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Original Research Article

Hygienic Quality of Mutton Grills Sold on the Outskirts of the Streets of Korhogo Town

Guédé Séri Serge[1*], Gragnon Biégo Guillaume[2], Kouamé Maimouna Liliane[1], Mbari Kiffopan Benjamin[3], Soro Yadé René[1, 4]

[1]Laboratoire de Biochimie, Microbiologie et Valorisation des Ressources Agricoles, Institut de Gestion Agropastorale, Université Peleforo Gon Coulibaly, Korhogo, Côte d'Ivoire
[2]Laboratoire National d'Appui au Développement Agricole, Korhogo (LANADA), Abidjan, Côte d'Ivoire
[3]Laboratoire de la Biologie, Production et santé Animale, Institut de Gestion Agropastorale, Université Peleforo Gon Coulibaly, Korhogo, Côte d'Ivoire
[4]Laboratoire de Biotechnologie, UFR des Biosciences, Université Félix Houphouët-Boigny, Abidjan, Côte d'Ivoire

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Abstract: In Korhogo town, there is a proliferation of places selling grilled meats. Also, controlling contamination of meat by pathogenic germs and toxic compounds is a major challenge for actors in the sector. It is in this context that a study was conducted to assess the hygienic quality of mutton grills sold on the outskirts of the streets of Korhogo town. To do this, a survey was conducted among sellers to describe the preparation and storage methods of mutton grills. Then, at points of sale, observations were made on the environment, equipment, raw material, method and workforce in order to assess the hygiene of mutton grills preparation. After that, the microbiological quality of mutton grills was assessed by looking for TMAF, faecal coliforms, *S. aureus* and *Salmonella spp*. Finally, the benzo[a]pyrene (BaP) content in mutton grills was estimated through a cooking test. The survey revealed that the majority of mutton grills sellers (60%) cooked the meat over an ember fire and stored the unsold grills at room temperature in basins or baskets. In most of the sale places visited (83.33%), the sellers did not comply with the principle of separating "clean" and "dirty" areas. Microbiological analysis showed that unpackaged mutton grills had better microbiological quality compared to mutton grills packaged in recovery paper, which served as a cement bag. However, the mutton grills overall quality was unsatisfactory in most cases (66.67%). The main microorganisms incriminated in the unsatisfactory quality of mutton grills were *S. aureus* (53.67%) and faecal coliforms (51.67%). Furthermore, the cooking test indicated that mutton cooked over an ember fire had a BaP content above the recommended maximum limit (2 µg/kg). Considering the results above, the mutton grills sold on the outskirts of the streets of Korhogo town would present a risk of food toxi-infection and poisoning for consumers. These results must be taken into account in order to carry out preventive actions, such as awareness-raising and training of grill sellers on good hygiene practices.

Keyword: Mutton grills, Hygienic conditions, Microbiological quality, Benzo(a)pyrene (BaP), Korhogo.

I. INTTRODUCTION

Meat is one of the most consumed foods in the world because of the importance of its nutritional value. Indeed, it is a source of proteins, vitamins, water, fats and iron (Dupin *et al*., 1992). In addition, it has sensory properties such as: color, tenderness, juiciness and flavor (Clinquart, 2016). In recent years, man has developed techniques that have allowed him to transform meat to ensure a long shelf life and improve its organoleptic quality (WHO, 2016). These meat processing techniques, such as grilling, are sources of income for ruminant and poultry farmers and for certain traders in West Africa, particularly in Ivory Coast. Indeed, grilled meats are commonly consumed at places

***Corresponding Author:** Guédé Séri Serge
Laboratoire de Biochimie, Microbiologie et Valorisation des Ressources Agricoles, Institut de Gestion Agropastorale, Université Peleforo Gon Coulibaly, Korhogo, Côte d'Ivoire

of sale, relaxation, leisure and during celebration events by a large part of the population (El-Hadef *et al*., 2005).

However, from slaughtering animals to cooking, the meat undergoes many manipulations before being delivered for human consumption. In addition, the poor hygiene practices noted at points of sale contribute to the dissemination and/or multiplication of pathogenic germs during the production and marketing of grilled meats (El-Hadef *et al*., 2005; Fosse *et al*. , 2006). Most pathogenic bacteria such as *Escherichia coli*, *Staphylococcus aureus*, *Clostridium spp* and *Salmonella spp* have often been detected in beef meats cooked in the grilled form (Bailly *et al*., 2002; Michel *et al*., 2005). These germs are incriminated in most of the food toxi-infections encountered in Ivory Coast. Therefore, particular importance should be given to them because of the severity or frequency of the risks they present (Michel *et al*., 2005).

