Microbiological and Physicochemical Quality of Honeys from South and South-West of Niger

Laredj Hocine1,2,*, Berakaa Tefiel2, Ali Moustapha2, Amine Allaoui2, Kheïra Benamara2

1Laboratory of Agro-Biotechnology and Nutrition in Semi-Arid Areas
2Faculty of Science of Nature and Life, University Ibn Khaldoun Tiaret, Algeria
*Corresponding author: lar_hocine@yahoo.fr

Abstract
With all the complexity of the biological composition of honey, our work focused on the microbiological (bacteriological and mycological) and physicochemical characterization of Nigerian honeys. The results showed a satisfactory bacteriological composition of honey samples in accordance with the standards, high mold and a very high yeast load making these honeys of mediocre quality and unfit for human consumption. Isolated yeast species: Schizosaccharomyces plombe, Zygosaccharomyces rouxii, Kluyveromyces thermotolerans, Saccharomyces cerevisiae and the isolated molds are: Aspergillus (Asp) fumigatus, Asp. candidus, Asp. niger, Asp. versicolor Asp. nidulans and Mucor. The study revealed that all honeys had pH, water content, electrical conductivity, ash content, free acidity, respectively, ranging within 3.8-4.95, 47.2-20 %, 0.484-0.669 mS/cm, 0.143-0.262 g/100g, 41.7-83.05 meq/kg. The quality of Nigerian honeys can be improved by applying Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP).

Keywords: quality, microbiological, physicochemical, honey, Niger


1. Introduction

The knowledge and use of honey by humans goes back to the most remote times. Food of the oldest of humanity, it is also recognized since the highest antiquity for its preventive and curative medicinal properties which made it use widely in an empirical therapeutic framework. Honey, the best known product of the hive, is one of the main pure and natural foods that enters into human nutrition as an important source of high-energy carbohydrates with various virtues [1]. The bee harvests nectar and honeydew to make honey and satisfy its nutritional needs and to feed the larvae. Bees extract pollen and nectar from trees in the forest and from fields, which enable them to produce the honey that is essential for the survival of larvae, the composition and characteristics of which are highly variable due to its geographical and botanical origin [2]. A natural honey can be contaminated by the flora of the air and the intestinal flora of the bee as well as by technological operations carried out on this food during its transformation [3,4]. Also the physicochemical properties intervene in the determination of its quality and are influenced by surrounding factors.

In Africa, where temperature and humidity are high, beekeeping encounters difficulties that negatively affect hive products [5]. In Niger honey is produced in a traditional way, despite the availability of the floral mass and a very significant natural production potential. Niger is one of the tropical countries characterized by a hot and humid climate, and because of insufficient studies on tropical honeys in general, it always suggests that these honeys are of mediocre quality because of the risks of alteration.

Thus, the physicochemical and microbiological evaluation is necessary for the control of the quality and the conformity of the products.

The objective of this study was to evaluate the physicochemical (water content, HMF, electrical conductivity, ash, pH and acidity) and microbiological (total germs, coliforms and Thermotolerant coliforms, anaerobic sulphite-reducing spores and Bacillus) characterization of Nigerian honey as well as identify of fungal flora (yeasts and molds)

2. Material and Methods

2.1. Sample Collection

Samples of honey were collected in five phytogeographical zones (Gaya, Magaria, Makoloundi, Madarounfa and Torodi) of Niger (Figure 1). The extraction mode of honey samples is of traditional type.

The regions shown in Figure 1 are located between two parallels 11 ° 37 and 16 ° north latitude, four of them are located in the Sahelian climate zone with a rainfall between 300 and 600 mm (samples 2, 3, 4 and 5) while Sample 1 is in an area with a rainfall greater than 600 mm and close to a nature reserve and that the origin of samples 3 and 5 is close to the Niger River.
2.2. Preparation of Samples for Analysis

Before conducting our analyzes, we distributed the samples of honey to be analyzed in clean and disinfected boxes, while working near the Bunsen burner and respecting the aseptic conditions. The samples were divided into two batches, one for microbiology and the other for physicochemical analyzes (Figure 2). The boxes containing the samples were then hermetically sealed, labeled and stored in a dry and cool place at laboratory temperature. All microbiological and physicochemical tests were performed in triplicate.

2.3. Physico-chemical Analyzes

2.3.1. Moisture Content

The water content was determined from the refractive index of honey, referring to the standard table of "Chataway" [6,7]. The honey to be analyzed must be perfectly liquid and homogeneous. At a constant temperature close to 20 °C, using a spatula, a few drops of honey are deposited and spread in a thin layer on the surface of the prism.

