

Health Risk Factors, Microbiological Quality of “Choukouya” (Braised Meats) Sold in the Districts of the City of Man

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Received December 11, 2024; Revised January 12, 2025; Accepted January 19, 2025

Abstract Diseases due to food poisoning caused by pathogenic microorganisms are a real health problem. Their appearance is often insidious and is accompanied by serious consequences for populations. In developing countries, street food is a factor favoring the occurrence of these diseases. In Côte d'Ivoire, and more particularly in Man, "choukouya", meat braised on a grill, is one of these street foods popular with populations that escape any health control by the authorities. The objective of this study was therefore to highlight the potential health risks linked to the consumption of this food by populations. As a result, a survey was conducted among "choukouya" sellers and among consuming populations in order to understand the behavior of sellers that could have an impact on the health of consumers. Also, microbiological analyses were carried out on pieces of "choukouya" in order to look for microorganisms such as total aerobic mesophilic flora (TAMF), *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* spp. whose presence is synonymous with poor hygiene conditions and potential danger for the consumer. The results obtained showed at the level of the sellers, a negligence of good hygiene practices in their sales environment which does not seem to concern the populations consuming this commodity. The microbiological analyses carried out showed the strong presence of microorganisms such as *Escherichia coli* and *Staphylococcus aureus*, which in some cases are involved in gastroenteritis disorders following poisoning. A collective awareness of sellers, consumers and authorities can help limit the appearance of these pathologies linked to poor hygiene conditions surrounding the sale of street food.

Keywords: Choukouyat, Street food, Microbiological quality, City of Man

Cite This Article: Yao Kamélé Kossonou, Affoué Carole Koffi, Vafi Soumahoro, Idrissa Doumbia, and Kablan Tano, “Health Risk Factors, Microbiological Quality of “Choukouya” (Braised Meats) Sold in the Districts of the City of Man.” *American Journal of Microbiological Research*, vol. 13, no. 1 (2025): 1-7. doi: 10.12691/ajmr-13-1-1.

1. Introduction

Street food is a widespread eating habit in Africa [1]. The term "street food" refers to ready-to-eat foods and beverages prepared or sold by street vendors or fixed vendors, especially in the streets and other similar public places [2]. These foods are appreciated by consumers for their accessibility, affordability and unique organoleptic properties [3]. Although these street foods constitute an economical solution adapted to the food and nutritional needs of populations in developing countries, the conditions of preparation, processing, preservation and distribution of these foods do not guarantee their quality, safety and the required hygiene conditions [4]. Among the multitude and diversity of street foods sold in Côte d'Ivoire, "choukouya" occupies a special place given the craze it arouses among consumers. "Choukouya" is a food product made from beef, mutton or goat meat cooked in

artisanal metal ovens. These ovens are made using recovered barrels or casks topped with metal mesh and with firewood used as fuel [5]. In Côte d'Ivoire, "choukouya" is a dish sold on the public highway, in the alleys of neighborhoods and generally consumed by a large number of people during wedding ceremonies, baptisms, birthdays and during night outings [6]. Unfortunately, the hygienic conditions in which this food is sold can lead to contamination by microorganisms. Consequently, the consumer and even the seller can be subject to cases of collective food poisoning. Recent studies conducted in the cities of Bouaké and Korogho have shown contamination by *Escherichia coli*, *Staphylococcus aureus*, *Clostridium* spp. and *Salmonella* spp. of approximately 66 to 100% of braised beef [5]. In view of the above, the consumption of "choukouya" can represent a real danger for the consumer. It would therefore be appropriate to draw more attention from the Ivorian authorities in order to better regulate the sale and consumption of "choukouya" for the well-being of the consumer. In several large cities of Côte

d'Ivoire such as Korhogo, Daloa, Yamoussoukro, Abengourou, Bouaké and Abidjan, such studies have already been conducted [5,6].

