

Physicochemical and Microbiological Characteristics of “Koki, Kossey, and Awara,” Three Traditional Foods Produced from Cowpea (*Vigna unguiculata*) and Soybean (*Glycine max*) in the City of Maroua (Far North Region, Cameroon)

Aimé Christian Ndih^{*1}, Charles Touwang¹, Sakinatou Milvidi Boubakari¹

¹Department of Agriculture Livestock and by Products, National Advanced School of Engineering, University of Maroua, Cameroon

ABSTRACT

This study was initiated with the aim of evaluating the physicochemical and microbial profile of three street food with a view for improving their hygienic quality. The assessment of technical practices revealed that this activity is carried out exclusively by women (100%). The processes were monitored in the three districts (Maroua 1,2, and 3) of the city of Maroua, and three street food production diagrams (Koki, Kossey, Awara) were developed and the products analyzed in terms of their physicochemical and microbiological properties.

The parameters pH (4.6 ± 0.5 - 6.35 ± 0.9); WC ($70 \pm 0.07\%$ - $53 \pm 0.05\%$); total protein ($15.22 \pm 1.22\%$ - $55.57 \pm 0.14\%$); total lipids ($3.87 \pm 0.12\%$ - $21.88 \pm 0.1\%$); and carbohydrates ($44.3 \pm 0.7\%$ - $3.75 \pm 0.06\%$) are among the main determinants of quality and have values within a range compatible with those commonly observed for street foods. However, from a microbiological point of view, the overall hygienic quality (TVC ($>10^5$ CFU/g); fecal coliforms ($>10^4$ CFU/g), *Staphylococcus aureus* ($>10^3$ CFU/g), sulfite-reducing *Clostridium* ($>10^3$ CFU/g), *Salmonella* ($>10^2$ CFU/g), Molds and yeasts ($>10^2$ CFU/g)) of Koki, Kosei and Awara does not comply with regulatory requirements and is mostly higher than the maximum values allowed by the microbiological criteria that cooked consumer products must meet in order to be officially recognized as fit for consumption, although there are some compliant profiles among production sites and products. Some operators therefore appear to have a more hygienic approach than others. These microbiological results confirm the issue of the hygienic quality of street food and point out the need to consider concrete actions in terms of systematic control of all inputs and training and awareness-raising for operators on Good Hygiene Practices (GHP) and Good Manufacturing Practices (GMP).

Keywords: Street food; Microbiological criteria; GHP; GMP; Quality

INTRODUCTION

Considered a driver of agricultural development and urban food security, food processing is the main source of food in urban centers in sub-Saharan Africa. It consists of small production, processing, and distribution units [1]. This craft industry draws on the potential offered by the diversity of available agricultural resources. In the northern regions of Cameroon, more than 5,000 artisanal processing units were identified in 1999 [2]. Today, according to the acceleration of urbanization is a source of concern

because it requires the flow of increasing quantities of goods to these centers of concentration and the organization of internal distribution within cities [3]. The food needs of this ever-growing urban population, combined with underemployment and the economic crisis, have fostered the development of the street food sector, which plays an important role both as a source of income and as a provider of nutritious and inexpensive food for others. The informal street food sector has been defined as “the sector producing food and beverages ready for consumption, prepared and/or sold specifically on the streets and in other similar public

Correspondence to: Aimé Christian Ndih, Department of Agriculture Livestock and by Products, National Advanced School of Engineering, University of Maroua, Cameroon, E-mail: ndihac@yahoo.fr

Received: 11-Feb-2026, Manuscript No. JFMSH-26-40868; **Editor assigned:** 13-Feb-2026, PreQC No. JFMSH-26-40868 (PQ); **Reviewed:** 27-Feb-2026, QC No. JFMSH-26-40868; **Revised:** 06-Mar-2026, Manuscript No. JFMSH-26-40868 (R); **Published:** 12-Mar-2025, DOI: 10.35248/2476-2059.26.11.349

Citation: Ndih AC, Touwang C, Boubakari SM (2026). Physicochemical and Microbiological Characteristics of “Koki, Kossey, and Awara,” Three Traditional Foods Produced from Cowpea (*Vigna unguiculata*) and Soybean (*Glycine max*) in the City of Maroua (Far North Region, Cameroon). J Food Microbiol Saf Hyg.11:349.

Copyright: © 2026 Ndih AC. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

places” [4]. These are precarious catering establishments set up spontaneously to facilitate access and meet the food needs of city dwellers, schoolchildren, students, construction workers and even civil servants. The eating habits of these street food consumers are motivated by a desire to recreate the food model of their society of origin, the quality of the food and, above all, the affordable price of the products on offer. Among the relatively varied range of food products offered in the region, soybeans and cowpeas seem to rank highest in terms of production growth over the past 15 years [3,5-7]. In terms of nutrition, soybeans contain fat-soluble vitamins A, D, E, and K, and are particularly rich in vitamin B and minerals. Cowpeas provide nutrients that are lacking in cereals. Dried seeds provide about 25%-30% protein, giving cowpeas a key role in the diets of low-income populations unable to obtain animal protein [8,9]. Regular consumption of these legumes may also be associated with the prevention and control of diabetes, cardiovascular disease, and colorectal cancer [10,11]. However, regular consumption of these legumes is justified more by their availability than by their nutraceutical benefits. There are many ways to consume them, and a panoramic observation of street food in the city of Maroua reveals a high rate of commercialization of cowpea cake, cowpea fritters, and soy cheese, known locally as Koki, Kossey, and Awara, respectively. The quality of these products is often criticized by non-consumers due to the poor hygiene conditions in production facilities, which are often located in busy areas, on the side of the road, and in the open air. Could the varying quality of the products sold be a result of the variability in production processes? The objective of this study is therefore to determine the physicochemical and microbiological characteristics of these products in the different municipalities of the city of Maroua with a view to identify the specific constraints that arise from this and proposing quality assurance strategies aimed at controlling the negative effects of selling food on public roads, while preserving the positive socio-economic and nutritional aspects.

