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Nutritional and Microbiological Quality of Peanut Cakes (koura-koura) Sold in the Markets and Streets of Ouagadougou and Kaya (Burkina Faso)

Sawadogo Yamkaye Aïcha[1], Zongo Oumarou[1], Cissé, Hama[1], Nikiéma Filbert[2], Kabré Elie[2] and Savadogo Aly[1*]

[1]*Department of Biochemistry and Microbiology, Laboratory of Applied Biochemistry and Immunology, University Joseph KI-ZERBO, Burkina Faso*

[2]*National Public Health Laboratory, Burkina Faso*

Correspondence should be addressed to Savadogo Aly, alysavadogo@gmail.com

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ABSTRACT

Koura-koura is a crispy pancake obtained from peanuts. It is produced by hand and is widely consumed. The present work aimed to evaluate the nutritional and microbiological quality of peanut cakes called "*koura-koura*" sold in the markets and streets of two cities of Burkina Faso. For the *koura-koura* analyzes, the samples (60) were taken from 15 outlets in the city of Ouagadougou and 5 outlets in the city of Kaya. HPLC and standard methods in physico-chemistry and microbiology were used for the several analyzes. Moisture, ash, fat, protein, total sugars and energy values ranged respectively between 4.89 ± 0.05 and 12.19 ± 0.18 (g/100g DM); 2.9 ± 0.05 and 5.19 ± 0.4 (g/100g DM); 16.81 ± 0.17 and 28.70 ± 0.07 (g/100g DM); 37.30 ± 0.07 and 49.35 ± 0.10 (g/100g DM); 13.49 ± 0.23 and 33.28 ± 0.19 (g/100g DM); 424.85 ± 0.67 and 505.64 ± 0.41 Kcal. The aflatoxin B1, B2, G1, G2 and total aflatoxin contents of the samples ranged from 5.52 ± 0.81 to 138.35 ± 0.14 µg/kg ; 3.51 ± 0.63 to 59.45 ± 0.22 µg/kg ; 3.51 ± 0.08 to 35.16 ± 0.06 µg/kg ; 4.46 ± 0.09 to 13.49 ± 0.09 µg/kg ; 21.02 ± 0.14 to 203.06 ± 0.08 µg/kg respectively. The results of total mesophilic aerobic flora, yeasts and molds, total coliforms and thermo-tolerant coliforms ranged respectively between 3.11x104 ± 1.10 and 3.29x109 ± 1.08 CFU/g ; 1.73x101 ± 1.07 and 7.12 × 104 ± 1.09 CFU/g ; 4.92 × 101 ± 1.11 and 4.22x104 ± 1.07 CFU/g ; 1.03x101 ± 0.92 and 8.84x102 ± 0.54 CFU/g. Concluding, these results show that *koura-koura* has important nutritional properties. However, a detoxification of the *koura-koura* is necessary before its consumption because of its toxins and its high microbiological load.

KEYWORDS

Koura-koura; Nutritional; Microbiological; Quality; Aflatoxin, Burkina Faso

INTRODUCTION

Food security remains the biggest challenge of all time. Globally, around 2 billion people are in moderate or severe food insecurity [1]. Developing countries face both access to and availability of food. On the other part, they must ensure the hygienic and nutritional quality of these foods. In fact, 91 million people in Africa are affected each year by food-borne diseases, and 137,000 die from the same cause, which is one third of the number of deaths from food-borne diseases [2]. In

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Burkina Faso, the nutritional situation remains worrying throughout the country with a global acute malnutrition (GAM) rate of 8.4% and a severe acute malnutrition (SAM) rate of 1.6% among children aged 6 months - 59 months based on preliminary results from the National Nutritional Survey [3]. However, several actions are being carried to eradicate malnutrition, especially that of children. One of the strategies of African countries is to use more and more local products such as *soumbala, gari, rabilé, koura-koura* to alleviate food problems. Incorporating local products for achieving food and nutrition security has many advantages. Indeed it not only speeds up the healing process because these products are already known and consumed. But it also helps to increase the economy of the country by increasing production. Peanut very nutrient-rich is widely grown and consumed in Burkina Faso. In fact, the consumption of natural peanuts and the various derivatives crosses the different social categories of the population [4]. After shelling, the seed can be eaten raw, roasted or boiled in water. The seeds are transformed into peanut paste which is used for the preparation of sauces, confectionery and appetizers. They are also processed into flour and oil. The crispy peanut cakes called *koura-koura* in Burkina Faso are mostly produced under precarious conditions. So before using *koura-koura* in solving food problems, it should be the subject of in-depth analysis. The objective of this work was to make a nutritional and microbiological characterization of peanut cakes sold in the markets and streets of Kaya and Ouagadougou in order to make it a tool of choice in the fight against food insecurity.