In Man, the large city in the far west of Côte d'Ivoire, data on this subject remain insufficient. This is why this study aims to assess the health risk factors and the microbial profile of contaminants in braised meats "choukouya" sold in the streets of the city of Man (Côte d'Ivoire).

Specifically, it will involve:

- collecting information from a survey on the hygiene practices of vendors, but also at the consumer level, the frequency of consumption of "choukouya";
- assessing the microbial quality of braised meats in order to assess the risk to consumer health.

2. Materials and Methods

2.1. Survey

The survey, conducted using a questionnaire in March 2023, was conducted among consumers and sellers of braised meat (choukouya) in five (05) neighborhoods selected for the study. The choice of the five districts was made based on the abundance of sellers in these neighborhoods. The five neighborhoods are Libreville, Dioulabougou, Doyagouiné, Commerce and Sari. The questionnaire administered to sellers and consumers of "choukouya" allowed at the seller level: to establish their socio-demographic profile, the assessment of their knowledge of good hygiene practices and the cooking time of the food. At the consumer level, the information sought was also their socio-demographic profile, the frequency of weekly purchase of "choukouya" and the appearance or not of intestinal disorders after consumption of this food. A total of 68 people were interviewed, including 15 sellers and 53 consumers. The 15 sellers represent all the "choukouya" sellers that we know in the 5 neighborhoods chosen for the study. As for the 53 consumers, they were buyers who were kind enough to give us some time for the interview. Many other buyers were in fact teenagers, sent by their parents, and were therefore unable to answer our questions.

These survey data should allow us to refute or confirm the results of the microbiological tests to be carried out.

2.2. Collection of "choukouya" Samples for Microbiological Analysis

In this study, pieces of meat sold on the streets of the city of Man were examined. The samples were taken from five neighborhoods of the city of Man. A total of 50 samples of braised meat were collected at a rate of 10 samples per neighborhood from March to April 2023. A sample consists of approximately 72 g of braised meat. Two (02) meat samples per district were taken per week and analyzed. The samples were collected using a stomacher bag, placed in a cooler and transported to the laboratory for analysis.

2.3. Microbiological Analyses

The microbiological analysis of braised meats is based

on the techniques for counting microorganisms as described in the work of [7]. This involves counting germs such as Total Mesophilic Aerobic Flora (TMAF), fecal and total coliforms, *Escherichia coli*, *Staphylococcus* sp. and *Salmonella* sp. The identification of a germ, a qualitative aspect, is characterized by its absence or presence. On the other hand, the counting of a germ is carried out by counting the colonies followed by a calculation method and therefore represents the quantitative aspect of it.

2.3.1. Preparation of the Mother Suspension and Decimal Dilutions [8]

25 g of each meat sample collected and then ground in Stomacher bags were added to 225 mL of Buffered Peptone Water (BPW) to obtain the mother solution. The solution obtained is then left to stand for about ten minutes at room temperature in order to reactivate the germs. 1 mL of this solution is added to 9 mL of BPW medium. The solution obtained is the 10⁻¹ dilution. This same action is repeated 3 more times to obtain the decimal dilutions 10⁻², 10⁻³ and 10⁻⁴ which will be used for inoculation in the boxes containing the culture media.

2.3.2. Enumeration of Total Mesophilic Aerobic Flora (TMAF)

The count was carried out by seeding in the mass. A volume of 1 mL of the stock suspension and its decimal dilutions in duplicate were seeded in plate counting agar (PCA) previously preserved in supercooling at 40 °C. The incubation was carried out at 30 °C for 72 h, then the counting and calculation of the average of the germs in Colony Forming Unit (CFU)/g of sample analyzed were carried out according to the method specified by the [9] standard. Only Petri dishes with a number of colonies between 30 and 300 were taken into account for the count.