MATERIALS AND METHODS

Study area

A survey was conducted in all three districts of the Diamaré department in the far north of Cameroon to identify areas of high production and consumption of koki, kossey, and awara. The survey was conducted in the municipalities of Maroua 1, Maroua 2, and Maroua 3, which have average populations of 134,934, 108,902, and 86,574, respectively (12 P C, 2005).

Sampling

Given the unavailability of data on the number of women producers of these different products, Purposive sampling was used to construct the study sample. This is a convenience sample, as it is based entirely on the availability of respondents and the structure in operation. A total of 150 producers, evenly distributed across the three districts of the city of Maroua, were surveyed [12].

Data collection

The survey was conducted in the form of visits to production sites, based on free conversation with producers in their production workshops and in the course of their work. This made it possible to observe the production process and identify the constraints inherent to the processes and the various tools used. Based on the reputation of the processor, the volume produced and sold, 12

samples per selected location were taken in sterile bottles and then transported to the laboratory where they were stored in a cold room at $4^{\circ}\text{C} \pm 2^{\circ}\text{C}$ for physicochemical and microbiological analysis.

Physicochemical analyses

The water content was obtained by mass loss. A mass ($M=5$ g) of the different samples was dried in an oven at 105°C for 24 hours and the residual moisture expressed as a percentage (gravimetric method (AOAC 950.46).

The pH was determined using the method described by 10 g of each product was added to 20ml of distilled water and then homogenized using a magnetic stirrer. After filtration on Wattman paper, the pH was read directly using a manual pH meter, model EQ-610. The total protein content was determined using the Kjeldahl method [15,16]. Finally, the lipid content was determined using the Association of Official Analytical Chemists (AOAC). method, 2000. The carbohydrate content was determined using the method [17,18]. The energy value was obtained using the Atwater indices (4 kcal per 1 g of carbohydrate and 1 g of protein; and 9 kcal per 1 g of lipid).

Microbiological analyses

Sampling, packaging, and transport of samples

Nine samples were collected at a rate of 500 g per sample and preserved in sterile, watertight polyethylene bags. They were transported to the laboratory in a cooler containing melting ice to prevent any temperature variations that could alter the microflora, and analyzed within one hour of collection [19].

Sample preparation and analysis

A 25 g fragment of each product sample was weighed in the tared bowl of a Blender-type grinder and homogenized for two minutes in the presence of 225 ml of sterile tryptone salt diluent (1 g tryptone; 8.5 g NaCl made up to 1000 ml with distilled water). A 1/10th dilution was thus produced and considered as the stock solution, and its decimal dilutions up to 10^{-6} , in accordance with International Organization for Standardization (ISO). 6887-2 (ISO, 2004) using tryptone-salt solution as the dilution liquid and following the recommendations of the Institut Pasteur Production [20,21]. The microorganisms counted make it possible to highlight the microbiological quality criteria that cooked street food products must meet in order to be officially recognized as fit for consumption [22].

The microbial flora counts for koki, kossey, and awara were performed using standard methods.

- The Total Mesophilic Aerobic Flora (TMAF) was counted on PCA (Plate Count Agar) medium by deep seeding the medium with 1 ml of the stock solution and its various dilutions, and incubating the petri dishes at 30°C for 72 hours according to the method specified by ISO 4833-1: 2013.
- Total coliforms were counted on BLBVB (Brilliant Green Lactose Broth) medium in accordance with ISO 4832.
- The enumeration and detection of *Staphylococcus aureus* was carried out on Baird Parker agar by seeding the surface of the medium with 0.1 ml of the stock solution and its various dilutions and incubating the petri dishes at 37°C for 48 hours according to the method described in ISO 6888-2: 2021. The detection of thermonuclease (thermo-resistant DNase) and coagulase on the black colonies surrounded by a clear halo counted led to the conclusion that the colonies tested are

enterotoxigenic *Staphylococcus aureus* colonies.

