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ORGANOLEPTIC CHARACTERISATION OF UNIFLORAL HONEYS FROM EASTERN MAU BEEKEEPERS

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ABSTRACT
A panel consisting of 12 trained assessors carried out an organoleptic characterisation of *Acacia*, *Eucalyptus*, *Croton*, *Cordia* and *Albizia* unifloral honeys from Eastern Mau forest using quantitative descriptive analyis with analog visual scales. All the honey samples had normal colours, mean colour intensities ranged from 4 to 6.3 with *Albizia* and *Cordia* unifloral honeys being of significantly different colour intensity. The most intense and persitent odour was observed in *Albizia* honey, lasting for 19 minutes. Floral fresh aroma family was the most dominant in 50% of the unifloral honey samples represented by *Acacia*, *Croton* and *Albizia* honey. Friedmans test (N=12, df=7, X^2 =14.07, LSD= 23.52) revealed a significant difference in the sum of rankings in all organoleptic attributes (colour intensity, odour intensity, aroma intensity and aftertaste, sweetness intensity, acidity, fluidity, and texture or graininess but nosignificant difference among the honey samples in their ranking of aroma persistence (Friedmans Q=0.08). These results demonstrate that the knowledge of the organoleptic profile of these honeys can contribute to characterization of its floral and geographical identity. Unifloral honey from Eastern Mau studied meet the Codex Alimentarus, EU Council directive and COMESA honey organoleptic standards.

KEY WORDS:
Unifloral honey,Trained assessors, Friedmans test, Organoleptic standards, Eastern Mau

INTRODUCTION

The possibility of producing monofloral honey could have a worthy impact on the income of rural household, the bee economy of the nation, and environment, and the food industry. Monofloral honey attract a premium price, which can be used as a good incentive for bee keepers. It also gives an opportunity to conserve honey plants, and utilise the forest in a standing position (Belay et al., 2016). Studies on the characterisation of monofloral honeys could be important incentive to help conserve flora and indiginous bees in various regions (Gabriela, 2006).

Although there is no official definition of "food authenticity", food is authentic if: it complies with legislation, has the necessary composition for a legal name, matches the description on the label, and is not economically adulterated by substitution of its ingredients with similar but cheaper ones. To test for the authentication would therefore imply confirming whether all requirements regarding product description or detection of fraudulent statements according to the proposed legal regulations have been fulfilled. Verifying the description of food in terms of its composition, processing or origin is a challenging task in food analysis. The classic authenticity assessment of food is usually based on finding a specific marker or markers. Food authenticity in a broader sense means fulfilling chemical and physical criteria prescribed by the proposed legislation (Milojkovic et al., 2015). Owing to the refined, unique flavour, and taste, monofloral honey are generally perceived as high quality products and consequently, the most susceptable to adulteration through incorrect labeling and fraudulent admixing with low cost and low quality honeys (Soares et al., 2017). Many consumers seek high quality products with a clear regional identity and sensory qualities associated with the areas of origin. Therefore, it is in the best interest of the apiculture industry to offer honeys with specific geographical characteristics and superior aroma or flavour quality to the consumers. In addition, honeys from specified botanical sources often command premium price due to their organoleptic or pharmacoactive properties.

According to *Codex Alimentarius*, 2001, the essential honey quality factors are: Honey sold as such shall not have added to it any food additives nor shall any other additions be made other than honey. Honey shall not have any objectionable sensory characteristics: matter, flavor, aroma, or taint absorbed from foreign matter during its processing and storage. The honey shall not have begun to ferment or effervesce. No pollen or constituent particular to honey may be removed except where this is unavoidable. Honey shall not be heated or

processed to such an extent that its essential composition is changed or its quality impaired. Chemical or biochemical treatments shall not be used to influence honey crystallization. In the European Union Council, the same essential composition and quality factors are mentioned but the text formulated differently thus according to both standards honey should be authentic (Bogdanov and Martin, 2002). The Kenyan honey standard does not explicitly refer to as essential quality factors and unlike the other honey standards e.g. COMESA, CODEX, EU it has only mentioned the maximum values of invert sugar, moisture, sucrose and ash.

Sensory analysis is scientific discipline used to examine a product through the evaluation of attributes perceptible by organoleptic attributes such as color, odor, taste, touch, texture, and noise (Pianna *et al*, 2004; Ligia *et al*, 2014). In sensory perception, the stimulus hits the sense organ and this is converted to a nervous signal, in the brain, the signal is organized and integrated into perceptions and the response formulated (Tzia, 2008).Taste is of major consideration and the industries tend to overlook other sensory perceptions. Sensory evaluation is quantitative science since numerical data are collected to establish the relationship between product characteristics and human perceptions. It is concerned with precision, accuracy, sensitivity, and avoiding false position results (Lawless and Heymann, 1998).
Application of sensory analysis dates back to France Italy and Spain (Gonzalez *et al*., 2010, IHC, 2009). Sensory analysis of honey can facilitate characterization and development of honey products by fixing the honey in to a predefined type or standard. This refers primarily to identification of honey as multifloral or unifloral and matching it to a declared origin (Council Directive, 110/2001). Sensory analysis determinines the floral origin for subsequent quality control practices which ultimately identifies consumer preferences toward the product. Sensory analysis compliments the determination of botanical and geographical origin, (Ciappini *et al*, 2013).

Sensory analysis can discriminate floral honey from honey dews, verify the absence of defects in honey, and honey conformity with honey reference standards (Gonzalez *et al*., 2010). Human senses can detect odorants at lower levels than any instrument (Lawless and Heymann, 2001). The simulation of sensory behavior by instruments cannot match the complex simultaneous activity during eating and chewing, again unlike instrumental information,sensory information is multidimensional. Instruments are useful in sensory evaluation in presence of good understanding of the relationship between instrument measurements, sensory perception and consumer behavior. Such good understanding is lacking at the moment (Stăncioiu *et al*., 2014).
Sensory characteristics among honey vary and honey being a health product investigation of its sensory characteristics is desirable (Vit, 2013). The Council directive 110/ 2001 requires honey botanical origin to agree with the pollen, physicochemical and sensory characterization .The three analytical techniques are therefore complimentary assays to honey characterization (Farid *et al*, 2011). According to *Codex Alimentarius* (2001), honey should not have any objectionable flavor, taste, and taint as the essential honey quality factors. These sensory features can only be determined by sensory analysis. Sensory analysis can reveal presence of botanical components not picked by physicochemical methods as well as melissopalynological analysis that at times alter the typical chemical characteristics, to the extent that honey cannot be marketed as unifloral honey. Small quantities of aromatic honey can considerably alter the organoleptic characteristics of unifloral honey. Sensory analysis is the basic criterion for selection of unifloral honey for commercial purposes (Pianna, 2004).