MATERIALS AND METHODS

Collection of samples

Samples (Figure 1) were taken from 15 outlets (markets and streets) in the city of Ouagadougou and 5 outlets (markets and streets) in the city of Kaya. In each point of sale 3 samples were taken from 3 different sellers. A quantity of 100 g was taken from each seller in sterile sachets and conveyed to the analysis laboratory in a cooler. In total there were 60 samples. The city of Kaya was chosen because it is the production center of the *koura-koura* and the city of Ouagadougou because it is the capital. These localities are the places of consumption by excellence.

Sample Preparation

In the laboratory, the 3 samples from the same outlets were ground together to give a single sample of 300 g. The samples were stored in 4°C before analysis.

Figure 1: A) *koura-koura* wrought in screw; B) *koura-koura* wrought in bracelet; C) *koura-koura* in powder.

Physico-chemical Analysis

Determination of moisture content

The moisture content was determined according to the AOAC method [5]. The moisture content was obtained by difference the weight after desiccation of a test portion in a capsule in an oven 105°C.

Determination of total ash content

The total ash content was carried out according to the AOAC method [5]. The total ash content was obtained by weight difference after calcination of a test portion in a crucible at a temperature of 500°C in an oven.

Determination of the protein content

The protein content was determined by the Kjedahl method [6]. It consisted of mineralization followed by distillation and titration with sulfuric acid. The protein content was obtained using a conversion coefficient of nitrogen to proteins of 6.25.

Determination of fat content

The determination of the fat was made by the Soxhlet method [7]. It consisted of extracting with hexane, followed by rinsing and drying in the Soxhlet device. The fat content was obtained by weight difference.

Total carbohydrate content

The total carbohydrate contents were determined using differential method to Egan et al. [8] according to the formula:

Total sugar content (%) = [100 - moisture content (%) + protein content (%) + fat content (%) + ash content (%)].

Energy value

The energy value was calculated from the conversion coefficients established by Atwater and Benedict [9], 4 kcal/g for carbohydrates and proteins and 9 kcal/g for lipids according to the following formula:

E (kcals) = 4 (kcal/g) × % Protein + 9 (kcal/g) × % Fat + 4 (kcal/g) × % Total Sugar.

Aflatoxin Content Determination by HPLC

Aflatoxin dosage has and done according to the ISO-16050 [10]. Immunoaffinity columns for sample purification of aflatoxins B1, B2, G1, and G2 prior to HPLC were brand "Puri-Fast® AFLA IAC" (libios, France). The column used was ZOBAX-SB-C18 4.6 mm × 255 mm. HPLC parameters were: mobile phase flow: 1.0 ml/min; injection volume: 50 µl (v6); excitation/ emission: 365/435 nm. Aflatoxins B1, B2, G1 and G2 are emitted on different waves (Figure 2 and Figure 3).

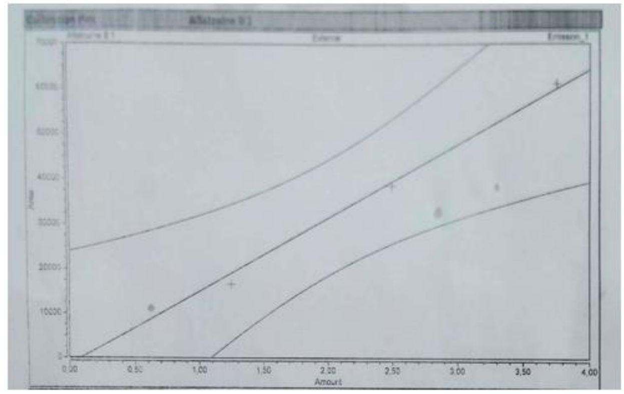

Figure 2: Calibration curve for aflatoxin quantification.

