

## Quality of Honey Harvested and Processed Using Traditional Methods in Rural Areas of Kenya

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### Abstract

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The honey consumed in most of Africa is harvested from traditional hives and processed using traditional methods. This work presents the quality characteristics of honey samples ( $n = 72$ ) processed using traditional methods and on sale in various important beekeeping zones in Kenya: West Pokot, Baringo, Mwingi, Tana, North Kinangop, Mbeere, Nandi Hills, Mida Creek, Kakamega and Taita. The quality of the honey was compared to international standards as proposed in the Codex Alimentarius. The quality markers analyzed were moisture, hydromethylfurfural (HMF), sugar content, diastase, proline content, and free acidity. Moisture was determined using a honey refractometer, HMF and Diastase content were determined through spectrophotometry, sugars were determined by High Performance Liquid Chromatography (HPLC), proline was determined through spectrophotometry and free acidity quantified by volumetry - titration technique. Average constituent values were at 16.00 - 21.20% (moisture); 3.70 - 389.36 mg/kg (HMF); 20.83 - 300.6 mg/kg (proline); 8.03 - 56.98 Schade units (diastase); 57.03 - 102.66% (fructose and glucose levels) and 18.00 - 71.85 50 mg/kg (free acidity). Most of the samples had constituent levels within the limits set in the Codex Alimentarius. Traditional honey harvesting and processing methods seem not to have negative effects on the major honey constituents. However, excessive smoking during harvesting had compromised the aroma and flavour of some samples. In an effort to promote beekeeping as an eco-friendly, sustainable alternate source of livelihoods, training in best apiculture practices, improved extension services and establishment of honey marketplaces is being done to improve honey quality in Kenya.

*Honey quality, traditional processing methods, sustainable livelihoods, Codex Alimentarius*

Beekeeping is an important component of agriculture, rural employment, human nutrition and economic development. Honey is the most important primary product of beekeeping both from a quantitative and economic point of view, and has been used by mankind for many years as a source of food, medicine and for religious and cultural ceremonies (Cartland 1970; Mcinerney 1990; Molan 1999). Kenya's honey production potential is estimated at 80 - 100,000 metric tones. However, only about 20% of this is realized because most of the highly productive areas are unexploited, with about 80% of honeys being produced in the Arid and Semi Arid Lands (ASALS). Like in many parts of Africa, the production of honey in Kenya mostly comes from traditional hives whose number is 1.1 million out of a total of 1.3 million hives in the country. The different honey types of the world show great variety. Flavour and aroma, often associated with the dominant pollen source (Crane 1990; Zhou et al. 2002), is one of the most attractive features of honey. In addition to this, honey is produced under many different climatic conditions. The main constituents in honey are, however, normally almost the same. Routine chemical analysis is aimed at verifying the authenticity of the product, to detect adulteration or poor handling of honey by monitoring certain indicators so that what is referred to as "pure honey" is always

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maintained with certain limits, and to address harvesting, storage, processing and market needs.

The quality factor that is used in the international honey trade, besides its organoleptic characteristics (flavour, consistency and colour), is its chemical composition mainly moisture and HMF content, the diastase index, pH, acidity as well as the content and proportion of the carbohydrates (sugars). The level of these indicators in a honey sample gives an indication of its quality. In Kenya, over 90% of beekeepers use traditional methods that presumably lead to honey of low quality (Mbae 1999). Beekeepers harvest honey by cutting the combs which are then put in a container. Normally, honey and wax are mashed up to create room for more honeycombs as harvesting progresses. Small-scale beekeepers commonly use the straining method to process the honey. Mashed honeycombs drip their honey with the wax, which is lighter than honey, settling on top. Some of the big pieces of wax are removed by hand, and honey is then tipped into a strainer and left to drain into a clean basin or bucket overnight or even for several days to remove smaller bits of wax and other impurities. Another method involves squeezing the honeycombs. Heating honey to fasten the straining process is done at varying uncontrolled temperatures. Refined honey is then packed in an array of containers, mostly pre-used beverage bottles and plastic containers. There is hardly any scientific information on the effect of traditional honey handling methods on the physicochemical constituents of honey in Kenya. The aim of this study was to determine the influence of traditional honey processing methods on the physicochemical properties of honey from different beekeeping regions in Kenya and compare this against recommended limits (Codex Alimentarius 2001). Results obtained in this study could serve as a reference point to other parts of Africa where traditional beekeeping practices are still practiced.