Colour is the physical property most immediately perceived by consumers. In Europe the price of honey depends on the honey colour; generally the lightest ones are the costliest. Therefore colour is a usefull and important parameter in classifying monofloral honey (Ligia et al., 2014) as it also influences the choice of consumers (Janaina et al., 2016), marketing and determination of its use. Darker colours are more often for industrial use while lighter honeys are marketed for direct consumption. In many countries apart from general quality determinations, colour is the single most important factor determining import and wholesale prices (FAO, Bullettin, Krell).in which

Sensory analysis adds value by differentiation of honey. Many authors have reported different floral markers for honey. Sensory analysis can be used to clear such an ambiguity (Vilma and Petras, 2010). Sometimes, the presence of a very small amount of “foreign” nectar of intense aroma may cause a serious defect of taste and odour. When identification of defects is considered, the sensory analysis of honey consents the recognition of contamination with foreign substances. Higher-quality unifloral honey is honey which, with regard to the specific features of odour, taste, appearance, and tactile properties, is as close as possible to the hypothetical honey “standard”, obtained entirely from the respective plant species (Milojikovic et al., 2015)

Traditionally sensory analysis has been viewed in the context of technical experts. This has evolved away from single technical expert to panel of experts due to product complexity. Much interest in sensory analysis in 1950s led to the introduction of the flavor profile alongside quantitative descriptive analysis that does not rely on individual expert but formalized subject screening and training procedures (Lawless and Heymann, 2010). In Italy gounets developed the standard harmonized evaluation form, tasting,training and selection of assessors, and sensory description of Italian unifloral honey. Currently, improved sensory analysis methods have been developed using panels of assessors, well defined and controlled experimental protocols as well as statistical techniques for processing of results (Persano-Oddo and Bogdanov, 2004; Pianna *et al*, 2004). A working group established by the International Honey Commission has enabled compilation of a glossary referring to all the attributes and terms used for sensory analysis of European unifloral honeys (Persano-Oddo and Bogdanov, 2004). The aroma and odor wheel alongside its descriptors previously developed in Belgium team (Piana *et al.*, 2004) has now been added some attributes to standardise terminology for precise consistent description of all possible variations of honey. Terms in the wheel are divided into families and subfamilies (Ciappini *et al*, 2013). Tasting characteristics of honey refer to all the chemical sensations perceived when small quantity of honey (1-2g) of raw honey at room temperature (18-25^{0}C) is put in the mouth dissolved and swallowed. This may include: sweetness, acidity, saltiness and bitterness. Aroma is the global odor perceived via the back of the nose when honey is dissolved in the mouth. It is described according to the terminology and references in the odour and aroma wheel.Persistence/aftertaste is the duration of sensations after swallowing. An aftertaste according to ISO 5492(1992) corresponds to a new sensation that appears during the period (Ciappini *et al*, 2013).

Honey crystallization is a natural phenomenon that happens when glucose in honey spontaneously precipitates out. The sensory evaluation of this geometrical textural attribute is related to the perception of the size and shape of sugar particles in the honey (Farid *et al*., 2011). Olfactory sensation this is honey odor perceived when sniffing a small amount of honey. The intensity of the odor refers to the overall intensity of sensations perceived when honey is smelled. The description of odor refers to the terminology and references of honey aroma wheel (Ciappini *et al*, 2013). Honey colour is the only characteristic that is completely related to botanic origin. The color intensity is the degree of lightness or darkness of the honey color when observed on its liquid form. The color can vary much following possible types of granulation and processing. Color grading has been used in the honey industry for many years. Honey color is an important characteristic used by producers, packers, and end users alike. Its measurement is vital in quality control process and it is estimated that 75% of industrial users of honey include color specification in their designations. In its natural condition, honey has a continuous range of colors related to mineral content and floral source. Light colored honey have strong flavor. Honey color names include: water white, extra white, white, extra light amber, light amber, amber, dark amber (NHB, 2013). Honey color may be appropriate for classification, in the Botanical origin of honey and is commonly used in international commerce (Farid *et al*., 2011).

Sensory analysis is based on the evaluation of olfactory and gustatory characteristics of honey by assessors trained to identify sensory stimuli on the basis of previously memorized standards (ISO 8586-1, 1993; ISO, 8586-2, 1994) and to quantify them on a unstructured scale of 15 cm (1SO 4121, 2008). Sensory evaluations are carried out according to the conditions and general methodology set down in ISO 6658 (1985) principles developed from psychology and physiology. The use of specific honey markers is necessary (Vilma and Petras, 2010). Evaluation of unifloral conformity is determined through organoleptic characterization (Pianna, 2004) and unifloral markers should be in conformity with the physicochemical and melissopalynological characteristics (Persano-Oddo and Bogdanov, 2004). Sensory analysis compliments the determination of botanical origin and physicochemical characteristics (Gonzalez *et al*, 2010). Melissopalynological quality criteria for unifloral honeys are not valid for all honey and thus at present pollen analysis is used in combination with the sensory and chemical analysis of unifloral honeys (Bogdanov *et al*, 2002). Currently the floral type is judged on the basis of pollen analysis. Pollen content is subject to considerable variation. Judgment of honey is based on a combination of several quality criteria. Honey dews/forest or fir honey are therefore labeled on the basis of sensory judgment and electrical conductivity measures (Bogdanov and Martin, 2002).

OBJECTIVES

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This study was intended to establish an organoleptic characteristics of unifloral honey of various botanical origin from Eastern Mau, Kenya bee keepers for their classification, differentiation and evaluation against honey standards.