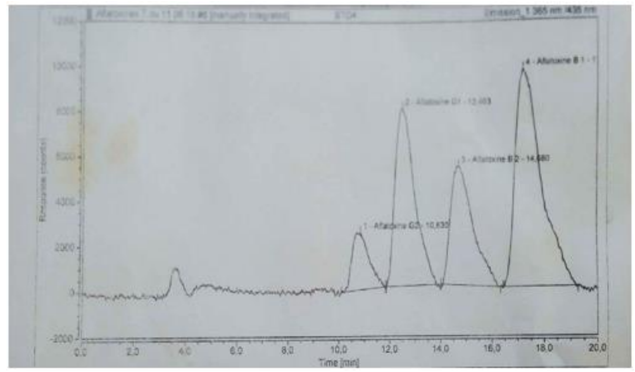

Figure 3: Chromatogram of sample.

Microbiological Analysis

The preparation of *koura-koura* samples was made according to standard NF EN ISO-6887 [11]. An amount of 10 g of *koura-koura* was homogenized in 90 ml of sterile peptone water using a stomacher. From this suspension, successive decimal dilutions (10^{-1} to 10^{-7}) were made in sterile peptone water. A volume of 0.1 mL was plated in Petri dishes containing the specific solidified culture.

Total mesophilic aerobic flora was determined on plate count agar (PCA) tool incubated aerobically at 37°C for 24 hours - 72 hours [12]. Yeasts and molds were determined on sabouraud chloramphenicol agar tool incubated at 25°C for 3 days to 5 days [13].

Coliforms (thermos-tolerant and total) were determined on Violet Red Bile Lactose agar tool (VRBL) and incubated at 30°C for total coliforms and 44°C for thermo-tolerant coliforms for 24 hours - 48 hours [14].

Statistical Analysis

The data was entered into excel 2013 and analyzed by the XL STAT 2019 software in order to compare the different averages of the physicochemical parameters. The difference between means is significant when p <0.05. The principal component analysis was performed using XLSAT 2016 software.

RESULTS AND DISCUSSION

Biochemical Characteristics

The representation was made along axis I, which expresses 38.49% of the variance, and axis II, which expresses 31.85% of the variance (Figure 4).

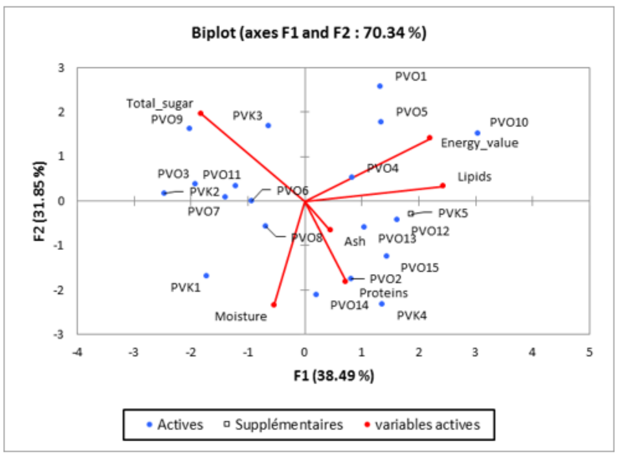

Figure 4: Principal component analysis.

The moisture and total ash content of *koura-koura* samples ranged respectively from 4.89% ± 0.05% (PVK3) to 12.19% ± 0.18% (PVK3) with an average of 8.03% ± 2.88% and from 2.9% ± 0.05 % (PVK2) to 5.19% ± 0.4% (PVO7) with an average of 4.05% ± 0.76%. The fat, protein and total sugar content of *koura-koura* samples ranged respectively from 16.81% ± 0.17% (PVO9) to 28.70% ± 0.07% (PVO10) with an average of 21.76% ± 3.60%, from 37.30% ± 0.07% (PVO1) to 49.35% ± 0.10% (PVO8) with an average of 42.71% ± 3.29% and from 13.49% ± 0.23% (PVK4) to 33.28% ± 0.19% (PVO9) with an average of 23.43% ± 5.49%. The energy value of *koura-koura* samples ranged from 424.85 Kcal ± 0.67 Kcal (PVK1) to 505.64 Kcal ± 0.41 Kcal (PVO10) with an average of 460.50 Kcal ± 20.97 Kcal. Averages show statistically significant differences ($p < 0.0001$). The results of the moisture content, total ash content, fat content, protein content, total sugar content and the energy value of *koura-koura* from the city of Ouagadougou and the city of Kaya are shown in Table 1.