2.3.2. Determination of Hydroxymethylfurfural (HMF)

The Winckler method is one of the methods used to determine the HMF content of a honey by colorimetry [6,7]. To perform the assay, a stock solution is prepared for each honey sample and two different reagent solution, barbituric acid and para-toluidine. The honey solution is prepared by dissolving 10 g of honey in 50 ml of de-aerated distilled water. The extinction curve as a function of time must have a maximum of 2 to 4 min.

2.3.3. pH and Free Acidity

Free acidity is the amount of free acids contained in honey. 10g of honey are dissolved in 75ml of distilled water. The electrode of the pH meter (HANNA 2211) was immersed in the honey solution. After reading the pH, the solution is titrated with the 0.1M sodium hydroxide solution to pH= 8.3 [6,7].
2.4.1. Research and Enumeration of Total viable count
homogeneous stock solution [8].

100 ml of distilled water) and shaking slightly to obtain a

value of the conductivity was directly determined by the

solution with respect to the dry matter of the honey. The

measurements were carried out at 20°C in a 20% aqueous

2.4.2. Research of Coliforms and Fecal Coliforms

For the search and enumeration of total viable count we

used two culture media, GN (nutrient agar) and PCA (plat

count agar). Introduce 1ml of the mother solution in a

colony, and then pour the culture medium at a rate of

15ml per dish, then homogenize. Allow the medium to

solidify and incubate the dishes at 30°C for 72h [9,10].

Collect some bacteria colonies on the GN and PCA media
to perform Gram stain.

2.4.3. Detection and Enumeration of Bacillus cereus

Mossel medium is used to observe possible Bacillus

colonies on medium VF (meat-liver). To 90 ml of this medium is added 10 ml of

diluent (0.1 g of peptone in 100 ml of distilled water) and shaking slightly to obtain a

homogeneous stock solution [8].

2.4.4. Detection of Spores of Sulfite-Reducing Clostridia

This research is carried out on the medium VF (meat-liver).

According to the method described by [6-7] using a

culture broth (Phywe instruments, 1370193). The

measurements were carried out at 20°C in a 20% aqueous

solution with respect to the dry matter of the honey. The

value of the conductivity was directly determined by the

cell in the solution after immersion. The results were

expressed in micro-Siemens per centimeter (μS/cm).

2.3.1. Ash Content

The ash content was determined by heating 5-10 g of

honey in a muffle furnace at 600°C for 2 hours. After

cooling, the ash content is determined [7].

2.4. Bacteriological Analyzes

The mother solution is obtained by mixing 2 g of honey

with 18 ml of already prepared diluent (0.1 g of peptone in

100 ml of distilled water) and shaking slightly to obtain a

homogeneous stock solution [8].

2.4.5. Spore Coloring

After the appearance of the colonies on medium VF

(Clostridium) and on medium Mossel (Bacillus) we

proceeded to the coloration of the spores according to the

method described in [17] using the malachite green to

5% and one against staining with safranine. The spores are
green and the bacterial cells are colored red.

2.5. Mycological Analyzes (Research of Yeasts and Molds)

To detect and enumerate the maximum number of yeast

and mold elements, it is recommended to use at least two

agar culture media [18].

2.5.1. Culture on OGA

Osmophilic yeasts and xerophilic molds are isolated on high glucose media such as YM40G medium

(Yeast extract, Malt extract, 40% Glucose). In this case, the
diluent used for the preparation of the stock solution
is glucose (0.1 g of peptone + 40 g of glucose + make up to 100 ml with distilled water) [8]. Spread 0.1
of the stock solution on the surface of the YM40G
medium and incubate at 28 °C beyond 03 days [12].

2.5.3. Isolation and Purification of Molds and Yeasts

Isolation and purification of yeasts and molds is done on inclined media (OGA and YM40G) at one point
for molds and streaks for yeasts. Incubate the tubes at
28 °C/3 days [20, 21].

2.5.3.1. Identification of Yeasts

Identification includes: a) - Study of cultural characteristics
(size, form, aspect and pigmentation of colonies) [22],
b) - Study of cellular morphological characters; the tests
carried out are: microscopic observation of vegetative cells
[21], PDA filamentation test and sporulation test on Mac
Clary medium [23], c) - physiological and biochemical
characters (fermentation of sugars [20], assimilation of
carbon sources on Yeast Nitrogen Base (YNB) medium
[22] and nitrogen sources on Yeast Carbon Base (YCB)
[21].