METHODOLOGY

Study site: Eastern Mau is one of the largest blocks in the Mau forest complex.The area is made up of class V vegetation of about 50-75% plant density. There is up to 40% dependence on honey production in Eastern Mau. The study site is located about 50 Km south of Nakuru Town, Kenya. The altitude ranges from 1200 and 2600 m. It is approximately 280 km^2 with the highest number of indigenous forest dwellers dominantly belonging to the Ogiek community. East Mau forest is an important watershed within the Mau Forest Complex, feeding major rivers and streams that make up the hydrological systems of Lake Victoria and inland Lakes of Nakuru, Baringo and Natron. It hosts endangered mammals (Sang, 2001). The forest ecosystem is therefore an important resource base for the local communities, national and international community. The total forest area has gone down by more than one half due to excision for human settlement in 2001(UNEP, 2006). The remaining area consists high forest, grassland and planted forest mainly of Cypress and Pines (KFS, 2012). Eastern Mau area terrain ranges from escarpments, hills, rolling land to plains with slopes ranging from 2% above 30% in the foothills. The soil is composed of quaternary and tertiary volcanic deposits. The adjoining settlements have gentle slopes with deep-fertile-volcanic soils suitable for maize, wheat, potatoes, horticultural crops and livestock keeping (Jaetzold and Schmidt, 1982). The area receives trimodal precipitation pattern with the long and intense rains from April to June; short rains in August; and shorter, less intense rains from November to December. Mean monthly rainfall ranges between 30 mm to 120 mm and total annual precipitation of 1200 mm (Kundu, 2007; Okello, 2008). The mean annual temperatures are in the range of 12 -16°C (Kundu, 2007). Honey from three forest strata units were purposively sampled using two main criteria: ethnic composition, presence of indigenous Ogiek community. The following administrative locations were selected: Mariashoni representing an old settlement predominantly occupied by Ogiek indigenous community (65%), Kapkembu – representing a recent settlement with a homogenous community of the Kipsigis and Ogiek (7.5%) , Nessuit – representing a recent settlement with a heterogeneous population of indigenous (Ogiek, 50%) and immigrant ethnic groups (Langat et al., 2015). Three honey samples were collected from each of strata (Mariashoni, Kapkembu, and Nessuit) at the end of April, 2016; August, 2016 and December, 2016 from the hives of Bee keeping Ogieks of the Eastern Mau forest region. Only the honey processed by straining using fine sieves or cheese-cloth were collected from the beekeepers, placed in sealed food grade screw cup bottles, and transported to the laboratory in cooler boxes. Samples from 3 beekeepers (three replicates) per population substratum were collected. Laboratory sample consisting of 100-200 g of honey, was transformed into the test sample by thorough stirring. Granulated hard samples were softened by slight warming. Dirty samples were liquefied at 40°C and strained through cheese-cloth. 10.0 g of honey was weighed and dissolved in 20 ml of hot distilled water at 39°C. and further processed and observed against reference slides according to Louveaux et al., (1978).

Botanical origin and pollen density through microscopical examination: The extent to which a given honey sample is derived from different plant sources was deduced from the frequencies of the pollen and honeydew elements in it. Honey was considered to have been produced mainly from one plant (unifloral honey) if the pollen of that plant is at least 45% predominant according to Louveaux et al., (1978). Honey was regarded honey dew only if ratio of HDE/P was equal to or greater than 3. Pollen reference slides were prepared. 500 pollen grains were counted for the determination of relative frequencies .Magnification of 400 to 1000X was used for identifying the various elements in the sediment. The Identification and counting of pollen grains is done in groups of 100, following 5 parallel equidistant lines uniformly distributed from one edge of the cover slip (22X22mm) to the other, until 500 grains are counted. Abortive, irregular or broken pollen grains are counted if they can be identified. A honey sample was regarded unifloral if a pollen type constituted more than 45% of the total; The identification of pollen types was based on shape, morphological characteristics and size of the pollen grains . Pollen types identified by using reference pollen slides. Acetolysed anther material according to Erdtman (1960) , from Eastern Mau apiflora observed in intial studies were used to develop reference slides. Fresh material from Musaceae and Lauraceae were only warmed with 2-5% KOH solution for 2 minutes instead of acetolysis and their slides sealed with paraffin wax.

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Organoleptic characterisation : Organoleptic characterisation was carried out in portable sensory booths made of carton boxes to simulate suitable, comfortable standardized environment as required by ISO 8589:1988 to facilitate work and production of repeatable results. Initial call and subsequent selection of panelists was made from Maseno University staff and students as per ISO 8586-1, 1993. Test for basic taste recognition (ISO 22935-1, 2009), odor recognition, and descriptions (ISO 5496, 2006a), order by strength test (ISO, 8587, 2006), color vision test- the Ishihara (1971). Test for description of textures using breakfast cereals was done as per ISO (8587 2008). 30 ml of each crude sample was prepared and presented at ISO 8589:2007 laboratory conditions from 11-12 am, at room temperature, in transparent glass jars (6cm in diameter and 6 cm in height). The panelists were trained to develop familiarity with the products, their characteristics, and their ability to recognize and identify attributes in order to improve their sensitivity and memory. The training was intended for accurate and consistent judgments as well as development of language awareness in describing the sensory characteristics. The training will be conducted in fifteen successive sessions as per (ISO, 8586-2, 1994). Once the training is complete and the assessors are able to identify at least 70% of the control samples, the panel analyses 6 samples by triplicate in balanced order scoring data for each assessor and entire panel using ANOVA (Ciappini *et al*, 2013). Significant variation between panelists is necessary to prove source of bias. Quantitative Descriptive Analysis (QDA): QDA will be applied to the honey evaluation by a trained panel. Comparing with standards previously memorized in the training step, visual, olfactory, gustatory, and tactile cues will be quantified in a series of structured visual scales (ISO 4121, 2008a; ISO 6564, 1985). Test conditions were as in the training sessions. Determination of organoleptic characteristics was done on 16 cm horizontal lines, anchored in 1 cm (minimum) and 15 cm (maximum) representing the continuous scale of 7 points for each attribute, the assessors indicated by a vertical line the perceived intensity for each attribute and sample. Upon completion of the trial, the leader of the panel measured the distance between the anchor and the mark left by the assessor as the measurement result and analyzed statistically. The analysis was complemented by qualitative descriptors for odor and flavor and the mention of other sensations that may be present. The assessors evaluated the honeys one at a time in separate booths without discussion of results nor reference served as intensity standards. Panelists used different parts of the scale to determine the sensory intensities by themselves, as a result the differences among the products produced by QDA analysis were a relative measurement.

