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Full Length Research Paper

Impacts of storage conditions on physicochemical characteristics of honey samples from Burkina Faso

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Apiculture is income generating activity that has known a real development in Burkina Faso. The quantity of honey produced was more and more increased. Unfortunately, data on physicochemical characteristics were scare. Honey samples collected from beekeepers since 2001 to 2005 and stored in the laboratory at temperature between 35 to 40°C and at the moisture between 50 to 60%, and some bought in the market in 2007 have been analysed according to the harmonised methods of European Honey Commission. The physicochemical characteristics as moisture, Hydroxymethylfurfural (HMF), acidity, electrical conductivity, pH, diastase, colour and sugars content of the honey samples were significantly different even though storage conditions affect honey physicochemical characteristics and reduced considerably the deadline for consummation to one year in the tropics, but they fulfilled the Codex Alimentarius norms except the Gourma (Go) sample, which can be considered as deteriorated honey. Two samples were honeydew honeys.

Key words: Burkina Faso, honey, physicochemical analysis, beekeeping.

INTRODUCTION

Honey is the beehive product that was most known in South Saharan Africa. It was defined as "the natural sweet substance produced by honey bees from the nectar of plants or from secretions of living parts of plants or excretions of plant sucking insects on the living parts of plants, which honey bees collect, process by combining with specific substances of their own, deposit, dehydrate, store and leave in the honey comb to ripen and mature inside the honey combs" (Bogdanov et al., 1997; Codex Alimentarius Commission, 2001, Breadbear, 2009).

Honey presents physicochemical characteristics, then the study determines its botanical origin, quality, or adulteration. Sales of honey generate incomes if it has quality that conforms to the Codex Alimentarius standard.

The physicochemical properties considered in this study are colour, moisture, HMF (5-[hydroxyméthyl]-furane-2-carbaldéhyde), pH, electrical conductivity, free acidity, sugar content, amylase which according to Joshi et al. (2000) are important in the determination of quality honey.

In Burkina Faso, beekeeping activities have undergone a noticeable development with the installation of bee-keeping promoting centres, training and financial helps to beekeeper organizations. All these have contributed to increase honey production. Researches were limited to the inventories of plant species visited by honeybee *Apis mellifera adansonii* Latreille (Nombré et al., 2009). However, there are no major study on physicochemical

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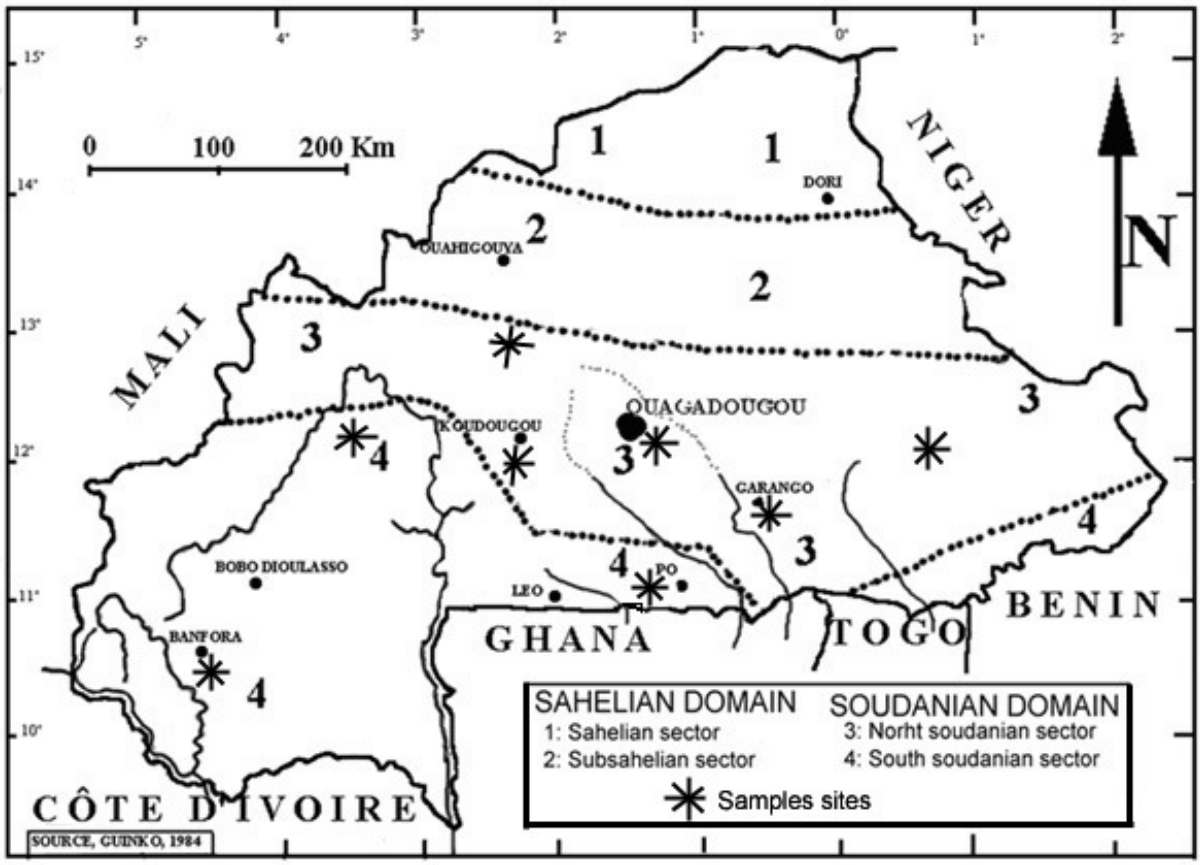