2.5.3.2. Identification of Molds

The identification of molds is based on: 1-The

macroscopic examination (colony consistency, surface,
the presence of rays, back and reverse color and the
presence of a diffusible pigment in the agar), 2-Microscopic examination: This microscopic examination
includes three techniques: a-Technique of flag, b-
Technique of culture on blade and c-Technique of
hydrolysis [12,21,24].
3. Results and Discussion

3.1. Physicochemical Parameters

Table 1 shows the results of the various physicochemical parameters studied.

Table 1. Physicochemical parameters of honey samples

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Samples</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture (%)</td>
<td>17.2</td>
<td>19.6</td>
<td>19.3</td>
<td>20.0</td>
<td>20.0</td>
<td></td>
</tr>
<tr>
<td>HMF (mg/kg)</td>
<td>19.2</td>
<td>6.72</td>
<td>10.752</td>
<td>7.104</td>
<td>4.032</td>
<td></td>
</tr>
<tr>
<td>pH</td>
<td>4.95</td>
<td>3.8</td>
<td>4.0</td>
<td>4.5</td>
<td>4.3</td>
<td></td>
</tr>
<tr>
<td>Free Acidity (meq/kg)</td>
<td>52.8</td>
<td>83.05</td>
<td>72.85</td>
<td>41.7</td>
<td>62.65</td>
<td></td>
</tr>
<tr>
<td>E.C (mS/cm)</td>
<td>0.669</td>
<td>0.484</td>
<td>0.503</td>
<td>0.507</td>
<td>0.513</td>
<td></td>
</tr>
<tr>
<td>Ash (%)</td>
<td>0.262</td>
<td>0.143</td>
<td>0.223</td>
<td>0.196</td>
<td>0.175</td>
<td></td>
</tr>
</tbody>
</table>

3.1.1. Water Content

Moisture content values ranged from 17.2 to 20.0% (Table 1). All samples contain a water content in accordance with the standard (≤20%) fixed by the JOCE [32]. These water contents can be explained by the atmospheric humidity due to the extraction areas of these honeys at the river's edge and the date of extraction corresponding to the rainy season in Niger as well as the raw material (nectar) can be very rich in water. The moisture content can be influenced by many factors, including: the timing of the harvest, the rate of shelf capping, storage conditions and climatic conditions at harvest [25]. The risk of fermentation is higher when the water content is high. It is very weak or non-existent when this content is less than 18% [26]. honeys with high water content are highly exposed to fermentation during storage [7]. All samples, except sample 1, present a fermentation risk.

The water content of honeys from neighboring countries such as Cameroonian honeys is very high ranging from 16 to 35% [27], for honeys from Nigeria 11.47 to 19.62% [28] and 16.380-30.820 [29], from 15.0 to 25.1% for honeys from Burkina Faso [30] on the other hand, for the benign honeys the values are very close 9.84 to 19.76 [31].

3.1.2. HMF content

The HMF content (mg/kg) of the honey samples ranged from 4.032 to 19.2 mg/kg (Table 1). All the analyzed samples have lower level than 40 mg/kg, threshold value of the norm fixed by JOCE [32], and with the maximum value of 80 mg/kg for the tropical countries fixed by the Codex Alimentarius [33]. The amount of HMF is a great indicator to assess the quality and freshness of honey [34, 35]. This is an important criterion for evaluating the storage time and damage caused by heat and aging of honey [36, 37]. For a honey of the year, the amount of HMF should be very low (less than 10 mg/kg) [38, 39]. The low HMF content of the samples (Table1) showed that these honeys were not heated and reflect a good degree of freshness. The results of the analyzes of neighboring countries show values ranging from 2.0 to 41.9 for Burkinabè hony [30], 17.06 to 41.96 mg/kg honeys from Benin [31], 17.66 to 68.86 for honeys from Madagascar [40].

3.1.3. pH and Free Acidity

The pH values of honey samples were well within the norms (3.2 to 5.5) recommended by [2]. The values obtained are between 3.8 and 4.95. All honeys were acidic; it is probably the bee that gives them this property, so pH strongly influenced the rate of degradation of sugars and the catalytic rate of enzymes [26]. According to the same author the nectar honeys have a pH between 3.5 and 4.5 against 4.5 and 5.5 for honeydew honeys. According to the values obtained, the honeys can be of floral origin.