The samples are divided into 2 main groups. The first group includes samples PVO9, PVK3, PVO3, PVK2, PVK1, PVO7, PVO6 and PVO11. The second group is divided into 2 subgroups, the first of which includes samples PVO14, PVO4, PVO8, PVO2 and PVO13 and the second includes samples PVO4, PVO15, PVO12, PVK5, PVO10, PVO1 and PVO5. The samples contain low amounts of water and are moderately rich in protein, ash and total sugars. On the other hand, they are highly energetic and rich in lipids. All samples had significantly above average moisture and total sugars content. The ash and lipid contents were slightly below average. Protein contents and energy values were below average.

The moisture content of the samples from the outlets of the same city are statistically different and are different from one city to another. The differences in value could be due the one part to the difference in the technology of production used. On the other part, they would be explained by the duration of storage and sale of cakes. Indeed the longer the product lasts in stock, the more there is exchange of gain or loss of water depending on the season and storage conditions. Overall, *koura-koura* samples have acceptable moisture levels for long-term storage under good conditions. Garba [17], Aletor and Ojelabi [18] obtained values below our values which are respectively of 5.27% ± 0.40% at 5.80% ± 0.42% in *kluiklui* and 6.0% ± 0.3% in the *kulikuli*. There is a statistically significant fluctuation of ash content between samples from the same city and between different cities. These differences could be due to the variety of peanuts used.

Origin	Samples	Content in (g/100g DM)					Energy value (Kcal/100g)
		Moisture	Ash	Lipids	Proteins	Total Sugar	
City of Ouagadougou	PVO1	5.38 ± 0.37	3.80 ± 0.06	26.24 ± 0.14	37.30 ± 0.07	27.26 ± 0.21	494.44 ± 2.46
	PVO2	8.60 ± 0.53	4.45 ± 0.10	21.51 ± 0.11	48.35 ± 0.12	17.08 ± 0.43	455.31 ± 2.62
	PVO3	9.38 ± 0.18	3.86 ± 0.07	18.59 ± 0.04	38.67 ± 0.11	29.49 ± 0.03	439.97 ± 0.21
	PVO4	6.81 ± 0.03	4.18 ± 0.08	23.33 ± 0.03	42.56 ± 0.11	23.11 ± 0.19	472.71 ± 0.62
	PVO5	6.09 ± 0.02	3.14 ± 0.03	25.55 ± 0.02	40.47 ± 0.16	24.73 ± 0.07	490.79 ± 0.08
	PVO6	7.95 ± 0.03	4.45 ± 0.04	19.39 ± 0.07	41.88 ± 0.05	26.32 ± 0.01	447.35 ± 0.41
	PVO7	8.23 ± 0.04	5.19 ± 0.40	18.80 ± 0.05	39.78 ± 0.10	27.99 ± 0.03	440.32 ± 0.05
	PVO8	6.55 ± 0.13	2.90 ± 0.05	17.62 ± 0.04	49.35 ± 0.10	23.57 ± 0.12	450.28 ± 0.55
	PVO9	5.42 ± 0.07	3.63 ± 0.06	16.81 ± 0.17	40.84 ± 0.03	33.28 ± 0.19	447.85 ± 0.96
	PVO10	5.05 ± 0.09	4.41 ± 0.09	28.70 ± 0.07	41.55 ± 0.09	20.28 ± 0.16	505.64 ± 0.41
	PVO11	6.40 ± 0.05	4.31 ± 0.80	17.89 ± 0.05	43.42 ± 0.14	27.97 ± 0.04	446.63 ± 0.81
	PVO12	8.17 ± 0.03	5.16 ± 0.02	25.21 ± 0.11	42.60 ± 0.09	18.86 ± 0.01	472.73 ± 0.56
	PVO13	7.46 ± 0.06	3.38 ± 0.17	22.57 ± 0.04	47.36 ± 0.06	19.21 ± 0.10	469.47 ± 0.20
	PVO14	11.49 ± 0.21	3.71 ± 0.60	21.75 ± 0.09	45.84 ± 0.02	17.19 ± 0.09	447.93 ± 1.08
	PVO15	9.34 ± 0.10	4.80 ± 0.72	24.46 ± 0.10	44.45 ± 0.25	16.93 ± 0.68	465.72 ± 2.80
City of Kaya	PVK1	1.19 ± 0.18	4.79 ± 0.10	18.55 ± 0.09	40.79 ± 0.08	23.67 ± 0.45	424.85 ± 0.67
	PVK2	10.55 ± 0.10	2.78 ± 0.13	17.67 ± 0.12	39.18 ± 0.04	29.80 ± 0.19	435.03 ± 0.51
	PVK3	4.89 ± 0.05	3.23 ± 0.12	19.69 ± 0.09	42.41 ± 0.05	29.77 ± 0.14	465.97 ± 1.16
	PVK4	12.08 ± 0.03	3.59 ± 0.12	24.66 ± 0.11	46.16 ± 0.03	13.49 ± 0.23	460.58 ± 0.05
	PVK5	8.51 ± 0.14	5.27 ± 0.07	26.32 ± 0.06	41.31 ± 0.04	18.58 ± 0.19	476.48 ± 1.19
Norms and Regulations	CODEX STAN 200 [15]	≤9	-	-	-	-	-
	CODEX STAN 174 [16]	-	≤10	-	≥40	-	-