Figure 1. Localization of main beekeeping centres where honey samples come from.

and melissopalynological analysis (Nombré et al., 2004 and Méda et al., 2005).

Knowing honey characteristics allows the packaging and storage of them in appropriated conditions in order to preserve their qualities and savour. It also allows to know if the practices of beekeepers are appropriate and keep honey qualities (Clément et al., 2002), and then it allows to put an add value on the sale of honey. Indeed, according to Ouchemoukh et al. (2007) physicochemical characteristics as electrical conductivity, pH, ash content and specific rotation are widely used to differentiate botanical and geographical origin of honey and then complete pollen analysis. Hydroxymethylfurfural (HMF) content reflects the age and the thermal past of the honey Bruneau (2005) and Jeanne (2005). The fructose-glucose ration allows todeterminethe crystallization speed of honey and its stabilization. The honey colour is the physical property perceived immediately by the consumers (Piana et al., 2004). This study was therefore aimed to study the physicochemical characteristics of Burkina Faso honey samples according to Codex Alimentrius norms, and to evaluate the impact of storage conditions on the physicochemical parameters.

MATERIALS AND METHODS

Study area

Burkina Faso is divided in two phytogeographical areas characterized by their climate, flora and vegetation. Honey samples were collected in the soudanian area (Figure 1) that is divided in North and south soudanian phytogeographical areas (Fontès and Guinko, 1995). It is the principal area for beekeeping activities with beekeeping promoting centers as “Centre de Production, de Formation et de Recherche en Apiculture”, “Centre Seelintaba”, “Centre de promotion apicole de Koudougou, “Faso miel” and content most of wooded formations. Annual rainfall fluctuates between 700 and 1400 mm. The rainy season lasts four months (June to September).

The annual temperature varies from 20.5 to 38.6°C. The vegetation goes from woody savannah to forest gallery or clear forest. According to Fontes and Guinko (1995), it is dominated by *Combretum glutinosum* Perr ex DC, *Terminalia avicenioides* Guill. and Perr., *Anogeissus leiocarpus* (DC.) Guill. and Perr., *Vitellaria paradoxa* Gaertn, *Parkia biglobosa* (Jacq.) Benth., *Acacia seyal* Del., *Lannea microcarpa* Engl. and K. Krause, *Detarium microcarpum* Guill. and Perr., *Danielia oliveri* (Rolfe) Hutch. and Dalz., *Afzelia Africana* Sm., *Isoberlinia doka* Craib and Stapf, or a herbaceous savannah dominated by *Andropogon gayanus* Kunth, *Loudetia togoensis* (Pilg) Hubb. and *Pennisetum pedicellatum* Trin (Figure 1).

Table 1. Average of physicochemical characteristics for Burkina Faso honeys, sampled in 2007.