2.3.3. Enumeration of Total Coliforms, Thermotolerant Coliforms and Dosage of *Escherichia coli*

The search for these different germs was carried out by inoculation for *E. coli*. One (1) mL of the mother suspension and its decimal dilutions in duplicate were inoculated in the crystal violet and neutral red lactose bile (VRBL) medium for the search for total and thermotolerant coliforms. The Tryptone Bile X Glucuronide (TBX) medium was used for the search for *E. coli*. The incubation was carried out at 30 °C for 24 h for total coliforms, 44°C for thermotolerant coliforms and *E. coli*. The counting and calculation of the average number of germs in Colony Forming Unit (CFU)/g of sample analyzed were carried out using Petri dishes containing 15 to 150 colonies for thermotolerant coliforms and between 30 and 300 for total coliforms, according to the method specified by the [10] et [11] standards. A qualitative search for *Escherichia coli* was carried out. The *E. coli* assay was carried out using the Leminor reduced rack. After observing the suspect coliform colonies on VRBL, five colonies were selected and inoculated on bromocresol purple medium (BCP). The presence of yellow colonies after incubation at 37°C, reflects the fermentation of lactose by coliforms and confirms the presence of these germs.

2.3.4. Enumeration of Staphylococci

The method used is that described by the [12] standard. The surface plating technique of 0.1 mL of inoculum (samples and decimal dilutions) on Baird Parker complete medium was used. The inoculated media were incubated at 37°C for 48 h. The inoculations were carried out in duplicate. Petri dishes containing a number of colonies between 15 and 150 were examined. The characteristic shiny black colonies surrounded by a clear halo were counted.

2.3.5. Detection of Salmonella

Buffered peptone water and Rappaport-Vassiliadis broth were used as pre-enrichment and enrichment broths respectively. Xylose-Lysine-Deoxycholate (XLD) and Hektoen agars were used as isolation media at 37 °C. The method used for this salmonella detection is that specified by the NF EN ISO 6579 [13] standard. Pre-enrichment is carried out directly from the mother suspension which is incubated at 37°C for 24 h. It allows the growth of bacteria subjected to stress or damaged by factors such as freezing, dehydration or preservatives.

For enrichment, a volume of 10 mL per tube of Rappaport Vassiliadis broth (RV10) was distributed in screw-top tubes. In this broth, 0.1 mL of the pre-enrichment solution is added using a sterile pipette. The whole is incubated in an incubator at 37°C for 24 h. The selectivity of the broth and the relatively high incubation temperature lead to the elimination of a large part of the accompanying flora and promote the growth of Salmonella strains. For the isolation of Salmonella, the enrichment broth was inoculated on Hektoen agar using the exhaustion streak technique. The plates are then incubated at 37°C.

2.3.6. Calculation of the Number of Colonies

Petri dishes containing between 15 and 300 colonies are selected. The formula below is applied to calculate the number N of CFU/g, as a weighted average from 2 successive dilutions :

$$N = \frac{\sum a}{V(n1 + 0.1n2)d} \quad (1)$$

With:

$\sum a$: sum of colonies counted on the plates selected from 2 successive dilutions

V : volume of inoculum inoculated

n1: number of plates at the 1st dilution

n2: number of plates at the 2nd dilution

d: dilution factor of the 1st dilution selected

If the Petri dish, at the level of the first dilution chosen, contains less than 15 colonies, the formula below is adopted to calculate the number N of CFU/g of the germ:

$$N = \frac{\sum a}{V.n.d} \quad (2)$$

With:

$\sum a$: sum of colonies of the retained dishes

V : volume of inoculum inoculated

n: number of retained dishes

d: dilution factor of the retained dilution.

2.3.7. Microbiological Criteria for Assessing the Hygienic Quality of Braised Meat Samples

The criteria for assessing the hygienic quality of the samples used are the French standards relating to the criteria that ready-made meals must meet (EC regulation, 2005). These criteria are presented in Table 1. The interpretation of the results is based on a three-class plan and is carried out as follows: when the values obtained are lower than the criteria and up to three (3) times the criterion, the product is of satisfactory microbiological quality (SMQ). The product is of acceptable microbiological quality (AMQ); when the values obtained are between three (3) and ten (10) times the criterion. Finally, the microbiological quality is unsatisfactory (UMQ); when the values obtained are greater than ten (10) times the criterion.