- Sulfite-reducing *Clostridium* were counted after heating 10 ml of the stock solution in a water bath at 80°C for 10 minutes to select spores and deep seeding (1 ml) and double layer seeding of TSN (Trypticase-Sulfite-Neomycin) agar.
- After incubating the petri dishes at 37°C for 24 hours in anaerobic conditions, the black colonies obtained were sulfite-reducing *Clostridium* colonies. This count was performed in accordance with ISO 15213-2.
- *Salmonella* detection and counting were performed after pre-enrichment of 25 g of sample in 225 ml of buffered peptone water medium at 37°C for 24 hours, enrichment of 2 ml of the pre-enriched sample in 20 ml of sodium selenite broth at 37°C for 24 hours, and surface inoculation with 0.1 ml of the enriched sample on SS (*Salmonella-Shigella*) agar and incubation at 37°C for 24 hours. Colorless and yellowish colonies with diameters greater than 5 mm measured with a graduated ruler, with or without a black center (lactose negative; urease negative; indole negative) are presumptive *Salmonella* colonies. The horizontal method standardized by ISO 6579-1:2017 was used.
- **Molds and yeasts:** Yeasts and molds were counted on Sabouraud Dextrose Agar medium, supplemented with 0.05% chloramphenicol by seeding the surface of the medium with 0.1 ml of the stock suspension and its dilutions and incubating the Petri dishes at 30°C for 72 hours in accordance with ISO 21527-1-2:2008.

Statistical analyses

All measurements were taken in triplicate and the results are expressed as mean \pm standard deviation. Analysis of Variance (ANOVA) of the means was used to evaluate the effect of the different factors, and Duncan's test was used to rank the significantly different means at a probability threshold of $p < 0.05$. XLSTAT 2007 and MINITAB.17 software were used for this purpose.

RESULTS

The production of koki, kossey, and awara are activities reserved exclusively for women. Production facilities are generally located along roadsides or in busy areas. Certain operations, such as winnowing and soaking, are often carried out at home due to their difficulty and considerable duration.

Description of production processes

The production of koki, kossey, and awara is carried out exclusively by women.

Koki

Koki is a traditional specialty originating from a group of peoples in the coastal, southwestern, and western regions of Cameroon, and is currently listed as part of Cameroon's national intangible cultural heritage. It is a dish originally made with white beans (*Phaseolus vulgaris*) as the main ingredient, grown in the Mungo department and in the western and southwestern regions of Cameroon. The decline in local white bean production and the rapid spread throughout the country of the technical system used to produce this dish, coupled with the high demand for koki, has led to a search for new raw materials to replace *Phaseolus vulgaris*. The black-eyed bean, also known as Niébé (*Vigna umguiculata*), widely cultivated in the northern regions of Cameroon and has been adopted for this purpose due to its technological properties similar to those of *Phaseolus vulgaris*.

The different stages of the production process can be described as follows (Figure 1):

Stage 1: The cowpea grains, which may or may not have been crushed beforehand, are soaked for 24 hours in a basin filled with clean water.

Step 2: The soaked beans are then peeled by hand before being ground together with garlic and onion to obtain a fine, smooth paste. The grinding is done by hand on a grinding stone, but the availability of mechanical mills in various parts of the country has facilitated the integration of this equipment into the technical production system.

Step 3: The paste is then salted and mixed with heated palm oil in a ratio of 3 kg of paste to 1 liter of palm oil to obtain a yellow-orange color. Plastic basins or flat-bottomed, wide-rimmed mortars carved from wood are the tools used for this step. The mixture is stirred using an aluminum ladle or wooden spatula.

Step 4: The product obtained after mixing is then wrapped in banana leaves, metal boxes, or plastic and steamed. The cooking time depends on the quantity of product, the type of packaging chosen, and the intensity of the heat. The energy source generally used is firewood. The producer decides when the cooking process is complete after testing the texture and degree of cooking of the dough. The resulting koki should have a firm yet supple texture and be tender in the mouth. The production process is shown in Figure 2.



Figure 1: Street food production structures in the city of Maroua.

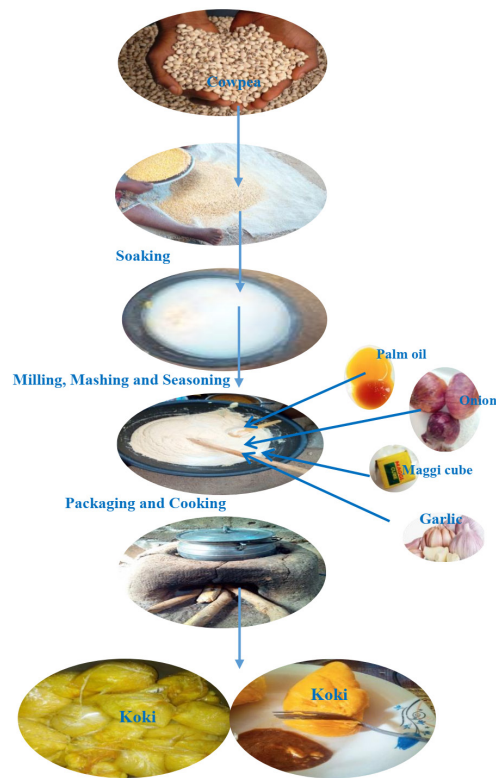


Figure 2: Koki production process.

Kossey

Kossey, or cowpea fritters, are produced regularly in northern Cameroon and seasonally in neighborhoods with Muslim communities in the rest of the country. Peaks in production generally coincide with the Ramadan period. These fritters are made by frying a paste of salted cowpea flour (*Vigna umguiculata*) mixed with onion and garlic in oil.