Table 1: Biochemical characteristics of *koura-koura* samples.
PVO: Outlets in the city of Ouagadougou; PVK: Outlets in the city of Kaya.

On the whole, the contents are enough low but respect the norm for a vegetable protein material whose ash content should not exceed 10%. The ash contents of the samples are lower than those obtained by Garba [17] in the *kluiklui* (5.76% ± 0.84% to 6.49% ± 1.14%). The values of the protein content of the samples are statistically different in the same city and from one city to another. These differences could be explained by the variety of peanuts used and the denaturation of proteins due to a long exposure time of *koura-koura* to heat and light. Indeed, Liu *et al.* [19] reported the decrease in solubility, emulsifying and foaming properties after thermal denaturation of the peanut protein isolate.

These values are higher than the values obtained by the Ministry of Health of Burkina Faso [20] in *koura-koura* (36.1%) and those found by Aletor and Ojelabi [18] in *kulikuli* (32.4 ± 0.2 %). They are close to those found by Garba [17] in *kluiklui* (41.29% ± 1.0% at 44.09% ± 1.71%). There are statistically significant differences for fat from the same city and from different cities. These differences would come from the variety of peanuts used and the manufacturing technology. Overall the fat values are enough high and this is appreciable in terms of energy. However the high content of lipids can lead to oxidation reactions that cause the loss of organoleptic quality (rancidity, color change,) and the decrease in nutritional value (oxidation of vitamins, loss of essential fatty acids, etc.). Garba [17] obtained higher lipid levels in *kluiklui* (25.17% ± 0.87% at 28.50% ± 1.15%) and Aletor and Ojelabi [18] in *kulikuli* (31.1% ± 0.1%). However, the Ministry of Health of Burkina Faso [20] obtained lower grades in *koura-koura* (17.8%). The values of total sugar contents show statistically significant variations in the same city and from one city to another. These differences in value would be attributable to the peanut varieties used and the production technique. Extraction with heat could lead to a decrease in the total sugar content due to Maillard reactions. Carbohydrates are important components of the body and provide the essential energy needs. The results obtained are superior to those obtained by Garba [17] in *kluiklui* (19.39% ± 1.6% and 22.44% ± 1.3%) and those obtained by Aletor and Ojelabi [18] in *kulikuli* (19.8%). They are lower than those found by the Ministry of Health of Burkina Faso [20] in *koura-koura* (38.7%). There is a fluctuation of energy values between cities and in the same city. These variations are due to the difference in composition of *koura-koura*. By its protein, fat and total sugar content, *koura-koura* is a very energetic food. The consumption of 100 grams of *koura-koura* would cover 19% - 23% of the energy needs of children aged 7 years - 9 years (2190 kcal /day) according to FAO/OMS [21]. The values are higher than those found by the Ministry of Health of Burkina Faso [20] in *koura-koura* (293 Kcal), by Kayode *et al.* [22] in *kulikuli* (343.21 kcal) but are lower than those found by Aletor and Ojelabi [18] in *kulikuli* (559.2 kcal).