Data analysis : The results of each samples was recorded in forms (sample ballots) easily completed and evaluated by the supervisor. Sensory analysis results will be represented using network spider plots and processed statistically using ANOVA. Type II error was minimized by increasing the number of observations in which the conclusion is based apart from reliable judges (Lawless and Heymann, 1988; 2010). Multivariate statistical techniques was applied to QDA data. Results of sensory analysis analysis of honeys were processed by cluster analysis, and Friedmans analysis of variance using SPSS Version 20. For cluster analysis a data matrix of 8x10 was prepared from 8 objects (honey samples) and 10 variables (Sites, seasons, pollen types, pollen density, honey types and Shannon weaver diversity index). The sum of squares for Friedmans test was reduced to Log.

RESULTS AND DISCUSSION

Table 1. Mean ranks of organoleptic characteristics of Eastern Mau unifloral honeys derived from visual analog scales

VARIABLE	MA-S1-AP	MA-S2-AP	MA-S3-AP	NE-S1-AP	KA-S1-AU	KA-S2-AU	MA-S1-AU	KA-S1-DE
	Acacia Honey	*Acacia* Honey	*Eucalyptus* honey	*Croton* Honey	*Albizia* Honey	*Cordia* Honey	*Croton* Honey	*Croton* Honey
Colour(Normal)	Light amber	Light amber	Amber	Amber	E.light amber	Amber	Amber	Light amber
Colour Intensity	5.2	5	5.6	6	4.2	6.3	5.6	5
Odour intensity	4.5	5	4	3	5.4	4	3.5	4
Odour persistence	3.5	5.5	3.8	4	6	4.5	3.9	4.2
Aroma (Family)	Floral fresh fruit/fruit	Floral fresh fruit/floral	Fresh/refreshi ng	Floral fresh fruit/fruit	Floral fresh fruit/floral	Woody/Resin ous	Warm/ subtle	Warm/subtle
Aroma (Subfamily)	Pear apple	Orange blossom	Eucalyptus	Pear Apple	Orange blossom	Propolis	beeswax	beeswax
Aroma (Intensity)	5	5.4	6.1	6	6.7	6.3	5.6	6.2

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Aroma aftertaste	5	5.9	6.2	4	6	5	4.8	5
Taste (Sweet) Intensity	5.3	5.4	5.9	0.6	5	4.3	5.2	4
Acidity	0	0	2	0	1	1	0	1
Texture /graininess	1	2	2	1	1	2	0	1
Fluidity	7.5	6.5	6	8.3	8	7.8	9.7	7.9

All honey samples had normal colours. The colours were light amber, amber and extra light amber in 3,3, and 1 sample respectively. Both *Acacia* honey samples were light amber. *Croton* honey were amber and light amber. There was no common colour for honeys harvested from the same season, place or of a given botanical origin. The highest colour intensities were observed in *Cordia* and *Croton* honey.The highest odour intensity and persistence was observed in *Albizia* honey. Floral fresh aroma was the most dominant. All *Acacia* honey had floral fresh aroma family. Highest aroma intensity was observed in *Albizia* honey. While highest aroma aftertaste was observed in Eucalyptus honey. All honey samples had sweet taste , *Eucalyptus* honey had the sweetest taste intensity. Acidity was generally low ranging from 0-2. Majority having no acidity. The graininess ranged from 0 (absent) to 2 (fine). 50% of the honey samples showed fine graininess. *Eucalyptus* , *Acacia* and *Cordia* honey was the most grainy.

Table 2. Friedman one way repeated analysis of variance by ranks of organoleptic variables (N=12, df=7, LSD=23.52, X^2 =14.07)

PARAMETER	Mean Rank	Mean Range	Log_{10}. SS	Friedmans Q	Pairwise comparison
Colour intensity	5.36	4.2-6.3	4.53	142.18	(KA-S1-AU*KA-S2-AU)
Odour intensity	4.18	3-5.4	4.32	36.68	(NE-S1-AP*KA-S1-AU)
Persistence	4.46	3.8-5.5	4.37	0.08	No significant difference.
Aroma intensity	5.91	5.0-6.7	4.61	239.5	(MA-S1-AP*MA-S2-AP), (MA-S1-AP*KA-S1-AU),(MA-S3-AP*KA-S1-AU)
Aroma aftertaste	5.24	4.0-6.2	4.51	122.57	(NE-S1-AP*MA-S3-AP),(NE-S1-AP*KA-S1-AU)
Sweetness/Taste intensity	4.46	0.57-5.85	4.41	33.89	NE-S1-AP*all other 7 samples)
Acidity	0.63	0.00-2.00	3	310	(MA-S3-AP*MA-S1-AP),(MA-S3-AP*MA-S2-AP),(MA-S3-AP*KA-S1-AU),(MA-S3-AP*MA-S1-AU)
Texture/Graininess	1.25	0.00-2.00	3.36	292	(MA-S1-AU*KA-S2-AU)
Fluidity	7.71	6.00-9.70	4.84	645.46	(MA-S1-AU*MA-S1-AP),(MA-SI-AU*MA-S2-AP),(MA-S1-AU*MA-S3-AP)

There was a significant variation in the organoleptic characteristics except in odour persistence. The *Albizia* and *Cordia* honey samples collected in August from Kapkembu differed significantly in colour intensity. NE-S1-AP (*Croton honey*) differed from all the other seven monofloral honey samples in the sweet taste intensity. There was no significant difference among *Croton* honey in any of the organoleptic characteristics. The highest variation was observed in the fluidity amongst honey samples (Friedmans Q=645.46) and aroma intensity (Friedmans Q=239.5). The two *Acacia* honey samples from different sites in Mariashoni (MA-S1-AP, MA-S2-AP) differed significantly in aroma intensity.