The different stages of production are described in figure 2 and consist of the following steps:

- Step 1: Crushing the cowpea grains, followed by winnowing
- Step 2: Soaking the crushed grains for 3 to 4 hours in a basin
- Step 3: Draining and grinding the crushed grains with garlic and onion
- Step 4: The lightly salted paste is cooked in oil. The type of oil used depends on the producer. These oils include cottonseed oil, peanut oil and, very rarely, palm oil. The overall production process is shown in Figure 3.

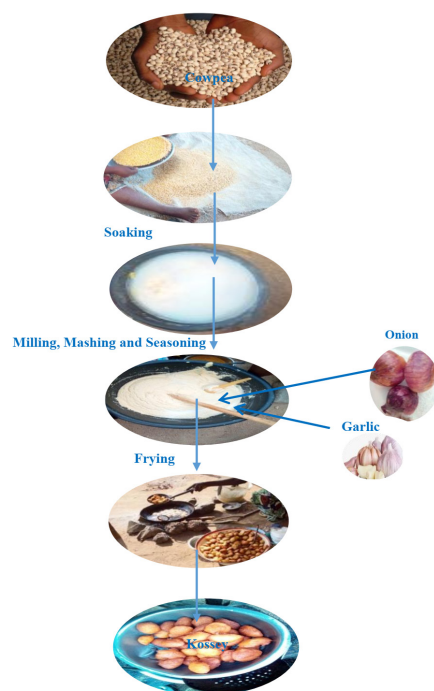


Figure 3: Kossey production process.

Awara

Chlorine compounds

Of the three products studied, the production of soy cheese, or awara, is the most complex. Highly prized by consumers, awara is considered as the meat of the poor due to its high protein content. The production process is the same in all three subdivisions, with differences related to the type of coagulant used. The production process consists of nine stages, as described below:

Step 1: The soybeans are dry hulled. The beans are first crushed, either with a stone or a mechanical mill, and then winnowed.

Step 2: The crushed and cleaned beans are soaked in a basin of water for an average of three hours.

Step 3: The beans are drained and rinsed in clean water, then ground into a paste.

Step 4: The paste is gradually hydrated at a ratio of 1 kg/15 L, then the milk is extracted directly by filtration using a very fine cloth.

Step 5: The milk is heated to boiling point. Depending on the producer, the boiling time varies between 1 and 5 minutes.

Step 6: The boiled milk is mixed with the coagulant in a ratio of 15L of milk to 2L of coagulant. The coagulant is obtained either by soaking tamarind or by spontaneous fermentation of the whey after coagulation of the soy milk.

Step 7: The cheese and whey mixture is placed in a fine mesh bag and pressed using a weight.

Step 8: After draining, the whey is kept for the next milk coagulation, while the cheese obtained is cut into pieces weighing approximately 25 g each.

Step 9: The pieces of cheese are fried in hot oil for about 5 minutes.

The fried cheese pieces are sold at 25 CFA francs each and eaten with a spicy sauce served free of charge.

The production process is shown in Figure 4:

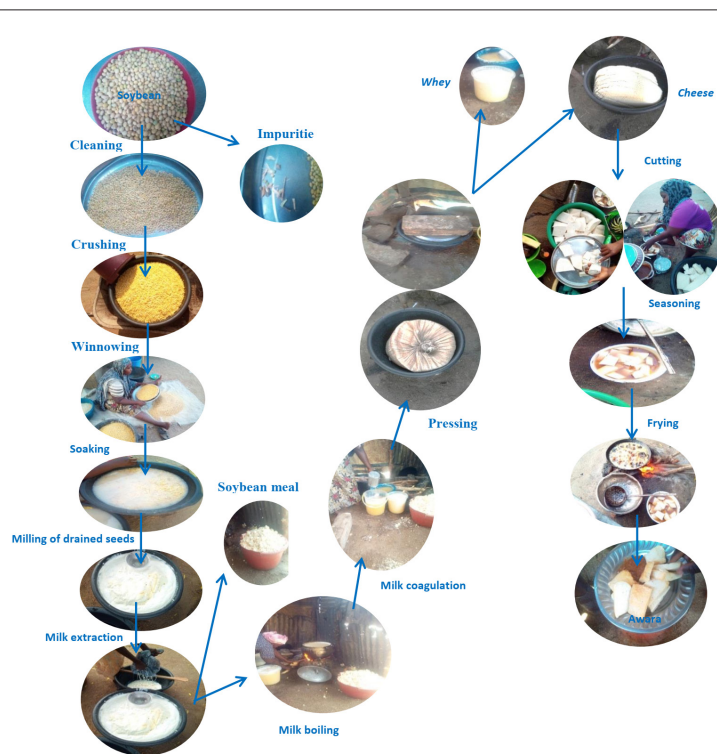


Figure 4: Awara production process.

Physicochemical characteristics and energy values of the different products

Water content, pH, and ash content

The physicochemical profiles of the products harvested in the three subdivisions of the city of Maroua are presented in tables 1, 2, and 3. Water content varies from one product to another, with average values ranging from 53 ± 0.05 to $70 \pm 0.07\%$. Table 1 for koki shows moisture content ranging from $56 \pm 0.1\%$ to $70 \pm 0.07\%$. Analysis of variance reveals a significant difference ($P < 0.05$) between the different samples. The koki from producers in Maroua 3 has a lower pH value (4.6 ± 0.5) than that from Maroua 1 (6.4 ± 0.1). The latter, on the other hand, has a higher ash content ($4.42 \pm 0.28\%$). Analysis of the variance shows a significant difference ($P < 0.05$) between the ash content of the Maroua 1 samples and

those from others subdivisions.