### Materials and Methods

#### Honey collection

A total of seventy two (72) honey samples, processed traditionally and ready for sale, were obtained from beekeepers or honey traders; 14 from Mwingi, 1 from Mbeere (Eastern Kenya); 23 from West Pokot, 26 from Baringo (Rift Valley), 2 from Mida creek, 2 from Tana River and 1 from Taita Hills (Coastal Kenya); 1 from Tiriki forest, 1 from the Nandi Hills (Western Kenya) and 1 from Kinangop Plateau (Central Kenya). Samples were collected within one month after harvesting between the months of June 2005 - January 2006 during the honey flow seasons of the respective regions. Collected samples were stored at room temperature (about 25 °C) away from direct sunlight, and analyzed within two weeks.

Eastern Kenya, the Rift Valley and parts of Coastal Kenya (Tana River) is characterized mostly by *Acacia* sp.; while Western Kenya where the samples were obtained is a remnant of the tropical equatorial forest, the honey is thus largely multifloral. The predominant flowering honey plant in Kinangop Plateau during this particular season was *Croton* sp. Pollen analysis was not under the scope of this study.

#### Physicochemical analysis

The methods used for analysis were based on those of the Association of the Official Analytical Chemists (AOAC 1990) or those of the Harmonised Methods of the European Honey Commission and International Honey Commission (Bogdanov et al. 1997; Bogdanov 1999). The percentage of moisture in honey was determined using a hand-held honey refractometer (HHR - ATAGO, Model REF 106c). Hydroxymethylfurfural (HMF) content was determined using the spectrophotometric method (White 1979) on UV absorbance at 284 nm (CECIL CE 3041 3000 Series, CECIL Instruments, Cambridge, England). Diastase activity of each honey sample was quantified by spectrophotometric method (Schade et al. 1958) at UV absorbance 660 nm (CECIL CE 3041 3000 Series, CECIL Instruments, Cambridge, England). Sugar content was determined by High Performance Liquid Chromatography (HPLC) with UV detection (192 nm). Peaks were identified on the basis of their retention times and quantification performed according to the external standard method on peak areas - the signal being compared with those from standards of known concentration. Free acidity was quantified by volumetry - titration of a honey sample titrated with 0.1M NaOH until a pH of 8.3 was attained and the result expressed in milliequivalents of acid per 1000 g of honey. Proline was quantified using spectrophotometric method and absorbance determined at 510 nm (CECIL CE 3041 3000 Series, CECIL Instruments, Cambridge, England)

#### Statistical Analysis

All the determinations were repeated at least three times (triplicates), and the means and standard errors determined.

## Results and Discussion

The means for the quality variables analyzed (moisture, HMF, diastase, proline, free acidity and sugars) are summarized in Table 1. The moisture content of the Kenyan honey samples ranged from 15.60 - 21.20%, (n = 72). Only one (1) sample had moisture content exceeding the limit allowed by the Codex and Council of the European Union (EU) of

Table 1. Means (= SE) of composition of 72 honey samples obtained from different regions in Kenya.