Honey samples	Colour	Moisture (%)	HMF (mg/Kg)	Conductivity (mS/cm)	pH	Free acidity (meq/kg)	Amylase (DN)
Go	119	16	384.1	0.483	5.72	3.2	4
Bo	115	16.6	61.8	0.982	4.38	25.5	13
Mo	63	14.8	40.1	0.257	3.87	14.3	7
Pa	118	17.7	30.1	1.002	4.57	13.9	26
Ca	117	19.1	46.8	0.996	4.31	26.1	25
So	125	19.9	75.2	0.924	4.19	27.5	22
Le	116	15.1	13.4	0.788	4.53	18.4	16

Go = Gourma, Bo = Boulkiemdé, Mo = Mouhoun, Pa = Passoré, Ca = Cascade, So = Sourou, Le = Lergo.

Honey samples

Five honey samples per beekeeping centre have been collected each year during five years (since 2001 until 2005) and stored in a cupboard at laboratory under surrounding conditions of temperature (30 to 40°C) and moisture (50 to 60%). Three honey samples coming from main beekeeping centres (CPFRA, Selintaba, CPAK, Faso miel, Mouhoun, Passoré, Sourou) have been bought at the market in June 2007.

Physicochemical analysis

Honey samples have been analysed in July, 2007 at "Centre d'Etudes Techniques Apicoles de Moselle/France" (CETAM) laboratory according to the harmonized methods of the European Honey Commission. Moisture was determined by refractometry using Abbe refractometer. Free acidity and pH were determined by automatic titrator by titration to pH 8.3 or to an equivalent point. Electrical conductivity (milliSiemens per cm) was determined by electrical conductivity-meter lower range 10^{-7} S.

Hydroxymethylfurfural was determined by Winkler method using spectrophotometer UV-Visible cary 50 lined to 550 nm. Diastase or amylase activity was determined with Phadebas method using spectrophotometer UV-Visible cary 50 lined to 620 nm. Total reducing sugars, reducing and non reducing sugars were determined by high pressure liquid chromatography (HPLC).

Organoleptic property

It is the examination of a product through the evaluation of the attributes perceptible by the sense organs (Piana et al., 2004). It allows distinguishing the botanical origin of honey and to identify and quantify some wastes. Honey colour was determined according to Lovibond and spectrophotometer methods and the unities were converted to Pfund colour unities.

RESULTS

The mean of physicochemical characteristics of the three honeys sampled per beekeeping centre were summarised in Table 1.

For honeys sampled in 2007, the mean of each physicochemical characteristics showed that, the moisture content has varied from 14.8 (Mo) to 19.9 (So). For the HMF, its content was less than 80 mg/kg except the Gourma (Go) sample that had a high concentration (384.1 mg/kg). The electrical conductivity values of four honey samples (Bo, Pa, Ca, So) were more than 0.8 mS/cm, while the three others samples had lower value. The pH values fluctuated between 3.87 (Mo) to 5.72 (Go). The free acidity concentration fluctuated from 3.2 (Go) to 27.5 (So). The diastasique index on Schade unity was more than 8, except Go sample that had low diastasique index (4). According to Pfund scale, most of honey samples were dark, except Mo sample, with 63 pfund scale appeared white.

For old honey samples, most of their physicochemical characteristics did not agree to Codex Alimentarius norms (Table 2). Indeed, honey colours was dark, their HMF concentration was high (> 80 mg/kg), the electrical conductivity values were lower than 0.8 mS/cm, the diastasique index was weak, the pH have decreased.

A different kind of sugars was found in the honey samples (Table 3). The total of reducing sugars for honeys sampled in 2007 was more than 65 /100 g (European Union and Codex Alimentarius norms) except for Bo (49.1 /100 g) and Ca (45.8 /100 g). It was lower than for old honeys. The saccharose concentration was less than 5 g/100 g. The fructose-glucose ration was more than one, and that for glucose and water was lower than two. Other sugars as maltose, isomaltose, turanose was found in all honey samples and raffinose only in Pa, Ca, So, Le (04), Le (03), Le (01), Wa (03), Ki (03) and Na (03).