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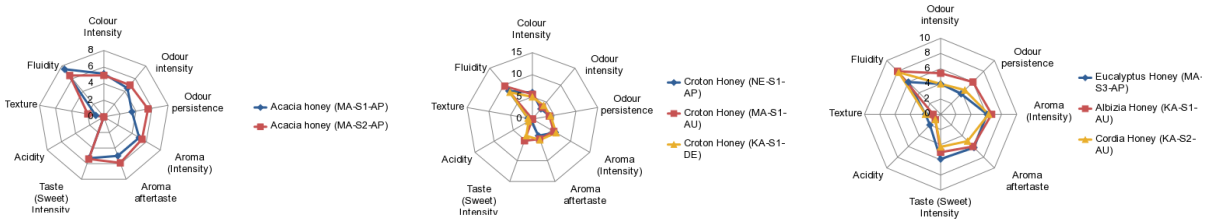

Figure 1. Spider plot of the various sensory attributes of the monofloral honey samples from Eastern Mau forest, Kenya.

Highest variation in Acacia honeys was observed in odour persistence. Acidity and texture was absent and modorate respectively in Acacia honeys. There less dispersion in fluidity, texture and acidity in monofloral honeys studied. Maximum dispersion was observed in odour persistence (*Acacia* honey samples), fluidity (*Croton* honey samples), and odour persistence (*Eucalyptus*, *Albizia*, *Cordia* honey).

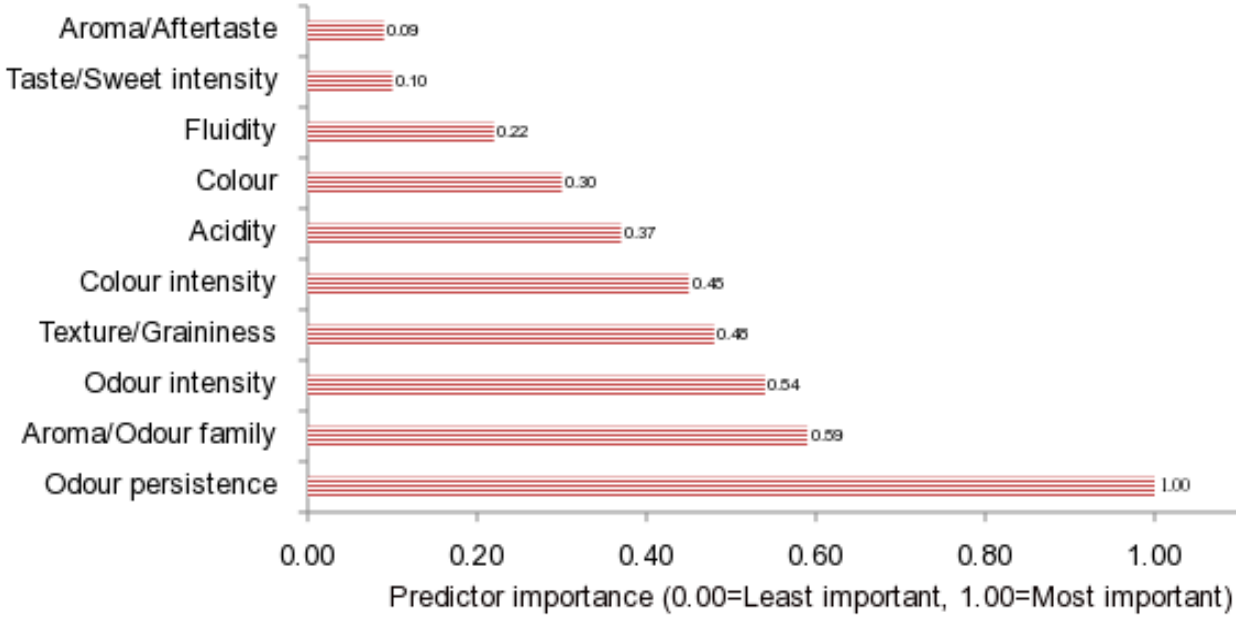

Figure 2. Two step cluster analysis predictor importance for the organoleptic characteristics of unifloral honeys.

The most important variable in predicting the monofloral honey type is the odour persistence. Aroma/aftertaste was the least important organoleptic trait in differentiating the monofloral honey studied. 70% of the organoleptic characteristics had less than 0.5 predictor importance. Odour intensity, aroma/odour family, and odour persistence had predictor importance of more than 0.5.

Table 3. Two step cluster membership of unifloral honey samples of varied pollen predominance

Honey sample	Botanical Origin	Predominant Pollen Content	Cluster Membership
MA-S1-AP	*Acacia sp.*	65%	1
MA-S2-AP	*Acacia sp.*	55.80%	2
MA-S3-AP	*Eucalyptus sp.*	56.50%	3
NE-S1-AP	*Croton sp.*	60%	1
KA-S1-AU	*Albizia sp.*	47.10%	2
KA-S2-AU	*Cordia sp.*	56%	3
MA-S1-AU	*Croton sp.*	50.20%	1
KA-S1-DE	*Croton sp.*	66.40%	1

The two step cluster analysis grouped the monofloral honey samples into 3 clusters. The *Acacia* honey fell in to cluster 1 and 2. All *Croton* honey grouped together in cluster 1. Cluster members included honey samples from different botanical origin.