Area Standard*	Moisture * [ $\leq 21\%$ ]	HMF [ $\leq 40 \text{ mg}\cdot\text{kg}^{-1}$ ]	Diastase [ $\geq 8 \text{ Schade units}$ ]	Proline [ $\geq 180 \text{ mg}\cdot\text{Kg}^{-1}$ ]	Free Acidity * [ $\leq 50 \text{ meq}\cdot\text{kg}^{-1}$ ]	Glucose & Fructose * [ $\geq 65\%$ ]	Sucrose * [ $\leq 5\%$ ]
W. Pokot (n=23)	16.74 $\pm$ 0.10	3.70 $\pm$ 0.95	20.50 $\pm$ 0.81	243.99 $\pm$ 7.44	28.16 $\pm$ 0.49	61.50 $\pm$ 1.74	N d
Baringo (n=26)	16.57 $\pm$ 0.11	3.70 $\pm$ 0.51	15.80 $\pm$ 0.32	300.61 $\pm$ 26.35	30.85 $\pm$ 0.99	66.50 $\pm$ 3.25	0.90 $\pm$ 0.42
Mwingi (n=14)	16.62 $\pm$ 0.33	29.20 $\pm$ 5.35	24.10 $\pm$ 7.03	220.08 $\pm$ 10.22	63.10 $\pm$ 6.21	65.00 $\pm$ 0.48	2.23 $\pm$ 0.48
Tana (n=2)	17.00 $\pm$ 0.44	10.30 $\pm$ 0.85	50.40 $\pm$ 0.40	122.27 $\pm$ 44.66	52.16 $\pm$ 8.50	77.83 $\pm$ 5.16	2.07 $\pm$ 0.13
Kinangop (n=1)	21.20 $\pm$ 0.02	53.66 $\pm$ 0.47	8.03 $\pm$ 0.29	20.83 $\pm$ 3.28	18.00 $\pm$ 0.58	102.66 $\pm$ 8.57	N d
Mbeere (n=1)	17.00 $\pm$ 0.04	68.13 $\pm$ 1.68	13.86 $\pm$ 0.59	96.66 $\pm$ 1.20	48.33 $\pm$ 1.66	70.13 $\pm$ 6.80	N d
Nandi Hills (n=1)	16.00 $\pm$ 0.03	389.36 $\pm$ 8.84	13.03 $\pm$ 2.03	39.40 $\pm$ 0.67	56.33 $\pm$ 2.40	59.13 $\pm$ 3.10	N d
Mida Creek (n=2)	19.62 $\pm$ 0.02	151.4 $\pm$ 43.8	35.02 $\pm$ 0.35	151.70 $\pm$ 2.08	71.85 $\pm$ 0.88	57.03 $\pm$ 0.98	N d
Kakamega (n=1)	20.20 $\pm$ 0.04	70.30 $\pm$ 0.20	56.98 $\pm$ 6.95	234.57 $\pm$ 3.32	42.75 $\pm$ 0.75	72.96 $\pm$ 3.52	N d
Taita (n=1)	17.00 $\pm$ 0.03	7.97 $\pm$ 0.62	21.30 $\pm$ 1.18	276.25 $\pm$ 28.95	46.00 $\pm$ 1.35	81.5 $\pm$ 0.31	N d
% of samples within set limits	98.61	91.67	100	90.27	73.61	63.88	100

\*Honey quality standards of the Codex Alimentarius for floral honeys. HMF = hydroxymethylfurfural  
N d = Not detected

$\leq 21\%$ . Eight (8) of the seventy two (72) samples had HMF levels above the minimum unacceptable limit  $\leq 40 \text{ mg/kg}$ . Diastase content ranged from 8.00 - 70.30 Schade units, all seventy two (72) samples tested had diastase amounts within the acceptable limit of  $\leq 8$  Schade units. Proline levels ranged from 20.80 - 673.30 mg/kg (n = 72). All 12 samples from Mwingi, 29 of the 30 samples from West Pokot, all 26 samples from Baringo, and a sample each from Kakamega and Taita Hills had proline levels within the acceptable limit of  $\leq 180 \text{ mg/kg}$ . However, samples from North Kinangop, Mbeere, Nandi hills and Mida Creek had proline levels lower than acceptable limit. Fructose and glucose content ranged from 55.80 - 103.0%. On average, the samples from Baringo, Mwingi, Mbeere, Tana and North Kinangop had more than the minimum limit of fructose and glucose, whereas the sample from Nandi Hills and Mida creek had lower fructose and glucose amounts than the minimum allowable content ( $\leq 65\%$ ). In addition, the level of sucrose in all the 72 honey samples was less than the maximum limit of 5%.