The water content of kossey varies significantly ($p < 0.05$) between subdivisions, ranging from 53 ± 0.05 to $70 \pm 0.07\%$ with koki from Maroua 3 being the most prevalent (Table 2). The pH values do not follow the same trend as the water content, with comparable values. Ash content follows the same trend as water content, with a significant difference ($p < 0.05$) driven by the production site, with a relatively high content in Maroua 1 for awara ($0.75 \pm 0.04\%$).

Water content (60.5 ± 0.7 - $64 \pm 0.1\%$), pH values (5.5 ± 0.1 - 5.64 ± 0.05) and ash content (0.87 ± 0.16 - $4.2 \pm 0.2\%$) of three products vary significantly ($p < 0.05$) between production sites. The pH and ash content of awara from producers in Maroua 1 are the highest, with values ranging from 5.64 ± 0.05 and $4.2 \pm 0.2\%$, respectively (Table 3).

Table 1: Water content, pH, and ash content of the different Koki samples.

Koki	Water content (%)	pH	Ash content (%)
Maroua 1	68.5 ± 0.7 ^b	6.4 ± 0.1 ^a	0.72 ± 0.04 ^b
Maroua 2	56.01 ± 0.1 ^c	5.85 ± 0.9 ^{ab}	1.55 ± 0.17 ^a
Maroua 3	70 ± 0.07 ^a	4.6 ± 0.5 ^b	1.29 ± 0.54 ^a

Table 2: Water content, pH, and ash content of the different Kossey samples.

Kossey	Water content (%)	pH	Ash content (%)
Maroua 1	54 ± 0.03 ^b	5.65 ± 0.5 ^a	0.17 ± 0.03 ^c
Maroua 2	53 ± 0.05 ^c	6.35 ± 0.9 ^a	0.63 ± 0.05 ^b
Maroua 3	55 ± 0.04 ^a	5.65 ± 0.6 ^a	0.75 ± 0.04 ^a

Table 3: Water content, pH and ash content of different awara samples.

Awara	Water content (%)	pH	Ash content (%)
Maroua 1	60.5 ± 0.7 ^c	5.64 ± 0.05 ^a	4.42 ± 0.28 ^a
Maroua 2	63 ± 0.4 ^b	5.5 ± 0.14 ^{ab}	1.99 ± 0.36 ^b
Maroua 3	64 ± 0.1 ^a	5.5 ± 0.1 ^b	0.87 ± 0.16 ^c

Protein, carbohydrate, lipid, and energy values of the three products

The protein content of the products has average values ranging from 15.22 ± 1.22% to 55.57 ± 0.14%. The protein content of koki varies significantly between production sites (16.28 ± 0.02%-24.96 ± 0.18%). Koki from Maroua 1 stands out for its low protein content. The protein content of kossey produced in the three municipalities showed significant differences ($p < 0.05$). These values ranged from 15.22 ± 1.22% (Maroua 1) to 20.74 ± 0.69% (Maroua 2) (Table 4).

The awara samples have the highest protein content. Maroua 3 offers consumers awara with a higher protein content (55.57 ± 0.58) compared to the same product obtained by producers in Maroua 1 (46.05 ± 0.26). The carbohydrate content values ranged to 44.3 ± 0.7-3.75 ± 0.06 for koki, kossey, and awara (Tables 5). Maroua

1 offers consumers awara with a carbohydrate content of 3.75% ± 0.06%, while producers in Maroua 2 and 3 offer consumers awara with carbohydrate contents of 4.46 ± 0.2 and 5.49 ± 0.06 respectively. A significant difference is observed ($p < 0.05$) between these last two products. The producers of koki and kossey in the municipality of Maroua 3 offer to their customer's products with higher carbohydrate values of 44.3 ± 0.7% and 37.38 ± 1.88% respectively. The quantification of lipids in koki and kossey products shows significantly different levels ($p < 0.05$) ranging from 3.87 ± 0.12 to 6.37 ± 0.36. Awara samples generally have higher lipid values (20.1 ± 0.06 to 21.88 ± 0.1 (Table 6)).

The average energy potential of the different foods produced in different locations varies from 208.16 ± 35.97 kcal to 441.23 ± 0.10 kcal. Tables 4, 5, and 6 show that koki, kossey, and awara products from Maroua 3 rank highest in terms of energy value.

Table 4: Protein, carbohydrate, lipid and energy values of the different Koki samples.

Koki	Protein (%)	Carbohydrates (%)	Lipids (%)	Energy values (Kcal)
Maroua 1	16.28 ± 0.02 ^a	33.55 ± 2.02 ^a	5.47 ± 0.11 ^b	238.73 ± 22.82 ^a
Maroua 2	23.73 ± 0.46 ^b	38.59 ± 0.44 ^b	3.87 ± 0.12 ^a	282.48 ± 8.75 ^{ab}
Maroua 3	24.96 ± 0.18 ^b	44.3 ± 0.7 ^c	5.91 ± 0.07 ^c	323.56 ± 7.07 ^b

Table 5: Protein, carbohydrate, lipid, and energy values of the different Kossey samples.

