honey stayed in the storage may also affect honey's colour. Honey appears lighter in colour after it has granulated. This depends upon the composition of the honey and its initial colour. Generally, the darkening of honey is temperature sensitive and occurs more rapidly when honey is stored at high temperatures. The determination of colour is a useful classification criterion for unifloral honeys. Honey colour is related with its flavour. Light coloured honey is mild whereas darker types have stronger flavours. Light honeys, like the Harenna forest honey, generally fetch the highest prices. Nevertheless, in Germany, Austria and Switzerland, dark honeys are especially appreciated. Dark coloured honeys are reported to contain more phenolic acid derivatives but less flavonoid than light coloured ones (Bogdanov, Ruoff, & Oddo, 2004).

Granulation is one of the characteristics for honey. Honey is a highly viscous sugar solution, often supersaturated and susceptible of time dependent crystallization, at a rate influenced by water content, presence of nucleation seeds, degree of supersaturation and viscosity (Venir, Spaziani, & Martini, 2010). Granulation of some honey kinds are faster and other kinds are slower. Speed of crystallization in honey is defined with a proportion and the content of carbohydrates in honey. It is known that carbohydrate glucose promotes the crystallization of honey, while carbohydrate fructose breaks crystallization of honey. It is necessary to note that honey can have a different speed of granulation (Dimins, Kuka, & Cakste, 2008). The origin of honey contributes to the rapid, medium and slow granulation process (Crane, Penelope, & Rosemary, 1984).

Many consumers still think that if honey has granulated it has gone bad or has been adulterated with sugar. Analysis of sensory properties of honey is used to evaluate flavours and identify certain defects such fermentation, impurities, and off-odors. It also plays an important role in defining product standards. Moreover, it is an essential part of consumer preference/aversion studies (Piana et al., 2004).

Natural crystallization of honey is usually an unwelcome process in honey industries. On the one hand, honey texture usually gets worse. On the other hand, an upper liquid phase poor in sugar content can lead to fermentation. In order to avoid these problems, induced granulation appears to be one of the alternatives. This process consists on seeding a liquid honey with finely crystallized honey at low temperature, so that crystals act as nuclei for growth. The resulting honey is creamy, smooth and very pleasant to taste (Cavia, Fernandez-Muino, Alonso-Torre, Huidobro, & Sancho, 2007).

During granulation water is freed. Consequently, the content of the liquid phase increases with increasing risk of fermentation. Granulated honey ferments more readily than the liquid honey, because when dextrose crystals are formed in the honey, the liquid phase has higher water content than the entire honey had when it was liquid and this lead to fermentation (Krell, 1996; Nuru, 1991). Water in honey is mainly fixed to sugars via hydrogen bonding. During granulation glucose is found as glucose monohydrate, each glucose molecule fixes only one molecule of water. The water fixed to glucose in solution is set free during the crystallization process which means that water activity (a_w) increases. Therefore, less water is fixed in the crystallized state (Gleiter, Horn, & Isengard, 2006). Thus, partially crystallized honey may present preservation problems, which is why controlled and complete crystallization is often induced deliberately. In addition, partially crystallized or reliquified honey is not an attractive presentation for retail shelves.

The growing interest on issues associated with the variety related identification of products has been observed in the domain of nutritional science for several years. In a number of scientific centers, various honey identification procedures have been studied (Kowalski, Łukasiewicz, & Berski, 2013; Tuberoso et al., 2014). The rapid promotion of honey production and quality characterisation are urgent needs for market development, because organic and fair trade honeys are fast growing market niches in the major honey consuming countries in the western part of the world. Introduction of fair trade and organic products will add to the value of Harenna forest honey and it will improve the income of farmers. These will convince the community to improve their beekeeping techniques and conserve the forest in a sustainable way for economic reasons.

Despite the large amount of honey produced and higher market demand for Ethiopian honey, there is little information about the botanical origin, colour, granulation and sensory properties of Ethiopian honey. Thus the objectives of this study were to investigate the Harenna forest honey based on botanical origin, colour, granulation and sensory property; and compare traditional and frame hive honeys with respect to these parameters.

2. Materials and methods

2.1. Study area

This study was conducted in Chiri and Wabero areas in Bale, Ethiopia, where the Harenna forest is delineated (Fig. 1). The Harenna Forest is one of the few remaining natural forests in the entire country of Ethiopia. It is located 550 km South East of Addis Ababa,