Acidity is also an important quality criterion because it gives very important indications of the state of honey [42]. The acidity were between 41.7 and 83.05 meq/kg (Table 1). All samples have values greater than 50 meq/kg, a threshold value fixed by the Codex Alimentarius [33] and JOCE [32], with the exception of sample 4 which has a value of 41.7 meq/kg. Very high acidity can indicate a fermentation of sugars into organic acids [41]. Some acids come from the digestive secretions of bees during the elaboration of honey and can make them susceptible to alteration by fermentation [43]. A strong acidity of honey is likely to cause the degradation of hexoses in HMF. For Malagasy honeys the pH varied between 4.53 and 4.75 and the free acidity between 10 and 67 meq/kg [40]; in Burkina Faso the pH values varied from 3.5 to 4.7 and the free acidity between 20.3 and 60.8 [30]. For honeys from Nigeria, the pH values was between 3.61 and 4.05 [28], 4.31-6.02 [29] and the free acidity ranged between 24.00 and 31.00 meq/kg [28]; for Camerooney honey the pH varied between 4.1-5.0 [27].

3.1.4. Electrical Conductivity (EC)

The electrical conductivity values of honey samples were between 0.484 and 0.669 mS/cm. Bogdanov et al. [44] reported that EC is a good criterion for determining the botanical origin of honey and is currently designated for routine honey testing instead of ash content. This measure depends on the mineral content and the acidity of the honey; the higher they are, the higher the corresponding conductivity. All samples were in the standards recommended by [38], which are 0.1 to 1.5 mS/cm. This measure distinguishes floral honeys (EC <0.8mS/cm) against honeydew honeys with a much higher conductivity (> 0.8 mS/cm) [45]. All honeys studied are therefore of floral origin and confirmed the pH results.

3.1.5. Ash Content

The ash content is a quality criterion that depends on the botanical origin of the honey. The values of the ash content of the honeys varied between 0.143 and 0.262% (Table 1). Light honeys are generally less rich in minerals than dark honeys [46], as is the case with honey samples, the darkest honey has the highest ash content (sample 1) (Table 1). Variations in ash content are a function of botanical origin [47, 48]. The low ash content of honey is characteristic of floral honeys [49]. According to the Codex Alimentarius Standard [50] and CRC [51], the ash content of honey nectar is not more than 0.6 g / 100g [44, 51], 1.2g / 100g [50]. All honeys were of floral origin and this
revealed the presence of bacilli and cocci G + and G- in the 
to 200 [48] , 30 to 1200 [55] , 75 to 1380 [56] and 10 to 
numbers were between 10 to 3450 [53] , 10-1416 [54] , 00 
can contain a number of mesophilic aerobic flora; thus 
confirmed by the  results of Hocine [53] . Gram stain 
3.2.1. Enumeration of Total viable count
These germ are represented by bacteria, yeasts and 
molds. Total mesophilic aerobic flora (CFU/g) on GN was 
between 210 and 486 whereas on PCA it is between 190 
and 1280 CFU / g (Table 2). It is found that the majority 
of the results obtained after a culture on GN and PCA are 
lower than 500, threshold value fixed by Fléché et al [52] .
This can be explained by: antimicrobial effect of honey; 
composition of the culture medium, because it is difficult 
to make a count of the true total flora of a food, since there 
are no media and culture conditions common to all 
microorganisms. Sample 5 has a very high load  of the 
total flora of which the majority is yeasts (Table 3). The 
detection of mesophilic aerobic flora reflected the general 
microbiological quality of natural products and allowed them 
to be controlled [10]. The absence of standards for the 
microbiological analysis of honeys makes interpretation 
difficult [8]. It seems that the PCA medium advocated by some authors [8] is better suited for honey. This has been 
confirmed by the results of Hocine [53]. Gram stain 
revealed the presence of bacilli and cocci G + and G - in 
the different samples. Several studies have shown that honey 
can contain a number of mesophilic aerobic flora; thus 
numbers were between 10 to 3450 [53], 10-1416 [54], 00 
to 200 [48], 30 to 1200 [55], 75 to 1380 [56] and 10 to 
75000 CFU / g [57].