Moisture content is the criterion that determines the capability of honey to remain stable and resist spoilage by yeast fermentation. High moisture content increases the probability/risk that the honey will ferment upon storage. The final water content of a honey sample depends on a number of environmental factors during production such as weather, humidity amounts inside the hive, nectar conditions and treatment of honey during storage and extraction. Only one sample of the 72 analyzed for moisture had higher moisture content than the acceptable minimum limit, an indication that most farmers harvest ripened capped honey and that generally honey is stored under suitable conditions.

The combinations of HMF, diastase and invertase enzyme levels indicate the extent of heat and storage damage of honey and can be used as markers of honey freshness and adulteration (White 1994). Hydroxymethylfurfural (HMF) is produced in honey to some degree all the

time, and is a breakdown product arising from the action of normal honey acidity on sugars (glucose and fructose) at ambient temperature. Naturally occurring levels of HMF are about 10 mg/kg (Crane 1990). The amount formed, however, increases with increasing heat treatment. Heating honey above 75 °C for a few minutes or storing honey at temperatures above 27 °C for several months increases HMF levels. A maximum content of  $\leq 40$  mg/kg is allowed in table honey in the international market. Amounts exceeding this maximum are considered a main indicator of honey deterioration (White 1979; White and Siciliano 1980; Bogdanov and Martin 2002) either through heating or long periods of storage (White et al. 1962). Uncharacteristically high levels of HMF were noted from two freshly harvested honey samples from Mida Creek (in the Kenyan coast). However, this phenomenon needs to be confirmed using a suitable number of samples. Diastase is an enzyme present in honey and is sensitive to heat and storage damage. All the honey samples were within the Codex Standard for Diastase, an indication that the honey had not stayed for long periods after harvesting, was under proper storage and/or had not been heated during processing.

The measurement of proline is used as an indication of honey ripeness - its quantity being an indication of adulteration when it falls below a certain limit. The proline amounts obtained in all the samples exceeded the minimum limit, an indication the honey samples were harvested after the process of ripening by the bees in the hives was complete. Louveaux (1985) reported that majority of the proline comes from bee salivary secretions. Bogdanov et al. (1999) reported that proline content varies considerably between different honeys; similarly, a great variation in proline content was observed during this study (a range of 20.8 - 673.3 mg/kg).

Sugar content (fructose and glucose) of three samples from Mida Creek and Nandi Hills was below the acceptable limit ( $\leq 65\%$ ). However, a higher number of samples need to be analyzed before a conclusion is made on the sugar content in honeys from these regions. It has been proposed that the relative amounts of these sugars determine the honey's tendency to crystallize (Crane 1990). The sucrose content of all honey samples was within the limits of the quality criteria established by the Codex Alimentarius. This is not unusual, considering that feeding colonies with sugar is not a common practice in the country.

Free acidity of the honey samples was within the recommended range with an exception of 2 samples from Tana, 2 samples from Mida Creek and 1 sample from Nandi Hills. The predominant acid in honey is gluconic acid, a derivative of dextrose (Stinson et al. 1960). The gluconic acid present in all honeys originates largely from the activity of glucose, added by the bee during ripening (White and Subers 1963), with some contribution from bacterial action during the ripening (Ruiz-Argueso and Rodriguez-Navarra 1973). The considerable variation in the amount of acids in honeys perhaps reflects the time required for nectar to be completely converted into honey under differing conditions of the environment, colony strength and the sugar concentration of the nectar.