Kossey	Protein (%)	Carbohydrates (%)	Lipids (%)	Energy values (Kcal)
Maroua 1	15.22 ± 1.22 ^c	25.57 ± 5.23 ^{ab}	5 ± 1.13 ^a	208.16 ± 35.97 ^{ab}
Maroua 2	20.74 ± 0.69 ^a	34.28 ± 4.92 ^a	5.47 ± 0.61 ^a	269.31 ± 27.93 ^a
Maroua 3	18.44 ± 1.19 ^b	37.38 ± 1.88 ^a	6.37 ± 0.35 ^a	280.61 ± 15.43 ^a

Table 6: Protein, carbohydrate, lipid, and energy values of the different Awara samples.

Awara	Proteins (%)	Carbohydrates (%)	Lipids (%)	Energy values (Kcal)
Maroua 1	46.05 ± 0.26 ^a	3.75 ± 0.06 ^a	21.4 ± 0.15 ^b	391.8 ± 2.63 ^a
Maroua 2	51.7 ± 0.28 ^b	4.46 ± 0.2 ^b	20.1 ± 0.06 ^a	405.36 ± 0.59 ^b
Maroua 3	55.57 ± 0.14 ^c	5.49 ± 0.06 ^c	21.88 ± 0.1 ^c	441.23 ± 0.10 ^c

Microbiological profiles of the three street foods studied

At the microbiological level, as other authors have pointed out, there is a problem with the hygienic looking at the overall quality of the three products, we see that, although this is a widespread problem, there are some differences in contamination levels between vendors and production sites [23-26]. Some vendors appear to have a more hygienic approach than others (Table 7). Analysis of the total mesophilic aerobic flora (0.61×10^5 - 9.04×10^5 CFU/g) of street foods suggests that the level of contamination in certain products

is acceptable, whereas in fact, the levels of contamination by other microflora are mostly higher than the maximum values allowed by the microbiological criteria that cooked street foods must meet in order to be officially recognized as fit for consumption. This is the case for total coliforms ($0.49 \times 10^4 \pm 0.02$ - $7.91 \times 10^4 \pm 0.05$ CFU/g), indicators of recent or constant contamination, *Staphylococcus aureus* ($3.75 \times 10^3 \pm 0.21$ - $15.37 \times 10^3 \pm 0.17$ CFU/g) and sulfite-reducing *Clostridium* ($0.23 \times 10^3 \pm 0.04$ - $8.03 \times 10^3 \pm 0.04$ CFU/g), found at levels above acceptable limits. This result is comparable to those of (23, 2425).

Table 7: Microbiological profile of the different street foods studied.

Street food	TMAF (CFU/g)	Total coliforms (CFU/g)	<i>Staphylococcus aureus</i> (CFU/g)	Sulfite-reducing <i>Clostridia</i> (CFU/g)	<i>Salmonella</i> spp. (CFU/g)	Molds and yeasts (CFU/g)
Koki	$1.42 \times 10^5 \pm 0.03^b$	$0.43 \times 10^4 \pm 0.05^a$	$3.75 \times 10^3 \pm 0.21^b$	$0.75 \times 10^3 \pm 0.07^b$	$0.48 \times 10^2 \pm 0.04^b$	$0.63 \times 10^2 \pm 0.04^a$
Kossey	$9.04 \times 10^5 \pm 0.19^e$	$2.88 \times 10^4 \pm 0.14^c$	$4.2 \times 10^3 \pm 0.28^c$	$0.73 \times 10^3 \pm 0.04^b$	$0.93 \times 10^2 \pm 0.04^c$	$1.13 \times 10^2 \pm 0.04^d$
Awara	$0.92 \times 10^5 \pm 0.01^a$	$4.54 \times 10^4 \pm 0.08^d$	$12.3 \times 10^3 \pm 0.14^f$	$5.73 \times 10^3 \pm 0.18^e$	$1.06 \times 10^2 \pm 0.06^c$	$1.25 \times 10^2 \pm 0.07^f$
Koki	$0.79 \times 10^5 \pm 0.01^a$	$0.49 \times 10^4 \pm 0.02^a$	$4.51 \times 10^3 \pm 0.02^c$	$1.28 \times 10^3 \pm 0.04^c$	$1.68 \times 10^2 \pm 0.04^c$	$0.93 \times 10^2 \pm 0.04^c$
Kossey	$4.68 \times 10^5 \pm 0.26^c$	$0.74 \times 10^4 \pm 0.06^b$	$11.22 \times 10^3 \pm 0.07^e$	$3.54 \times 10^3 \pm 0.06^c$	$2.4 \times 10^2 \pm 0.14^f$	$0.82 \times 10^2 \pm 0.03^b$
Awara	$5.45 \times 10^5 \pm 0.35^d$	$7.91 \times 10^4 \pm 0.05^f$	$13.76 \times 10^3 \pm 0.08^g$	$4.32 \times 10^3 \pm 0.02^f$	$3.32 \times 10^2 \pm 0.02^g$	$1.58 \times 10^2 \pm 0.04^h$
Koki	$0.61 \times 10^5 \pm 0.02^a$	$0.85 \times 10^4 \pm 0.07^b$	$3.4 \times 10^3 \pm 0.02^a$	$0.23 \times 10^3 \pm 0.04^a$	$0.23 \times 10^2 \pm 0.02^a$	$0.72 \times 10^2 \pm 0.03^{ab}$
Kossey	$0.73 \times 10^5 \pm 0.04^a$	$5.18 \times 10^4 \pm 0.03^c$	$9.1 \times 10^3 \pm 0.14^d$	$1.73 \times 10^3 \pm 0.04^d$	$1.4 \times 10^2 \pm 0.14^d$	$1.15 \times 10^2 \pm 0.07^{de}$
Awara	$8.93 \times 10^5 \pm 0.04^e$	$5.13 \times 10^4 \pm 0.02^c$	$15.37 \times 10^3 \pm 0.17^h$	$8.03 \times 10^3 \pm 0.04^b$	$5.03 \times 10^2 \pm 0.03^b$	$1.38 \times 10^2 \pm 0.04^g$
-	3.10^5	10^3	10^2	30	Absence/25 ^g	10^2