Table 1. Microbiological criteria [14]

Microorganisms	CFU/g
TAMF	3.10 ⁵
<i>Escherichia coli</i>	1.0.10
<i>Staphylococcus</i> spp.	1.10 ²
<i>Salmonella</i> spp.	Absence in 25 g

TAMF : total aerobic mesophilic flora ; CFU : colony forming unit

2.3.8. Data Processing

The analysis of data from the survey conducted among sellers and consumers of "choukouya" as well as the microbiological analyses carried out on this commodity are reflected in the presence of various tables and graphs (histograms and pie charts). The tables and graphs were produced using EXCEL 2021 software.

3. Results

3.1. Survey of "choukouya" Sellers

3.1.1. Sellers Profile

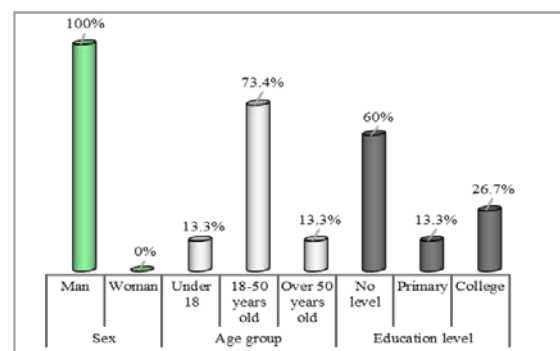


Figure 1. Distribution of "choukouya" sellers according to gender, age and level of education

The socio-demographic data collected show that the sale of "choukouya" is only carried out by men because, in fact, out of the 15 sellers selected, all are men. Among these men, 73.4% are between 18 and 50 years old, which shows that the majority of sellers are young people (Figure 1). In this figure, we can also see that men exercising this profession are generally people who have no level of education (60% of respondents). Only 13.3%

have reached primary level and the rest (26.7%), secondary level. Figure 2 gives the nationality of people exercising the profession of "choukouya" sellers. They are nigeriens (53.3%), burkinabe (33.3%) and guineans (13.3%). There are no ivorians present among these sellers.

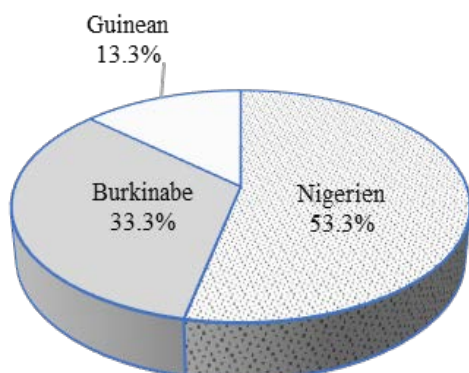


Figure 2. Proportion of "choukouya" sellers according to their nationality

3.1.2. Hygiene of Sellers, Sales Environment and Ingredients of "Choukouya"

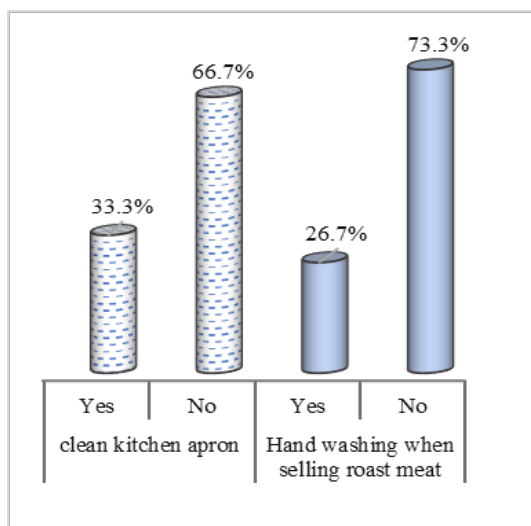


Figure 3. Proportion of "choukouya" sellers wearing clean work clothes and washing their hands during the sale