Unifloral honeys differ from each other, among other features, in volatile organic composition which influences remarkably the individual sensory characteristics of each honey type (Christy et al., 2011). *Acacia* honeys in this study were of light amber colour and with floral fresh aroma. Honeys from same floral source were observed to have similar sensory attributes by Janaina et al. (2016). There was a significant variation in the organoleptic characteristics of the honey samples except for odour persistence. The differences between the sensory profiles of honeys highlight the blossom effect on the product's volatile composition.The maintenance of the same volatile compound profiles in honeys from the same floral origin was previously reported by Bicchi et al. (1983), who observed the same chromatographic profile of volatile compounds of honeys from the Piedmont region in different harvest years. The qualitative diversity was evident in honeys of different botanical origins. However, these profiles were not uniform for all samples from the same blossom as earlier observed by Jerkovic and Kus (2014) . This could be attributed to the fact that because by definition honey could be considered monofloral when it contained 45% pollen from the same plant. Thus, the honey can maintain the same melissopalinological classification even if 55% of the pollen composition varies, which will result in different compositional profiles (Jerkovic & Kus, 2014).
The accumulation of phytochemicals and the precursors of volatile components, including carbohydrates, phenols and volatile organic compounds, depends on the climatic conditions and soil characteristics. Differences between honeys with the same botanical origin produced by different species in different regions are presumably associated with different nectar or pollen compositions, which have the strongest effects on the chemical composition of the honey (Jerkovic & Kus, 2014). Generally, only partial similarities between the volatile constituents of nectar, flower extracts, and honeys have been found. Differences between honey and flower extracts are expected because the honey aroma compounds are constituents of various flower and plant parts (Jerkovic & Kus, 2014), the volatile compound profiles mostly varied from sample to sample in studies by Ana et al. (2018). Honeys from same floral source were observed to have similar sensory attributes. The sensory characteristics of honey vary according to maturation time and weather (Jananina et al.,2016; Gabriela, 2006). *Acacia* honey has shown highest sensory quality in studies of Romananian honey (Plostcutanu and Uliescu, 2018). Honey from similar locations were observed to differ in sensory profiles eg Colour intensity,aroma intensity, sweetness intensity and, acidity . This is due to the fact that honey has distinct and uniques flavours related to the origin of the location (local sensory uniqueness. differences in sensory profiles from hoeny from similar locations have also been reported in studies by Plostcutanu and Uliescu (2018).

The differences in the volatile fraction compositions of monofloral honeys greatly affect the individual sensory characteristics of each type of honey. Volatile compounds, which primarily account for food aroma and flavor, are present in honey at very low concentrations as complex mixtures of different chemical classes, including monoterpenes, norisoprenoids, sesquiterpenes, benzenoids, alcohols, esters, ketones and aldehydes (Silva et al., 2016). Volatile composition and sensory impression of honey samples are greatly influenced by the Geographic origin, an important quality factor closely correlated with the chemical and sensory characteristics of honey. Generally, volatile organic compounds (VOCs) could be derived from the plant or nectar source, transformation of plant compounds by the bee metabolism, heating or handling during honey processing and storage, from microbial or environmental contamination (Christy et al., 2011). *Eucalyptus* honeys are an important unifloral honey commercialised worlwide. Honey from different species of *Eucalyptus* trees displaying wide variations in the sensorial characteristics. The aroma of *Eucalyptus* honey has long been investigated and attributed to hydroxycetones, sulfur compounds, diketones, norisoprenoids, alkanes, aliphatic compounds, and monoterpenes as characteristic compounds in their composition (Maria et al., 2014). Sensory evaluation have revealed significant differences in taste and aroma between samples. Adulterated honey samples have a less intensive aroma or do not have aroma at all (Sedik et al., 2018). Sweet, aromatic, resin, wax aroma notes have been reported in *Cordia* honey by Ligia et al. (2014). Consumers prefer less , honeys with lower aroma intensity (Plostcutanu and Uliescu, 2018). Fruity, chemical and fermented notes were not reported in studies by Gabriela (2006). The acids in honeys cause different aromas that range from spicy to rancid depending on the length of the molecule's carbon chain. Short-chain acids, including acetic acid, have spicy flavors and aromas, whereas long-chain acids are associated with a rancid aroma (Ana et al.,2018).

There was low honey acidity level observed in this study. Honey acidity may be caused by either its mineral content or bacterial activity during the product maturation stage (Pasini et al., 2013). This derives from the organic acids of different nectar origins, and D-glucose oxidase enzymatic activity, which catalyzes the conversion of D-glucose into gluconic acid (Belay, 2013). A negative correlation has been reported (r=-0.63) between acidity and colour. Honey with less intense amber colour have more intense acid taste (Janaina et al., 2016). Our results are in the contrary in that *Cordia* honey with more intense amber colour showed highest levels of acidity. *Acacia* honeys did not show any acidity contrary to studies by Plostcutanu and Uliescu (2018) in which *Acacia* honey recorded high scores for all the investigated attributes .

Average colour score for this study was 5.36 with a range of 4.2-6.3. This was comparable to studies by Plostcutanu and Uliescu (2018) in which the average honey colour score was 5, ranging from 5-8.4. High honey colour scores have been given by *Acacia* monfloral Honey (8.6) in studies by Plostcutanu and Uliescu (2018), in this study highest colour intensity was observed in Cordia honey (6.3). According to Janaina et al. (2016), honey with less intense amber colour have more intense aroma. Colour in liquid honey varies from clear and colourless to dark amber or black. The various honey colours are basically nuances of yellow amber. Colour varies with age, botanical origin, and storage conditions. Less common honey colours eg reddish undertones (Chest nut), greyish (*Eucalyptus*) and greenish (honey dew) have been reported. Once crystallised honey turns lighter in colour because the glucose crystals are white (Krell, FAO). *Croton* honey have been reported with highest proportion (33.15%) glucose (Ligia et al., 2014). Some of the honeys reportedly "as white as milk" in some parts of East Africa are finely crystallised honey, almost water white (colourless) in their liquid state (FAO Bullettin, Krell). Previous studies have reported honey colour intensity varying according to pH, mineral content, exposure to light, storage time and enzymatic reactions. Dark honeys show having a high content of phenolic compounds and flavanoids (Tlemcani et al., 2018). Honey colour have also provided major contribution to first principal component in studies by Jananina et al. (2016). Extra light amber, white/amber, dark amber, light amber for *Croton* honey have been reported (Ligia et al., 2014).