3.2.2. Detection of Coliforms and Fecal Coliforms
These honeys have not been contaminated or these 
types of mesophilic aerobic flora cannot survive in 
honey. These results are consistent with many authors 
[41,48,53,54,55,56,58,59]. This can be explained by the 
fact that honey is an environment hostile to the development of 
this flora [60]. The absence of these flora indicated that 
honey samples are of good hygienic quality. Some studies 
mentioned a number of 30 CFU / g [28], a high number of 
fecal coliforms (in particular E. coli) in honey sold at the 
Bukavu market in Congo [61].

3.2.3. Enumeration of Bacillus Cereus
Two positive results in samples 4 and 5 were with 12 
and 25 CFU / g respectively. The Bacillus counts 
obtained in the present study are very low (samples 1-3).
Gram stain and malachite green spore colored green 
gram + and central spores. These results are very low 
compared to 10^4 CFU / g found by Martins et al [19].
Above 10^8 CFU/g, a toxigenic risk is possible [62, 63].
Many regulations allow a maximum of 10^6 CFU / g [64]. In 
honey Bacillus are part of mesophilic flora induced by 
bees (nectar or honeydew) [52]. Spores of B. cereus are 
found in the soil, digestive system of insects and warm-blooded animals [65]. In honey from Nigeria, the 
vegetative form of Bacillus constituted most of the 
mesophilic flora and the number of bacterial endospores 
ranged from 8.0 × 10^2 to 2.0 × 10^3 [28].

3.2.4. Spores of Sulphite-reducing clostridia
Only one sample (Sample 4) showed a very small 
number with 2 CFU / g. Gram staining shows Gram + 
cells and spore staining with malachite green shows 
subterminal spores. The presence of spores of sulfite-
reducing Clostridium originates from the manipulation of 
Nigerian beekeepers who pose their traditional braided 
straw hives on the ground to smoke the hive. The presence 
of Clostridium sulfite-reducing agents in honey may be 
considered as an indicator of negligence of hygiene 
conditions in the extraction rooms or during the packaging 
and storage of honey [66]. These microorganisms are part of 
the normal flora of the gastrointestinal tract of bees 
and cause acute or chronic poisoning to consumers. The 
absence of these flora indicated that honey is not 
contaminated with anaerobic sulfite-reducing bacteria.

3.3. Mycological Analyzes
Table 3 summarized mycological analyzes. The presence 
of moulds in food usually indicates microbial contamination 
due to lack of clean materials and hygiene at work and 
growth of the moulds in the food can lead to alteration in 
the nutritional values, thereby producing undesirable 
flavour and sensory characteristic. Some of the moulds 
(fungi) produce mycotoxins which diffuse in food matrix 
and cause acute or chronic poisoning to consumers. The 
presences of some moulds as earlier observed in this study 
may be due to lack of hygienic procedures during 
harvesting, packaging and/or storage of the honey samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Total viable count</th>
<th>Coliforms</th>
<th>Fecal coliforms</th>
<th>Bacillus cereus</th>
<th>Spores of Sulfite-Reducing Clostridia</th>
</tr>
</thead>
<tbody>
<tr>
<td>GN</td>
<td>PCA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>300</td>
<td>220</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
</tr>
<tr>
<td>2</td>
<td>260</td>
<td>190</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
</tr>
<tr>
<td>3</td>
<td>210</td>
<td>320</td>
<td>≤10</td>
<td>≤10</td>
<td>≤10</td>
</tr>
<tr>
<td>4</td>
<td>360</td>
<td>420</td>
<td>≤10</td>
<td>12</td>
<td>≤10</td>
</tr>
<tr>
<td>5</td>
<td>486</td>
<td>1280</td>
<td>≤10</td>
<td>25</td>
<td>≤10</td>
</tr>
</tbody>
</table>

Table 3. Yeast and Mold Results (CFU / g)

<table>
<thead>
<tr>
<th>Samples</th>
<th>Yeasts</th>
<th>Molds</th>
</tr>
</thead>
<tbody>
<tr>
<td>OGA</td>
<td>YM40G</td>
<td>OGA</td>
</tr>
<tr>
<td>1</td>
<td>00</td>
<td>00</td>
</tr>
<tr>
<td>2</td>
<td>21.75 x 10^2</td>
<td>50 x 10^2</td>
</tr>
<tr>
<td>3</td>
<td>12.25 x 10^2</td>
<td>82 x 10^2</td>
</tr>
<tr>
<td>4</td>
<td>13.50 x 10^2</td>
<td>50 x 10^2</td>
</tr>
<tr>
<td>5</td>
<td>14 x 10^2</td>
<td>105 x 10^2</td>
</tr>
</tbody>
</table>
3.3.1. Yeasts