DISCUSSION

Two kinds of physicochemical parameters have been studied. The qualities control which group moisture, HMF and diastasique activity and the control of origin and designation with conductivity, coloration, sugars and acidimetry. Honey colour is the physical property perceived immediately by the consumer (Bogdanov et al., 2004). Most of honeys sampled in 2007 fulfil colour norms because according to Krell (1996) and Anchling

Table 2. Mean of physicochemical characteristics of honey samples stored in laboratory since 2001 until 2005.

Honey samples	Colour	Moisture (%)	HMF (mg/Kg)	Conductivity (mS/cm)	pH	Free acidity (meq/kg)	Amylase(DN)
Le (05)	142	15.1	379.1	0.587	4.17	4.17	3
Le (04)	130	14.7	501.0	0.612	4.25	4.25	2
Le (03)	>142	17.4	918.5	0.695	3.66	3.66	4
Le (01)	>142	18.8	668.0	0.590	4.01	4.01	3
Ko (04)	>142	17.4	1169.0	1.114	3.85	3.85	6
Wa (03)	>142	17.3	584.5	0.542	3.74	3.74	6
ki (03)	>142	14.4	501.0	0.447	3.92	3.92	12
Na (03)	>142	15.3	673.0	0.497	3.88	3.88	11

Le = Lergo, Ko = Koubri, Wa = Wangala, Ki = Konki Ipala, Na = Nazinga. Numbers in parenthesis indicate years of honey harvesting: 05 (2005), 04 (2004), 03 (2003), 01 (2001).

Table 3. Sugars composition of Burkina Faso honey samples.

Honey samples	Glucose	Fructose	Isomaltose	Saccharose	Turanose	Raffinose	Maltose	G/W	F/G	F+G	Total sugars
Go (07)	32.7	32.1	0.8	2.1	1.1	-	2.4	2.0	2.0	64.8	71.2
Bo (07)	20.7	28.4	1.0	1.0	1.2	-	1.0	1.2	1.71	49.1	53.3
Mo (07)	32.8	44.1	0.6	0.7	0.6	-	1.9	2.2	2.98	76.9	80.7
Pa (07)	27.1	37.0	1.2	1.8	1.3	0.2	0.9	1.5	2.09	64.1	69.5
Ca (07)	19.5	26.3	1.4	1.5	1.0	0.2	0.6	1.0	1.38	45.8	50.5
So (07)	27.9	38.4	1.2	1.1	0.8	0.1	0.9	1.4	1.93	66.3	70.4
Le (07)	29.7	40.1	1.7	1.8	1.4	-	2.4	2.0	2.66	69.8	77.1
Le (05)	27.9	40.4	1.7	2.0	3.1	-	1.7	1.8	2.67	68.3	76.8
Le (04)	26.4	38.6	1.6	2.2	2.7	0.2	2.9	1.8	2.63	65.0	74.6
Le (03)	27.5	37.0	1.2	1.1	1.6	0.1	1.6	1.6	2.12	64.5	70.1
Le (01)	26.2	36.0	1.7	1.8	2.9	0.1	1.4	1.4	2.43	62.2	70.1
Ko (04)	19.8	34.4	2.1	2.0	2.4	-	0.7	1.1	1.98	54.2	61.4
Wa (03)	26.2	37.9	1.0	1.8	2.7	0.2	1.1	1.5	2.19	64.1	70.9
ki (03)	26.5	38.7	1.9	3.8	2.7	0.4	1.2	1.8	2.68	65.2	75.2
Na (03)	26.2	37.7	3.3	3.7	3.7	0.4	1.4	1.7	3.73	63.9	76.4

G/W = Glucose/Water, F/G= Fructose/Glucose, F+G = Fructose + Glucose.

(2007), honey colour varies from colourless to dark and it was influenced by nectar coloration, pollen colour, sugar reactions and the age of frames.

Honey water comes from nectar moisture. It is influenced by many factors as the harvesting period, the percentage of capped cells, the storage and the climatic conditions during the harvesting period (Clément et al., 2002). It is the most important honey characteristics because it is highly important in honey quality, its viscosity, its crystallization, its fermentation and its savour. The values obtained are lower than 21%, the maximum allowed by the European Union and Codex Alimentarius for tropical honeys. These values allow honeys not to be fermented according to Bogdanov et al. (1999).