A significant variation in fluidity was observed. This was the attribute with highest variation amongst honey samples. Freshly extracted honey is a viscous liquid. The viscousity depends on honeys composition and particularly with its water content (Krell, FAO Bulletin). Honey with lower water content have been reported to be of high viscosity attribute (Janaina et al., 2016). Honey from different origins have been reported as following Newtonian behaviour.However results indicating for non-Newtonian behavoiurs (thixotropic/dilatancy/pseudoplasticity) for some honeys have also been published (Stelmakiene et al., 2012). Dilatancy has been reported in Nigerian, *Eucalyptus* honeys. Rheology of honeys may inform something about its composition. Thixotropy is thought to be associated with proteins in honey, whereas the presence of high-molecular weight dextran in honey can cause dilatancy. Newtonian behaviour usually is expected for a concentrated solution of low molecular weight compounds, indicating absence of macromolecules and/or particles in suspension. Unusuall non-Newtonian pseudoplastic behaviour in honeys can signify the addition of foreign substances to honey such as molasses or starch. The variation observed in honey viscosity is greatly affected by composition parameters, such as water, sugar and protein contents, which change with the geographical and botanical origin of each honey (Fransisco et al., 2014).

Highest graininess was shown equally among *Eucalyptus*, *Acacia* and *Cordia* honey. The crystallisation as well as graininess could be attributed to fructose-glucose and glucose-water ratio in the honey composition (White, 1978; Fransisco et al., 2014). Fructose-glucose ratio is an important parameter for the prediction of crystallisation tendency of honey. Honey samples that do not crystallise for a long time, have a fructose-glucose ratio higher than 1.33 (White ,1978). Fructose-glucose ratio less than 1.11, honey crystallises quickly. Glucose-water ratio may be used to evaluate the honey propensity to crystallise. Glucose -water ratio above 1.7 means a high probability of the honey to crystallise (Fransisco et al., 2014). *Cordia* honey was liquid with crystals, of powdery texture and crystalline nature in studies by Ligia et al. (2014), this was comparable to our results in whcih *Cordia* honey had fine graininess. Our two step cluster analysis results show that the most important variable in predicting the monofloral honey type is the odour persistence. Odour intensity, aroma/odour family, and odour persistence had predictor importance of more than 0.5 and contributed to the largest proportion of honey variability. This is in contrast to reports by Gabriela (2006) in which principal component analysis indicated that colour , honey flavour, and sweet taste defined most of the variability.

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CONCLUSION

These results indicate that the organoleptic characteristics of the unifloral honeys from Eastern Mau are within the acceptable limits as stipulated in Codex, and EU directive on honey. The honey are also most distiguishabale with use of odour persitence and least distinguishable with aroma aftertaste. Aroma intensity, acidity and fluidity contribute most of the variability in unifloral honeys of Eastern Mau. The producers of the honey took appropriate measures in to safeguard of the unifloral honey sensory quality.

REFERENCES

[1] Ana, C., Janaína, M. B., Maria, A., Azevedo, P., Deborah, S. G., Marta, S. M. (2018) Sensory and volatile profiles of monofloral honeys produced by native stingless bees of the brazilian semiarid region. Food Research International 105 (2018) 110–120.

[2] Belay,A., Gulelat, D.H., Marc, B., Hannelore, B., Admasu. A., Kaleab, B., Samuel, M. (2016). Rheology and botanical origin of Ethiopian monofloral honey. Food Science and Technology 75 (2017) 393-401. www.elsevier.com/locate/lwt

[3] Bicchi, C., Belliardo, F., & Frattini, C. (1983). Identification of the volatile components of some Piedmontese honeys. Journal of Apicultural Research, (22) 130–136.

[4] Christy, E., Roland, N., and Anna, M. (2011). Int. J. Mol. Sci. 2011, 12, 9514-9532; doi:10.3390/ijms12129514. International Journal of Molecular Sciences ISSN 1422-0067

[5] Ciappini, M.C., Di Vito M.V., Gatti M.B., and Calviño, A.M. (2013). Development of a quantitative descriptive sensory honey analysis: Application to Eucalyptus and Clover Honeys. Advance Journal of Food Science and Technology, (7), 829-838.

[6] Codex Alimentarius (2001). Revised codex standard for honey. Pp 1-8.

[7] COMESA/FDHS 002 (2004). Standards for honey. Pp 1-8. Accessed onJuly 4, 2014. https://law.resource.org/pub/com/ibr/comesa.002.

[8] Council Directive 2001/110/EC. (2001). Council directive relating to honey. Official Journal L 10, 12 January 2002, pp. 47-52.

[9] Degaga, A. H. (2017). Identification of honey source bee floras during major and minor honey harvesting seasons in Jimma Zone , Southwest Ethiopia. Journal of Environment and Earth Science. ISSN 2225-0948. Vol7 (3). Pp 25-32.

[10] Erdtman, G. (1960). Investigation of honey pollen. The acetolysis method. Svensk Botanisk Tidskrift, (54), 561-564.

[11] Fransisco, K.G., Antonio, N., Dantas, F., Ricardo, H.L., Edna, M.M., Andarair, G. S., and Thiago, A. O. (2014). Rheological and some physicochemical characteristics of selected floral honeys from plants of caatinga.(Annals of the Brazilian Academy of Sciences).Printed version ISSN 0001-3765 . 86(2):981-994.

[12] Gabriela, I. (2006). From bee to plate – A sensoryforay in honey world. Buletin USA MV-CN, 62/2006 (264-269). ISSN 1454-2382

[13] IBM SPSS, (2011). IBM SPSS Statistics 20 briefguide. pp 1-70.http://www.ibm.com/spss/rd/students.

[14] IHC (2001). Minutes of the IHC meetings on sensory characterization of European unifloral honeys. Lovainela Neuve, Belgium, April 23-24, 2001 Online at: http:// www.apis.admin.ch/host/honey/minutes.htm (accessed on 5 July 2014).

[15] IHC (2009). Harmonised methods of the International Honey Commission. World Network of Honey Science. Pp 1-61.

[16] Ishihara, S. (1971). Test for Colour Blindness. Kanahara Shuppan, Kyoto.Pp 1-50.

[17] ISO 11037 (1999). Sensory Analysis. General Guidance and Test Method for the Assessment of the Color of Foods. International Organization for Standardization, Geneva (http://www.iso.org).

[18] ISO 4121 (2008). Sensory Analysis. Guidelines for the Use of Quantitative Response Scales. InternationalOrganization for Standardization, Geneva. (http://www.iso.org).

[19] ISO 5492 (2008). Sensory Analysis-Vocabulary. International Organization for Standardization, Geneva (http://www.iso.org).