Figure 3, Figure 4 and Figure 5 present the behavior of "choukouya" sellers in relation to good hygiene practices in relation to their work clothes, hand washing, cleaning the condiments that accompany the braised meat and the work environment. It is noted that 66.7% and 73.3% of sellers respectively wear dirty work clothes and do not wash their hands while selling cooked meat. Only 33.3% wear clean work clothes and 26.7% wash their hands during the sale (Figure 3). Furthermore, it is noted that almost all sellers wash the meat before cooking it (86.7%) while only 46.7% clean the condiments before using them (Figure 4). Regarding the sales environment, Figure 5 shows that 60% of sales locations are in a poor state of hygiene compared to 40% that display good hygiene. In short, we see that the sellers of "choukouya" do not put into practice the rules of hygiene for healthy eating of consumers.

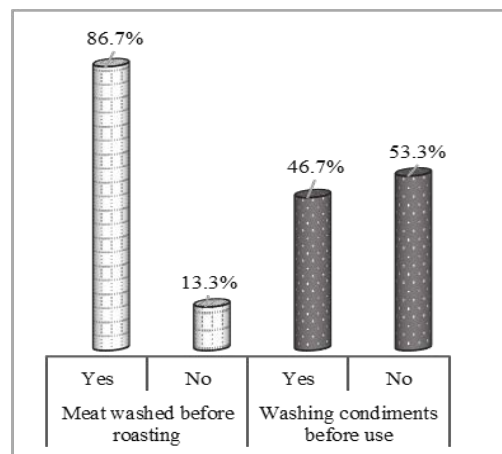


Figure 4. Proportion of "choukouya" sellers cleaning meat and condiments before cooking

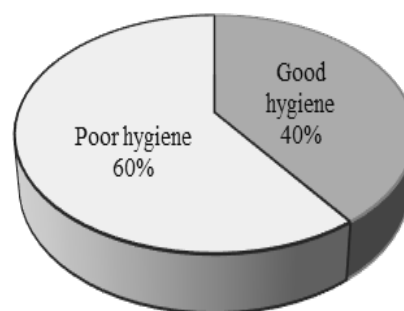


Figure 5. Proportion of "choukouya" sellers cleaning their workplace

3.1.3. Meat Cooking Time

During the survey, it was found that all sellers used wood bundles as fuel to cook meat. 86.7% of them cooked meat slowly, between 1 hour and 1 hour 30 minutes, at low cooking temperature while the remaining 13.3% preferred to reduce the cooking time to less than one hour while increasing the cooking temperature (Figure 6).

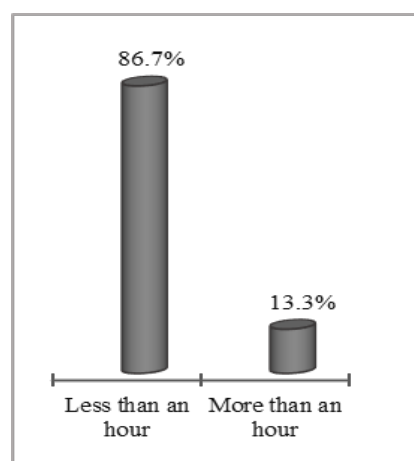


Figure 6. Distribution of sellers according to meat cooking time

3.2. Survey of "choukouya" Consumers

3.2.1. Consumers Profile

The socio-demographic data collected from "choukouya" consumers show that out of the 53 consumers surveyed, 62.3% were men compared to 37.7%

who were women (Figure 7). According to this figure, these are people working in the private sector (54.7%), civil servants of the Ivorian State (13.2%), students (17%) and the unemployed (15.1%). According to this data, "choukouya" is a commodity appreciated by all social classes.