Origin	Designation	Aflatoxin B1 (µg/kg)	Aflatoxin B2 (µg/kg)	Aflatoxin G1 (µg/kg)	Aflatoxin G2 (µg/kg)	Total Aflatoxin (µg/kg)
City of Ouagadougou	PVO1	7.42 ± 0.08	13.60 ± 0.05	-	-	21.02 ± 0.14
	PVO2	54.98 ± 0.12	8.23 ± 0.12	-	-	63.21 ± 0.25
	PVO3	18.05 ± 0.13	3.51 ± 0.63	4.29 ± 0.04	-	25.85 ± 0.15
	PVO4	62.24 ± 0.34	9.10 ± 0.06	-	-	71.34 ± 0.19
	PVO5	138.35 ± 0.14	21.41 ± 0.23	35.16 ± 0.06	8.14 ± 0.05	203.06 ± 0.08
	PVO6	5.52 ± 0.81	32.67 ± 0.12	-	-	38.19 ± 0.04
	PVO7	21.60 ± 0.09	4.42 ± 0.23	-	-	26.02 ± 0.32
	PVO8	56.13 ± 0.28	9.31± 0.19	4.15 ± 0.05	13.49 ± 0.09	83.08 ± 0.25
	PVO9	78.48 ± 0.17	6.34 ± 0.08	5.18 ± 0.07	-	90.00 ± 0.01
	PVO10	34.89 ± 0.07	4.81 ± 0.84	-	-	39.70 ± 0.18
	PVO11	108.18 ± 0.52	13.21 ± 0.91	3.51 ± 0.08	9.33 ± 0.08	134.23 ± 0.07
	PVO12	68.18 ± 0.05	11.34 ± 0.11	-	-	79.52 ± 0.05
	PVO13	52.55 ± 0.11	7.20 ± 0.04	-	-	59.75 ± 0.15
	PVO14	18.31 ± 0.43	43.20 ± 0.13	-	-	61.51 ± 0.24
	PVO15	36.82 ± 0.04	4.91 ± 0.49	-	7.45 ± 0.12	49.18 ± 0.02
City of Kaya	PVK1	81.55 ± 0.03	15.21 ± 0.14	5.40 ± 0.03	-	102.16 ± 0.21
	PVK2	13.57 ± 0.35	59.45 ± 0.22	-	-	73.02 ± 0.09
	PVK3	11.68 ± 0.22	6.33 ± 0.77	-	4.46 ± 0.09	22.47 ± 0.39
	PVO4	29.54 ± 0.10	7.52 ± 0.18	11.31 ±0.08	4.91 ± 0.07	53.28 ± 0.41
	PVK5	82.27 ± 0.48	17.30 ± 0.07	-	-	99.57 ± 0.15
CODEX STAN 193 [23]: Maximum limit for Peanuts: 15 µg/kg						

Table 2: Aflatoxin content of *koura-koura*.

Aflatoxin Content

The aflatoxin B1 concentration in the koura-koura samples was between 5.52 µg/kg ± 0.81 µg/kg (PVO6) and 138.35 µg/kg ± 0.14 µg/kg (PVO5); the aflatoxin B2 concentration varied from 3.51 µg/kg ± 0.63 µg/kg (PVO3) to 59.45 µg/kg ± 0.22 µg/kg (PVK2). The aflatoxin G1 concentration varied from 3.51 µg/kg ± 0.08 µg/kg (PVO11) to 35.16 µg/kg ± 0.06 µg/kg (PVO5) and that of G2 from 4.46 µg/kg ± 0.09 µg/kg (PVK3) at 13.49 µg/kg ± 0.09 µg/kg (PVO8). The concentration of total aflatoxins ranged from 21.02 µg/kg ± 0.14 µg/kg (PVO1) to 203.06 µg/kg ± 0.08 µg/kg (PVO5). The differences between the means are significant ($p < 0.05$). The aflatoxin concentrations (B1, B2, G1, and G2) of the koura-koura are given in Table 2.

There is a statistical difference between the samples of the same city and between the samples of the cities between them. The Ouagadougou samples are more contaminated with an average of 69.71 μg/kg than the Kaya samples (average of 23.36 μg/kg). The consumption of *koura-koura* would present a danger (liver cancer) for health with these high contents. In fact, the aflatoxin contents are far above the maximum limit for Peanuts which is 15 μg/kg according to CODEX STAN 193 [23]. *Koura-koura* samples are contaminated with four types of aflatoxins (B1, B2, G1 and G2). All *koura-koura* samples are contaminated with group B aflatoxin (B1 and B2) unlike group G aflatoxin, only 35% for G1 and 30% for G2 are present. Adjou *et al.* [24] found in *kluiklui* (25.54 μg/kg to 455.22 μg/kg for aflatoxin B1, 33.94 μg/kg to 491.20 μg/kg for aflatoxin B2).