Different management, harvesting and processing techniques can influence the final quality of honey (Krell et al. 1988; Krell 1991). In view of the results obtained in this study, it seems that the quality of honeys harvested from traditional hives and subjected to traditional methods of extraction is of a quality largely acceptable for both domestic and international markets, particularly the EU. These results contrast the common assumption that honey harvested and processed through traditional methods is generally of low quality. It seems that traditional methods for bee handling are well established and that the skills and knowledge are informally passed from one generation to the next. It seems that most beekeepers take deliberate measures to ensure that honey quality is maintained, for example, harvesting completely sealed combs and minimizing contact with humid air between harvesting and extraction regulates honey moisture content; harvesting only ripe honey ensures proper

proline levels; honey is not exposed to extreme temperatures as indicated by the acceptable levels of HMF and Diastase. However, some samples had constituent levels either below or above the recommended levels, an indication that not all people handling honey (in harvesting, processing and storing) take deliberate measures to maintain its quality.

However, there is still need to improve the methods already in use in the local bee-human relationships. Honey adulteration by dishonest traders and middle-men may be the reason for the assumption that honey from traditional hives and/or processed by traditional methods is of poor quality. In an effort to promote beekeeping as an alternative source of livelihood, training of beekeeping extensionists, proper extension services for beekeepers, mobilization of beekeepers into groups to bulk production and establishment of collection centers to facilitate faster movement of honey from beekeepers to the processing units is currently being encouraged.

Due to the variety inherent in honeys from different regions, there is a need for regional honey standardization to avoid unfair criticism of a sample, if standards for regional markets are not set (White 1967). It might therefore be fitting for different regions within the tropics to carry out mass analysis of their honeys and come up with a set of guidelines suitable for their particular regions. Such initiatives have been reported in Burkina Faso (Meda et al. 2005) and Qatar (Al-Jedah et al. 2003).

### **Kvalita získávání a zpracování medu ve venkovských oblastech Keni s využitím tradičních metod**

Med konzumovaný na většině území Afriky je získáván z tradičních úlů a zpracováván s využitím tradičních metod. Tato práce porovnává ukazatele kvality vzorků medu ( $n = 72$ ) získávaných tradičním způsobem a z prodeje v různých významných včelařských oblastech Keni: Západní Pokot, Baringo, Mwingi, Tana, Severní Kinangop, Mbeere, Nandi Hills, Mida Creek, Kakamega a Taita. Kvalita medu byla srovnána s mezinárodními standardy uvedenými v Codex Alimentarius. Analyzovanými ukazateli byl obsah vody, hydroxymethylfurfural (HMF), obsah cukru, aktivita diastázy, obsah prolinu a titrační kyselost. Obsah vody byl zjišťován pomocí medového refraktometru, HMF a aktivita diastázy byly stanovovány spektrofotometricky, cukry byly stanovovány metodou HPLC (High Performance Liquid Chromatography) a kyselost měřena volumetricky - titrací zásadou. Průměrné hodnoty měřených parametrů se pohybovaly v rozmezích: 16,00 - 21,20% (obsah vody); 3,70 - 389,36 mg·kg<sup>-1</sup> (HMF); 20,83 - 300,6 mg·kg<sup>-1</sup> (prolin); 8,03 - 56,98 Schadeho jednotek (diastáza); 57,03 - 102,66 % (množství fruktózy a glukózy) a 18,00 - 71,85 50 mq·kg<sup>-1</sup> (titrační kyselost). Hodnoty těchto základních parametrů se pohybovaly u většiny vzorků v limitech uvedených v Codex Alimentarius. Zdá se, že tradiční způsob získávání a zpracování medu nemá negativní vliv na hlavní ukazatele kvality medu. Nadměrné vykuřování při získávání medu ovlivnilo vůni a chuť některých vzorků. Za účelem podpory ekologického včelařství jako trvale udržitelného alternativního zdroje obživy a zlepšení kvality keňského medu se provádí výuka nejlepších včelařských technik, zlepšuje se zpracovatelský průmysl a zakládají se thry s medem.

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