[20] ISO 6658 (1985). Sensory analysis Methodology General guidance, International Organization for Standardization, Geneva (http://www.iso.org).
[21] ISO 6564 (1985). Sensory Analysis Methodology Flavour Profile. International Organization for Standardization, Geneva (http://www.iso.org).
[22] ISO 8586-1 (1993). Sensory analysis – General guidance for the selection, training and monitoring of assessors - Part 1: Selected assessors, International Organization for Standardization, Geneva (http://www.iso.org).
[23] ISO 8586-2 (1994). Sensory analysis – General guidance for the selection, training and monitoring of assessors – Part 2: Experts, International Organization for Standardization, Geneva (http://www.iso.org).
[24] ISO 8587 (2006). Sensory Analysis. Methodology Ranking. International Organization for Standardization, Geneva. (http://www.iso.org).
[25] ISO 8589 (2007). Sensory Analysis. General Guidance for the Designs of Test Rooms. International Organization for Standardization, Geneva. (http://www.iso.org).
[26] Janaína, M., Evandro, L., Gilmardes, M., Marta, de T.B., Beatriz, G., Maria, M. P., Marciane, M. (2016). Sugar profile, physicochemical and sensory aspects of monofloral honeys produced by different stingless bee species in Brazilian semi-arid region. Food Science and Technology 65 (2016) 645-651
[27] Jerkovic, I., and Kus, P. M. (2014). Terpenes in honey: Occurrence, origin and their role as chemical biomarkers. The Royal Society of Chemistry, 4, 31710–31728.
[28] KFS (Kenya Forest Service), (2012). Forest status, Nakuru County: KFS (unpublished report).
[29] Krell, R.(1996) Value added products from bee keeping. FAO Agricultural Services Bulletin N0-124. 103819- 8. ISBN 9251038198.Pp 3-424.
[30] Kundu, P.M. (2007). Application of Remote Sensing and GIS Techniques to Evaluate the Impact of Land Use Cover Change on Stream flows: The case of River Njoro in Eastern Mau- Kenya, PhD Thesis, Egerton University, Kenya
[31] Langat, D., Maranga, E.K., Cheboiwo, J., Aboiud, A.A. (2015). Forest use and dependence by adjacent households on East Mau forest ecosystem. Journal of Agricultural economics, Extension and rural development . ISSN-2360-798X. 3(10):Pp 326-337.
[32] Lawless, H.T., and Heymann, H. (1998). Sensory Evaluation of Food: Principles and Practices. New York: Chapman & Hall. Pp 1-150.
[33]Lawless, H.T., and Heymann, H. (2010). Physiological and Psychological Foundations of Sensory Function. Accessed on http://www.springer.com. Pp19-57.
[34] Ligia, B., Renato, J., Sousaa, O., and Peter Gallmannc (2014). Preliminary data on Brazilian Monofloral honey from the NorthEast region using FT- IR ATR Spectroscopic, palynological, and colour analysis. Quim. Nova, Vol. 37(4),Pp 716-719, 2014.
[35] Louveaux, J., Maurizo, A., and Vorwohl, G. (1978). Methods of Melissopalynology, Bee World, (59), 139-157.
[36] Maria, S., Olga, E.P., and Maria, C. (2014). Characterisation of Eucalyptus globulus honeys produced in the Eurosiberian area of the Iberian Peninsula. International Journal of Food Properties, 17:10, 2177-2191,DOI: 10.1080/10942912.2013.790050.
[37] Milojković, D., Dražen, L., and Živoslav, T. (2015). Modern analytical techniques in the assessment of the authenticity of Serbian honey .Arh Hig Rada Toksikol 2015;66:233-241DOI: 10.1515/aiht-2015-66-2721
[38] Okelo, M.O. (2008). Analysis of soil erosion, infiltration and runoff in different land uses in upper river Njoro, watershed, Kenya. Msc Environmental Science thesis, Egerton University, Njoro, Kenya.
[39] Pasini, F., Gardini, S., Marcazzan, G. L., and Carboni, M. F. (2013). Buckwheat honeys: Screening of composition and properties. Food Chemistry, 141 (3), 2802–2811. http://dx.doi.org/10.1016/j.foodchem.2013.05.102.
[40] Plostcutanu, G., Uliescu M (2018). Sensorial evaluation of Romanian honey. The Scientific Journal of Cahul State University. Vol 1 (3)85-89.http://jees.usch.md.
[41] Sang, J.K. (2001). The Ogiek in Mau Forest: Case study 3-Kenya - Forest Peoples Program. http://www.forestpeoples.org/sites/fpp/files/publication/2010/10/kenyaeng.pdf).
[42] Šedík,P., Renáta, B.P.,and Elena, H.(2018) Consumption patterns and sensory perception of honey by young segment in Slovakia. Ekonomika, Management, Inovace Vol. 10 (3) 2018. ISSN: 1804-1299.

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[43] Silva, P. M., Gauche, C., Gonzaga, L. V., Costa, A. C. O., and Fett, R. (2016). Honey: Chemical composition, stability and authenticity. Food Chemistry, 196, 309–323. http://dx.doi.org/10.1016/j.foodchem.2015.09.051.
[44] Soares, S., Joana, S. A., Maria, B., and Isabel, M.(2017). A comprehensive review on the main honey authentication issues: production and origin. Comprehensive reviews in Food Science and Food safety. Vol 16 (5)Pp 1072-1100. https.doi.org/10.1111/1541-4337.12278.
[45] Stelmakiene, A., Ramanauskiene, K., Briedis, V., and Leskauskaite, D. (2012). Examination of rheological and physicochemical characteristics in Lithuanian honey. Afric J Biotech 11: 12406-12414.
[46]Tlemcani, I., Bouchamma, E., Idrissi Chbihi, Z., Errachidi, F., Chabir, R., Ghadraoui, L., Haloti, S., Taouda, H., Hinchi, I.(2018). Physicochemical quality and sensory analysis of Moroccan honeys. International Journal of Scientific & Engineering Research Volume 9 (12) Pp 661-665. ISSN 2229-5518.
[47] UNEP (2006). Eastern and South West Mau Forest Reserves; Assessment and Way forward. Pp 1-36.
[48] White, J.R. (1978). Honey. Adv Food Res 24: 288-354.