Microbiological Results

The total mesophilic aerobic flora is between $3.11 \times 10^4 \pm 1.10$ CFU/g (PVO15) and $3.29 \times 10^9 \pm 1.08$ CFU/g (PVO14). The flora of yeasts and molds is between $1.73 x 10^1 \pm 1.07$ CFU/g (PVO15) and $7.12 \times 10^4 \pm 1.09$ CFU/g (PVO9). Total coliform flora ranged from $4.92 \times 10^1 \pm 1.11$ CFU/g (PVO15) to $4.22 \times 10^4 \pm 1.07$ CFU/g (PVO2) and thermo-tolerant coliforms from $1.03 \times 10^1 \pm 0.92$ CFU/g (PVK5) at $8.84 \times 10^2 \pm 0.54$ CFU/g (PVO14). The results microbiological analysis of *koura-koura* samples from the city of Ouagadougou and the city of Kaya are shown in Table 3.

Origin	Samples	Total aerobic Mesophilic Flora (CFU/g)	Yeasts and molds (CFU/g)	Total Coliforms (CFU/g)	Thermo-tolérants Coliforms (CFU/g)
City of Ouagadougou	PVO1	$4.57 \times 10^6 \pm 1.05$	$1.89 \times 10^3 \pm 1.04$	$2.50 \times 10^2 \pm 0.23$	$6.13 \times 10^1 \pm 1.04$
	PVO2	$8.76 \times 10^8 \pm 0.86$	$4.26 \times 10^2 \pm 0.87$	$4.22 \times 10^3 \pm 1.07$	$3.48 \times 10^2 \pm 1.16$
	PVO3	$5.15 \times 10^7 \pm 1.06$	$2.36 \times 10^2 \pm 0.91$	$2.18 \times 10^3 \pm 0.65$	$2.62 \times 10^1 \pm 0.46$
	PVO4	$1.09 \times 10^8 \pm 0.85$	$2.11 \times 10^1 \pm 0.04$	$9.79 \times 10^2 \pm 1.14$	$1.01 \times 10^2 \pm 0.86$
	PVO5	$6.25 \times 10^7 \pm 1.07$	$1.82 \times 10^1 \pm 0.92$	$1.75 \times 10^3 \pm 0.92$	$5.51 \times 10^1 \pm 1.15$
	PVO6	$2.24 \times 10^8 \pm 0.86$	$5.47 \times 10^3 \pm 0.89$	$4.28 \times 10^3 \pm 0.47$	$7.04 \times 10^1 \pm 0.25$
	PVO7	$6.62 \times 10^6 \pm 1.05$	$5.75 \times 10^2 \pm 0.73$	$4.65 \times 10^2 \pm 0.56$	$2.24 \times 10^1 \pm 0.68$
	PVO8	$3.72 \times 10^6 \pm 0.92$	$6.19 \times 10^3 \pm 0.94$	$9.25 \times 10^1 \pm 0.91$	$1.24 \times 10^1 \pm 1.14$
	PVO9	$2.48.10^8 \pm 1.01$	$7.12 \times 10^4 \pm 1.09$	$3.17 \times 10^3 \pm 0.93$	$4.32 \times 10^1 \pm 0.91$
	PVO10	$2.94 \times 10^9 \pm 0.93$	$1.41 \times 10^3 \pm 0.82$	$2.71 \times 10^4 \pm 1.57$	$1.72 \times 10^2 \pm 0.49$
	PVO11	$2.78 \times 10^6 \pm 1.11$	$4.52 \times 10^2 \pm 0.97$	$8.62 \times 10^1 \pm 1.10$	$2.08 \times 10^1 \pm 1.06$
	PVO12	$3.39 \times 10^8 \pm 1.08$	$2.52 \times 10^3 \pm 1.07$	$1.98 \times 10^2 \pm 0.28$	$3.18 \times 10^1 \pm 0.42$
	PVO13	$4.65 \times 10^8 \pm 0.96$	$1.56 \times 10^3 \pm 0.91$	$4.36 \times 10^3 \pm 0.91$	$5.25 \times 10^1 \pm 1.15$
	PVO14	$3.29 \times 10^9 \pm 1.08$	$7.35 \times 10^2 \pm 0.89$	$5.08 \times 10^4 \pm 0.99$	$8.84 \times 10^2 \pm 0.54$
	PVO15	$3.11 \times 10^4 \pm 1.10$	$1.73 \times 10^1 \pm 1.07$	$4.92 \times 10^1 \pm 1.11$	$2.02 \times 10^1 \pm 1.64$
City of Kaya	PVK1	$6.15 \times 10^6 \pm 1.12$	$1.48 \times 10^2 \pm 0.04$	$1.83 \times 10^2 \pm 1.10$	$8.02 \times 10^1 \pm 1.08$
	PVK2	$2.17 \times 10^6 \pm 0.97$	$3.14 \times 10^1 \pm 0.89$	$1.10 \times 10^3 \pm 1.11$	$3.84 \times 10^1 \pm 0.57$
	PVK3	$5.31 \times 10^5 \pm 1.07$	$3.71 \times 10^1 \pm 0.82$	$6.51 \times 10^1 \pm 0.83$	$3.23 \times 10^1 \pm 1.04$
	PVK4	$2.35 \times 10^5 \pm 0.92$	$4.03 \times 10^1 \pm 1.07$	$6.16 \times 10^2 \pm 0.90$	$3.68 \times 10^1 \pm 1.09$
	PVK5	$2.23 \times 10^8 \pm 1.09$	$3.68 \times 10^3 \pm 0.84$	$2.76 \times 10^2 \pm 0.93$	$1.03 \times 10^1 \pm 0.92$
Norms and Regulations	Afssa [25]	10^6	10^3	-	-
	NM 08.0.124 [26]	15.10^3	10^3	10	-