Note: (Guiraud and Galzy. 1980; Hitchins et al. 1992)

DISCUSSION

The higher water content found in koki is justified by the producer's desire to achieve a softer, more pliable texture. The more acidic pH of the koki produced by the Maroua 3 producers is linked to the slightly longer soaking time (24 hours) of the raw material. During soaking, the longer the time, the greater the extraction of grain compounds and microbial activity [27]. The naturally occurring lactic acid bacteria ferment the sugars and produce lactic acid, thereby lowering the pH. The higher ash content indicates a more complete flour [28]. Kossey producers emphasize the hulling of cowpea grains in order to obtain a very smooth paste that is easy to cook in oil. On the other hand, since awara is produced from soy milk, producers hope to increase their milk yield by seeking

a more complete paste before filtration. The husks of the beans are not completely removed during hulling and are used during the filtration phase. The ash content of awara compared to other products can also be explained by their different raw materials. Soybeans have a higher ash content than cowpeas [29].

The lipid content of soybeans is at least twice as high as that of cowpeas. Although processing affects the final lipid content of awara, the high lipid content obtained is intrinsically correlated with cowpeas in terms of lipid potential, but above all with the frying oil used [30,31].

There are two main reasons for the low carbohydrate content of awara. The first is that soybeans are generally low in carbohydrates compared to cowpeas. Secondly, awara is a product made from

soy milk, i.e., a filtered liquid extract. Starch is a large molecule and is very often bound to fiber, so it mainly remains in the solid residue called meal. Soybean meal is composed of insoluble fiber, and almost all of the starch present, because it is ungelatinized and highly insoluble, is trapped in the fibrous material. Heat treatment of the harvested milk will then convert some or all of the starch into carbohydrates. This carbohydrate content is similar to that obtained by in the artisanal production of tofu in Antananarivo. In light of Cameroonian microbiological standards issued by ANOR and those of the Codex Alimentarius, the microbiological profiles of the street foods analyzed do not meet the regulatory requirements that food products must satisfy in order to be consumed. The results obtained suggest poor compliance with good hygiene and manufacturing practices at the manufacturing sites. The presence of toxinogenic flora such as *Staphylococcus aureus* *Salmonella sp* and *Clostridium perfringens* represents potential risks to public health, which could lead to serious collective food poisoning [32].

These microbiological results confirm the problem of the hygienic quality of street food and point out concrete actions in terms of quality assurance and training/awareness-raising for producers on hygiene rules and quality assurance procedures.

CONCLUSION

The study determined the physicochemical characteristics and microbiological profiles of Koki, Kossey, and Awara and provided insight into the reasons for the differences in processing methods. It appears that the manufacturing processes for each product are broadly similar across all three municipalities in the city of Maroua, with slight variations in the processing for certain desired characteristics. The characterization of the three street food showed that all the physicochemical parameters studied, namely dry matter content, pH, protein, lipid, and carbohydrate content, as well as energy values and microbiological qualities, vary depending on the production site. The products offered by producers in the municipality of Maroua 3 provide consumers with the highest energy values. In fact, hulling yields and lack of control over the coagulant dose appear to affect the variability in the texture of the different awaras. However, the overall analysis of the microbial profile exceeds regulatory requirements and suggests a need to support producers in a quality assurance approach with a view to complying with ANOR regulatory requirements.

FUNDING

No financial support was received for the study and preparation of the manuscript.

AUTHORSHIP CONTRIBUTION

All the authors were involved in collecting data, treatment and writing the manuscript. All authors approved the submission.

DECLARATION OF COMPETING INTEREST

All authors declared no competing interest in carrying out the work.