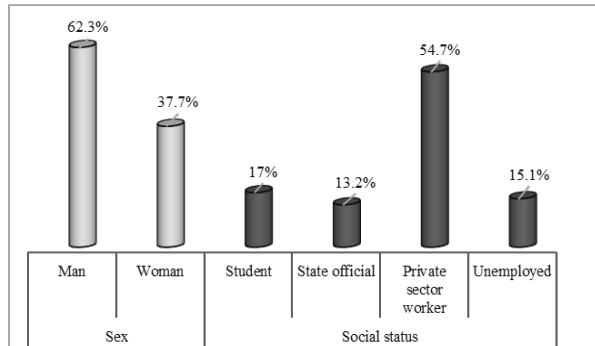


Figure 7. Distribution of consumers by gender and social status

3.2.2. Frequency of Weekly Purchase of "choukouya" by Consumers

Figure 8 shows the weekly frequency of purchase of "choukouya" by consumers. According to this figure, only 3.77% of respondents buy "choukouya" every day of the week, 32.10% buy it once (01) a week, 16.98% do it twice (02) a week, 22.64%, three (03) times a week and the remaining 24.51% do not have a clear idea of their frequency of purchase.

3.2.3. Appearance or Absence of Intestinal Disorders After Consumption of "choukouya"

Concerning the appearance of possible discomfort among consumers of braised meat, the data show that 17% of respondents reported having experienced disorders at least once after consuming this food. However, according to them, it would be difficult to establish a direct link relating to the consumption of "choukouya". The remaining 83% of consumers claim not to have experienced any intestinal disorders (Figure 9).

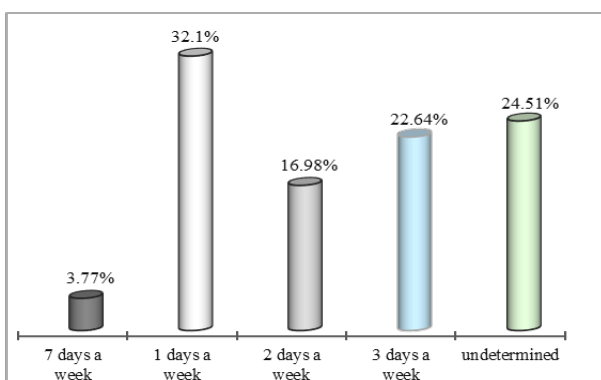


Figure 8. Proportion of consumers according to the frequency of purchasing "choukouya"

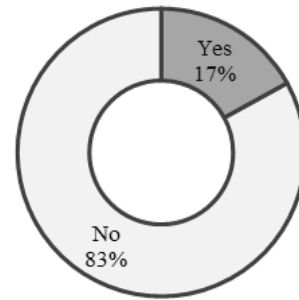


Figure 9. Proportion of "choukouya" consumers who have had intestinal problems

3.3. Results of Microbiological Analyses

The microbiological analyses carried out on the samples of "choukouya" taken from the sellers in each neighborhood gave the results recorded in Table 2.