Table 3: Microbiological characteristics of *koura-koura* samples.

Aerobic mesophilic flora is enough important in *koura-koura* samples. This high level of contamination is due, on the one hand, to the deficiency of hygiene during the manufacturing process. On the other hand, it would be the result of decontamination during storage/sale. In fact, traditional agro-food processing is characterized by manual processing of food with painful and unhygienic operations [27-29]. *Koura-koura* would not be acceptable according to Afssa [25] which recommends a maximum of 106 for pastries and other desserts. The results are superior to those found by Kayode *et al.* [20] in *kulikuli* in Nigeria (4.75 × 10^3 CFU/g) and those obtained by Garba [15] in *kluiklui* in Benin (4.8 × 10^3 CFU/g). Yeast and mold flora are high for the samples. Afssa [25] recommends a maximum of 10^3 for pastries and other desserts and the Moroccan standard NM 08.0.124 [26] recommends a maximum of 10^3 for peanuts. These germs would come from re-contamination after the heat treatment because the frying most often destroys the vegetative form of these germs or the development of the spores present in the *koura-koura* or in the environment. Garba [17] and Kayode *et al.* [22] obtained lower results which are respectively 5.1 × 10^2 CFU/g in *kluiklui* and 0.23 × 10^3 CFU/g in *kulikuli*. *Koura-koura* samples are largely contaminated with total coliforms and thermo-tolerant coliforms. These germs, which are hygiene indicators, show that hygiene rules were deficiency in the manufacturing and storage process. Indeed manual handling is enough present during production, storage and sale. And hands are the most important vehicle for transferring microorganisms from feces, nose and skin to food [30]. The samples do not conform to the Moroccan standard (NM 08.0.124) [26] which recommends a maximum of 10 for total coliforms. Adjou *et al.* [24] obtained in *kluiklui* for total coliforms values from 1.6 × 10^1 to 14.0 × 10^2 CFU/g and for thermo-tolerant coliforms from 1.0 × 10^1 to 11.0 × 10^2 CFU/g.

CONCLUSION

This study has highlighted the nutritional and microbiological values of *koura-koura*. Its nutritional characterization shows that it is a very nutritious food with high levels of protein and energy. However, its high concentration of aflatoxin could pose a health hazard to the consumer. On the other part, microbiological characterization revealed rather high levels of contamination and not acceptable hygienically. The application of good manufacturing, storage and preservation practices is necessary to ensure the health of consumers. With satisfactory microbiological values, *koura-koura* would be a food of choice for achieving food security and the fight against protein-energy diseases.

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CONFLICT OF INTEREST

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

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