The HMF comes from fructose degradation by molecular dehydration. Its formation is a natural process because honeys are acid, but temperature accelerates the process and the HMF concentration increases according to storage duration and also according to beekeeping practices (Jeanne, 2005). Then, the quantity of HMF reflects the age of honey and shows if honey has been heated or not. Six honey samples among the seven have a HMF value lower than the codex alimentarius standard (80 mg/kg for tropical honeys) and attest of good beekeeping practices. Indeed, in these beekeeping centres, beekeepers have been trained in modern beekeeping techniques and they use movable-comb hives as the Kenyan Top-Bar Hive, the Modified African long hive and the Kenyan hives with trapezoidal frames. They harvest honey using protective equipments as clothing and especially smokers, and the honey is extracted using sieves or centrifugal extractor. These honeys need to be storage under appropriate conditions

as a lower temperature (< 30°C) because according to Jeanne (2005), the HMF value is multiplied by 1.10 in six months and by two in one year when honeys were stored between 15 and 20°C in temperate areas or, in tropical areas the mean temperatures is close to 30°C, and then accelerates the HMF formation. One sample (Go) has a high HMF value (384.1 mg/kg) and a small diastasique index (4) and according to Jeanne (2005), these values can be a proof of deteriorated honey by excessive heating. Indeed, this centre produces a lot of honey each year that one part comes from traditional beekeepers which use traditional hives and did not often applied appropriate conditions and techniques for harvesting, extracting and packaging honey. So, in mixing this honey to that coming from modern hives, and especially the duration and the conditions (temperature > 35°C) of storage in the shops can explain that high HMF value.

The pH and the free acidity (meq/kg of honey) can influence honey stability and its storage conditions. They give some information on honey origin. The acidity of honey is due to the presence of organic acids, particularly the gluconic acid and the inorganic ions such as phosphate and chloride (Ouchemoukh et al., 2007). The value of honeys acidity, lower than 50 meq/kg of honey, means that honeys will not be fermented.

The electrical conductivity is widely used for discrimination between honeydew and blossom honeys (Bogdanov et al., 1999). The honeydew honeys are characterized by their very dark colour and high values of pH, ash content and electrical conductivity (Diez et al., 2004). In the 2007 honey samples, Bo and Ca are honeydew honeys. That was confirmed by the total sugar content that is lower than the Codex Alimentarius and the European Union norms and the total of fructose and glucose is also lower than 60 /100 g. The Bo sample comes from a centre that buys honeys from the Ca production area; that could explain the similarity of their characteristics.

The total of reducing sugars, more than 65% confirm that sugars represent the main constituents of honey. The fructose-glucose ration and the glucose-water ratio are respectively, more than one and lower too, which allows honeys to stay in liquid for a long time and attests also, with a low value of saccharose, the lack of adulterated honey samples.

Two honey samples Le and Mo fulfilled all quality norms both for Codex Alimentarius, the European Union and as well as for Official Journal. The physicochemical characteristics of old honeys are influenced by storage conditions (temperature > 35°C). Indeed, the temperature accelerates for example the diastase destruction from 10 to 33% in one year and from 31 to 37.5% in two years (Bruneau, 2005).

The age of honey also affects its characteristics. Indeed, diastase and total sugars content decreased whereas HMF concentration increased. These values are higher than those found by Jeanne (2005). During the storage, sugars content is modified with the lost of glucose and fructose and a great increase of disaccharides as maltose. That involves a modification of fructose-glucose ratio and the production of HMF which increases from 5 to 15 mg/kg in 2 years according to Clément et al. (2002).

The results found agree with those reported by others authors (Ramirez Cervantes et al., 2000; Joshi et al., 2000; Karabournioti and Zervalaki 2001). However, they differ in some characteristics (moisture, HMF content) from those found by Méda et al. (2005), because they have stored their samples between 0 and 4°C. Whereas, honey is hygroscopic. That can explain the high value of moisture content (25%) that they have found.

Conclusion

Based on these results, the practices of beekeepers from these beekeeping centres are good and the honeys sampled in 2007 fulfil international norms. But the storage conditions notably the high temperature (> 35°C) influence the physicochemical parameters and reduce considerably the deadline for consummation of tropical honeys to one year.

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