This table presents the hygienic quality of the samples of braised meat taken according to the average bacterial load in CFU/g of the germs studied. The germs sought are total aerobic mesophilic flora (TAMF), *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* spp. Concerning the total aerobic mesophilic flora (TAMF), the microbiological quality of the samples is satisfactory (SMQ) for the samples from the Doyagouiné and Commerce neighborhoods with bacterial loads lower than 3.10^5 CFU/g (reference microbiological criterion). For the samples from the Libreville, Dioulabougou and Sari neighborhoods, the microbiological quality is acceptable (AMQ), the bacterial loads observed being lower than 3 to 10 times the reference limit. For *Escherichia coli*, the lowest bacterial load is that of the sample taken in the Sari neighborhood. It is $4.91.10^2$ CFU/g, more than 10 times higher than the reference limit of 10 CFU/g. The highest value of bacterial loads is that of the sample taken in the Commerce neighborhood ($6.55.10^3$ CFU/g). The high values of bacterial loads observed in all samples show that these meat samples have an unsatisfactory microbiological quality (UMQ). As for the *Staphylococcus aureus* germ, the reference microbiological criterion is 10^2 CFU/g. The samples taken in the neighborhoods of Libreville, Dioulabougou and Doyagouiné presented bacterial loads more than 10 times higher than the reference value. The microbiological quality of these three samples is therefore unsatisfactory. For the Commerce and Sari neighborhoods, the bacterial loads of *S. aureus* observed in the samples are less than 10 times higher than the reference value. The microbiological quality for these two samples is therefore acceptable. For the search and enumeration of salmonella, the results obtained show a total absence of these microorganisms in the "choukouya" samples taken in the five neighborhoods. In short, it is noted that the meat samples taken in the five neighborhoods are of unsatisfactory microbiological quality due to the high bacterial loads of *Escherichia coli* and *Staphylococcus aureus*.

Table 2. Microbiological quality of "choukouya" samples taken from sellers in the five neighborhoods

Germs studied		Samples of "choukouya" taken in the neighborhoods (n=10 per neighborhood)					Reference criteria
		Libreville	Dioulabougou	Doyagouiné	Commerce	Sari	
TAMF	(CFU/g)	3,24.10 ⁵ ± 0,25	3,12.10 ⁵ ± 1,34	3,69.10 ⁴ ± 0,08	4,53.10 ³ ± 0,06	5,21.10 ⁵ ± 0,15	3.10 ⁵
	Quality	AMQ	AMQ	SMQ	SMQ	AMQ	
<i>Escherichia coli</i>	(CFU/g)	(CFU/g)	2,19.10 ³ ± 0,09	2,88.10 ³ ± 0,12	2,79.10 ³ ± 0,10	6,55.10 ³ ± 0,05	10
	Quality	Quality	UMQ	UMQ	UMQ	UMQ	
<i>Staphylococcus aureus</i>	(CFU/g)	(CFU/g)	2,20.10 ³ ± 0,34	3,55.10 ³ ± 1,11	6,82.10 ³ ± 0,13	9,73.10 ² ± 0,01	10 ²
	Quality	Quality	UMQ	UMQ	UMQ	AMQ	
<i>Salmonella spp</i>	(CFU/g)	(CFU/g)	Absence	Absence	Absence	Absence	Abs/ 25 g
	Quality	Quality	SMQ	SMQ	SMQ	SMQ	

TAMF: total aerobic mesophilic flora; SMQ: satisfactory microbiological quality; AMQ: acceptable microbiological quality; UMQ: unsatisfactory microbiological quality; CFU: colony forming unit

4. Discussion

The assessment of the health status of braised meats "choukouya" in the city of Man allowed us to assess the hygienic practices of the sellers during the sale, and the microbiological quality of these braised meats.

The surveys revealed that all the sellers of "choukouya" are men of a young age (under 50 years old) and of foreign nationality. This result is partly similar to that of Youbgare [15], carried out in Senegal, in which he showed that this profession was practiced at more than 97% by men under 50 years old. The major difference between the two results lies in the nationality of the sellers of braised meats. Unlike Côte d'Ivoire, in Senegal, approximately 37% of the sellers are Senegalese. Also, the survey of the sellers showed that the majority of the sellers have no level of education. Indeed, 60% of these sellers are illiterate compared to only 40% who have reached primary or secondary level. These results are similar to those of Kouassi et al. [16] who in a study on the "hygiene conditions of sellers and diseases related to the consumption of cooked beef sold in the streets of the city of Abidjan (Côte d'Ivoire)", showed that nearly 72% of sellers were illiterate. Furthermore, regarding the hygiene conditions surrounding the sale of "choukouya", the results also showed that more than half of the places of sale are unsanitary and to this is added the lack of hygiene at the level of the cutting of meat, the unclean work clothes of the sellers and the soiled packaging in which the customers are served. All these observations suggest the existence of potential sources (environment, equipment, material, method and labor) of food contamination. These working conditions could promote the proliferation of microorganisms in the places of sale and the contamination of braised meats [17]. These results are consistent with those of Kouassi et al. [16] who stated that the diversity of microorganisms present in grilled meats is due to non-compliance with hygiene, poor sanitary conditions observed in sales locations, frequent and unhygienic handling of meats and cross-contamination with soiled materials and packaging. The non-application of good hygiene practices by vendors may be linked to their level of education. Indeed, according to Azagoh et al. [18], the level of education has a strong correlation with the knowledge and practice of hygiene.