REFERENCES

1. Bricas, Tchanda C, Mouton F. Africa conquers its domestic food market. AFD. 2016.
2. Cerdan C, Ndjouenkeu R, Mbayhoudel K. Valorization of food crops: Place and role in the economic development of the savannas of Central Africa. J Francoph Agric Stud. Res. 2004;13:85-96.
3. Perkins EG. Composition of soybean and soybean products. Pract Handb Soybean Process Util AOCS Press. 1995.
4. FAO. Street foods: Report of an FAO expert consultation. National Library of Australia. 1990.
5. Konnon D, Ahoueya J. Overview of the soybean sector in Benin and identification of its promising Value Chains (VCs). Provisional report, GIZ & MAEP/Benin. 2017;133.
6. Outlook OF. Agriculture in Sub-Saharan Africa: Prospects and challenges for the next decade. OECD-FAO Agricultural. 2016.
7. Houssou PAF, Dansou V. Good Hygiene and Manufacturing Practices Guides for Soy-Based Cheese in Benin. Technical and Information Document (DT&I). 2022;19.
8. Pasquet R, Echikh N, Gepts J, Baudoin JP. The domestication of cowpea, *Vigna unguiculata* (L.) Walp. Horizon Publisher. 1997.
9. Kondi Y, Mawuli A, Agnassim B, Yentchabre P, Koffy T. Evaluation of four cultivars of niebe (*Vigna unguiculata* (L.) Walp.) for their resistance to water deficit and to the advent parasite, striga gesnerioides (willd.) Vatke in Togo. Scientific Journal. 2018;14:215-228.
10. Rémond D, Walrand S. Legume grains: Nutritional characteristics and health effects. Agronomic Innovations. 2017;60:133-144.
11. Mazengo KD, Tryphone GM. Response of common bean genotypes (*Phaseolus vulgaris* L.) to drought for growth and yield characteristics in the southern highlands of Tanzania. Int j environ agric biotechnol. 2019.
12. Paul N'DA. 48 Caroline Robitaille et Alexandra Vallée. Methodol. Sci. 2017;18.
13. Bridier B. Food crafts: A specific place and function. ECART. 1994.
14. Cunniff P, Washington D. Official methods of analysis of AOAC International, 16th edition. J. AOAC Int. 1995.
15. Association of Official Analytical Chemists. Official methods of analysis of the Association of Official Analytical Chemists. The Association. 2000.
16. Dubois M, Gilles K, Hamilton J, Rebers P, Smith F. Colorimetric method for determination of sugars and related substances. Anal Chem. 1956;28:350-356.
17. Nout MJR, Rombouts FM, Havelaar A. Effect of accelerated natural lactic fermentation of infant food ingredients on some pathogenic microorganisms. Inst J Food Microbiol. 1989;8:351-361.
18. Bourgeois CM, Leveau JY, Lavoisier É. Techniques of analysis and control in the agro-food industries. Microbiol ed Tec Doc. 1991;454.
19. Buttiaux R, Beerens H, Taquet A. Manual of bacteriological techniques. Flammarion. 1974;700.
20. Institut Pasteur Production. Pasteur Laboratory Media and Reagents. Institut Pasteur-Paris. 1980;573.
21. Joffin C, Joffin JN. Microbiologie alimentaire. SciEP. 1985.
22. Ndihi A C, Ndjouenkeu R, Touwang C, Etoa FX. Influence of aging on the unwinding ability of the eye round and the scoter in the differentiated construction of the Kilishi Lamellae. J Food Sci Nutr Res. 2025;8:35-40.
23. Mbawala A, Daoudou B, Ngassoum MB. Microbiological quality of kilishi (dried meat product) produced in the city of Ngaoundéré (Cameroon). Tropicicultura. 2010;28:153-160.
24. Fonkem DN, Tanya VN, Ebangi AL. Effects of season on the microbiological quality of kilishi, a traditional Cameroonian dried beef product. Tropicicultura. 2010;28:10-15.
25. Njongmeta NLA, Ejoh RA, Djoulde RD, Mbofung CM, Etoa XF.

- Microbiological and safety evaluation of street sold meat and meat product in Ngaoundere metropolis (Cameroon). *Microb Hyg Alim.* 2004;16;43-48.
26. Louembé J, Brawman A, Tchicaya F, Kodawila SC. Microbiological and biochemical study of corn porridge (poto poto). *Microbiol Food Nutr.* 1996;14:245-253.
 27. Khaoula T. Flour Quality Control: Case Study of the Southern Grand Mills, Oumach, Biskra. Mohamed Khider University of Biskra. 2023.
 28. Ouattara S, Bougouma-Yaméogo VM, Nianogo AJ, Savadogo B. Influence of substituting roasted soybean (*Glycine max*) seeds by those of cowpea (*Vigna unguiculata*) and of the protein level in the diet on the performance of the local-breed guinea fowl in Burkina Faso. *Rev Elev Med Vet Pays Trop.* 2016;69:117-123.
 29. Cheftel JC, Cuq JL, Lorient D. Food Proteins: Biochemistry, functional properties, nutritional value. Tec ed and Doc. Lavoisier. 1985:306-308.
 30. Marou HS. Comparative analysis of the nutritional potential of Wankoun and Atchawe-tola cowpea varieties and traditional cowpea-based dishes consumed in Cotonou, Benin. *Dicames.* 2019.
 31. Hailu F. Genetic diversity and grain protein composition of tetraploid wheat (*Triticum Durum Desf*) germplasm from Ethiopia. *Acta Univ Agric Suec.* 2011.
 32. Sagbohan TG, Aboudou K, Gougbe A, Noukpozoukou MS, Alidou C, Soumanou Mm, et al. Analysis of endogenous practices for the production and preservation of soy cheese produced in Benin. *Afr sci.* 2024;24:33-46.