Osmophilic yeasts are probably good indicators of the microbiological quality of honey [69]. The number of yeasts varies according to the culture medium. This number oscillates between ≤10 and 105 x 10² on medium YM40G and between 0 and 2.175 x 10² on OGA medium (Table 3). From these results it appeared that the YM40G medium is more favorable to search for yeasts in honey. This is consistent with the results of Hocine [53] and the suggestions of Ward and Trueman [8] for the use of this medium in the search for osmophilic yeasts. These yeasts are demanding in high concentration of sugar for their growth. The number of yeast in different types of honeys can vary between 1/10g to 100,000/g [70,71]. All samples, except sample 1, exceed 100 CFU/g, threshold value for a good conservation honey proposed by Fléché et al [52], Mercosur (market of Latin American countries) [49] and the Codex Alimentarius of the Slovak Republic [56]. Honey that contained more than 17% water is susceptible to fermentation and honey with more than 19% moisture is very likely to ferment [62]. Based on the Lochhead distribution [1,42], all samples, except No. 1, contained a high number of yeasts (Table 3) and a water content > 18% (Table 1) and are therefore highly exposed to the risk of fermentation or are already in the fermentation phase. The various identification tests identified the following species:

- *Schizosaccharomyces plombe* (samples 2, 3, 4, 5);
- *Zygosaccharomyces rouxii* (samples 2, 4, 5);
- *Kluyveromyces thermotolerans* (samples 2, 3, 4, 5);
- *Saccharomyces cerevisiae* (samples 3, 4, 5).

3.3.2. Molds

The number of molds on OGA medium varied between 50 and 450 CFU/g whereas on the YM40G medium the number was between ≤10 and 250 CFU/g (Table 3). The load of molds was much lower compared to yeasts. This is reported by [48,49,52,56,72]. Only sample 1 contained less than 100 CFU/g. According to Moreau [73], the mold count without identification has no valid meaning. The isolates were identify the following species:

- *Aspergillus (Asp.) niger* (samples 2, 3, 4, 5);
- *Asp. versicolor* (sample 2);
- *Asp. candidus* (samples 2, 3, 4, 5);
- *Asp. nidulans* (samples 2,4);
- *Asp. fumigatus* (samples 4,5) and *Mucor* (sample 4).

The most widespread molds isolated were *Aspergillus flavus, Asp. niger, Asp. fumigatus, Asp. versicolor* [69]. The frequency spectrum of yeasts and molds in CFU/g is represented in Figure 3. This figure showed the dominance of yeasts with respect to molds. *Saccharomyces cerevisiae* is the most dominant yeast in number of cells per gram of honey. All yeasts identified are osmophilic and are agents of fermentation and alteration of honey. For molds, there is the dominance of the genus *Aspergillus*.

4. Conclusion

Honey is a biological product that is distinguished by its physico-chemical and biological properties, its quality is determined by physicochemical and microbiological characters. The results of physicochemical properties (water content, pH, HMF, EC and ash) of honeys from southern Niger showed that all samples comply with quality standards. The acidity records values above 50 meq/g except for sample 4. Like other foods, natural honey can be contaminated during its extraction and packaging. The results of the bacteriological analyzes showed the absence of indicator bacteria of hygienic quality, absence of pathogens or toxicogens or a very small number reflect a good level of quality of Nigerian honeys. However, the mycological analyzes show a high number of yeasts and molds making these honeys unfit for consumption and are mostly at risk of fermentation. The quality of Nigerian honeys can be improved by applying good production and manufacturing practices.

The yeast species identified are: *Schizosaccharomyces plombe, Zygosaccharomyces rouxii, Kluyveromyces thermotolerans, Saccharomyces cerevisiae* and Mold species identified as: *Asp. fumigatus, Asp. candidus, Asp. niger, Asp. Versicolor, Asp. nidulans* and *Mucor*.

Finally, this study recommended Nigerian beekeepers to follow the good practices of extraction and packaging of honey while respecting hygiene conditions to avoid contamination that can cause food poisoning or alteration of honey.

Figure 3. Distribution of yeast and mold in the honey samples
Acknowledgments

The authors thank the laboratory of nutrition and agro biotechnology in semi-arid zone for the supply of reagents and culture media.

Conflict of Interest

The authors declared that they have no conflict of interest.

References

413

Journal of Food and Nutrition Research