As for consumers, the survey showed that they were made up of all social classes. The main reasons that

pushed them to consume "choukouya" are: the taste and its not too expensive cost. However, they do not seem to be concerned about the hygiene conditions around the sale of "choukouya". Among them, some (17%) said they felt unwell after consuming "choukouya". These discomforts characterized by vomiting, diarrhea and stomach aches, are generally synonymous with food contamination by microorganisms. Furthermore, the microbiological study showed the presence of *Staphylococcus aureus*, *Escherichia coli* and total mesophilic aerobic flora in the braised meat samples. These same germs are among those revealed by the work of Salifou et al. [19]. However, the absence of salmonella is noted in all samples. This absence of salmonella in the samples analyzed is a guarantee of food safety against salmonellosis. *Salmonella* sp. is a pathogenic germ whose presence concludes that the product is dangerous for consumption. Concerning the detected TAMF, although this germ is not dangerous for health, but a high bacterial load in TAMF in the samples may indicate that the meats have been exposed to poor handling, inadequate processing methods and inappropriate storage conditions [20]. As for the presence of staphylococci, the results showed that several samples that contained them were of unsatisfactory microbiological quality. These high values in the samples may be linked to non-compliance with hygiene rules since slaughter, washing, transport, preparation and especially handling after cooking. Staphylococci are generally considered commensal bacteria of humans, but can under certain conditions cause food poisoning [21]. As for the *Escherichia coli* germ, all the "choukouya" samples contained a high concentration. The microbiological quality for all these samples was unsatisfactory. According to Kossonou et al. [7], this presence suggests the confirmation of fecal contamination, directly linked to unsanitary conditions. Indeed, this bacterium comes exclusively from the intestines of humans and animals. Certain serotypes can cause gastrointestinal diseases. Infections by this microorganism are most often caused by the consumption of contaminated and undercooked beef. In such a context, the education of meat sellers and consumers is essential to prevent foodborne diseases by applying good hygiene practices at the point of sale [7].

5. Conclusion

In Ivory Coast, and more specifically in the city of Man,

establishments intended for the sale of braised meats displayed in the open air were created in order to satisfy the consumer. Thus, this study was carried out with the aim of making us, consumers, understand the probable risk incurred by indulging in the consumption of this food. The results showed that the sale of "choukouya" in the city of Man is not done in healthy hygienic conditions for better health of the populations who consume it. The microbiological analyses carried out confirmed the observations made at the different places of sale of the vendors interviewed. According to these analyses, a strong presence of germs such as total mesophilic aerobic flora, *Escherichia coli* and *Staphylococcus aureus* was highlighted. The presence of these microorganisms, although not always worrying for consumers, highlights the non-application of the rules of good hygiene practices by the vendors of this foodstuff. Although germs such as salmonella have not been detected, the hygienic state around the points of sale does not rule out the possibility.

The results of this study lead to recommendations to be made to the local authorities of the city of Man so that they create the conditions for the supervision and training of sellers on good hygiene practices at the points of sale. Thus, the populations who rush towards this food will be able to eat safely.

Conflicts of Interest

The authors have declared that they have no conflicts of interest.

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