Apart from food toxi-infections, the consumption of grilled meats can cause metabolic diseases due to their possible contamination by many harmful substances. In fact, during grilling, transformers or sellers use various unrecommended combustibles. These are rubberwood, wood resulting from eviction operations often covered with paint, varnish, moth repellent, etc. (Yaya *et al*., 2019). These materials used to cook meat can generate potentially toxic compounds, such as polycyclic aromatic hydrocarbons (PAHs), which come from the pyrolysis of organic matter (Cartier and Moevi, 2007). The United States Environmental Protection Agency (US-EPA) has identified 16 PAHs, among which Benzo(a)pyrene (BaP) has been declared the most carcinogenic (US-EPA, 1993). PAHs can cause acute toxicity (Szczeklik *et al*., 1994) and especially chronic toxicity (Okona-Mensah *et al*., 2005). These compounds can contaminate grilled meats during cooking, and thus constitute a danger or a threat to the health of big consumers.

Faced with recurrent cases of food toxi-infection and/or poisoning, in some African countries, works were carried out in the sector of selling food on the edges of the streets. These works made it possible to identify the specific problems and, to propose and implement strategies in order to control the negative effects, while maintaining the positive aspects, mainly the socio-economic aspects (FAO/WHO, 2005; AFRISTAT, 2009). In Ivory Coast, despite the increase in demand for meat and frequency of street foods consumption, very few studies have been conducted to assess the health status of these foods. In addition, in the north of Ivory Coast, particularly in Korhogo town, over the past decade there has been a proliferation of places selling grilled meats commonly called "choukouya" (Koffi-Nevry *et al*., 2012). However, in this area, studies on the quality of grilled meats are non-existent. It is therefore to fill this information gap that this study was carried out. The main objective of this work was to assess the hygienic quality of mutton grills sold on the outskirts of the streets of Korhogo town.

II. MATERIAL AND METHODS

2.1 Survey material

The equipment used for the investigation consisted of:

- A questionnaire for sellers to collect information on the methods of preparing and storing mutton grills;
- An observation grid for the places (of preparation and) of sale relating to the environment, equipment, raw material, method and workforce to assess the hygiene of the mutton grills preparation.

2.2 Biological material

The biological material consisted of mutton grills. The samples were purchased from sellers of braised meats located along the streets of Korhogo town. This town is located in the north of Ivory Coast (latitude 9°27'41" north, longitude 5°38'19" west), 635 km from Abidjan (Korhogo, 2022).

2.3 Choice of survey sites

The choice of sites was made randomly. Fifteen neighborhood of Korhogo town have been selected, namely: Air-France, Belle-Ville, Delafosse, Haoussabougou, Kôkô, Logokaha, Nouveau-Quartier, Petit-Paris, Prémafolo, Quartier-14, Sinistré, Soba, Tchékélézo, Téguéré and Trois-Poteaux (Figure 1).

2.4 Survey of mutton grill sellers

In each neighborhood selected, three mutton grill sellers were randomly chosen and then met at their workplaces. In total, forty-five (45) places of sale were visited along the streets of Korhogo town. The sellers were submitted to a questionnaire on their methods of preparing and storing mutton grills. Finally, on the places (of preparation and) of sale, the environment, equipment, raw material, method and workforce were carefully evaluated using the observation grid relating to their sanitary and hygienic conditions.

2.5 Sampling of mutton grills for microbiological analysis

At each point of sale, two types of mutton grill were taken, namely:

- Packed Mutton Grill (PMG) which is a grilled meat packaged in recovery paper, having served as a cement bag, and placed on the cooking grill awaiting consumers (Figure 2);
- Unpacked Mutton Grill (UMG) which is a set of small pieces of grilled meat taken and cut at the request of a customer, from large pieces of mutton cooked and placed on the cooking grill (Figure 2).

After sampling, the samples were packaged in sterile plastic bags, which were carefully closed and labeled, mentioning the date of sampling, the name of the neighborhood, the type of sample and the seller's reference. Then they were placed in a cooler containing bottles of dry ice to maintain the cold chain. Finally, all the samples were quickly transported to the LANADA bacteriology laboratory, stored at 4°C, then analyzed the same day. A total of 90 samples were taken, including 45 PMG and 45 UMG.

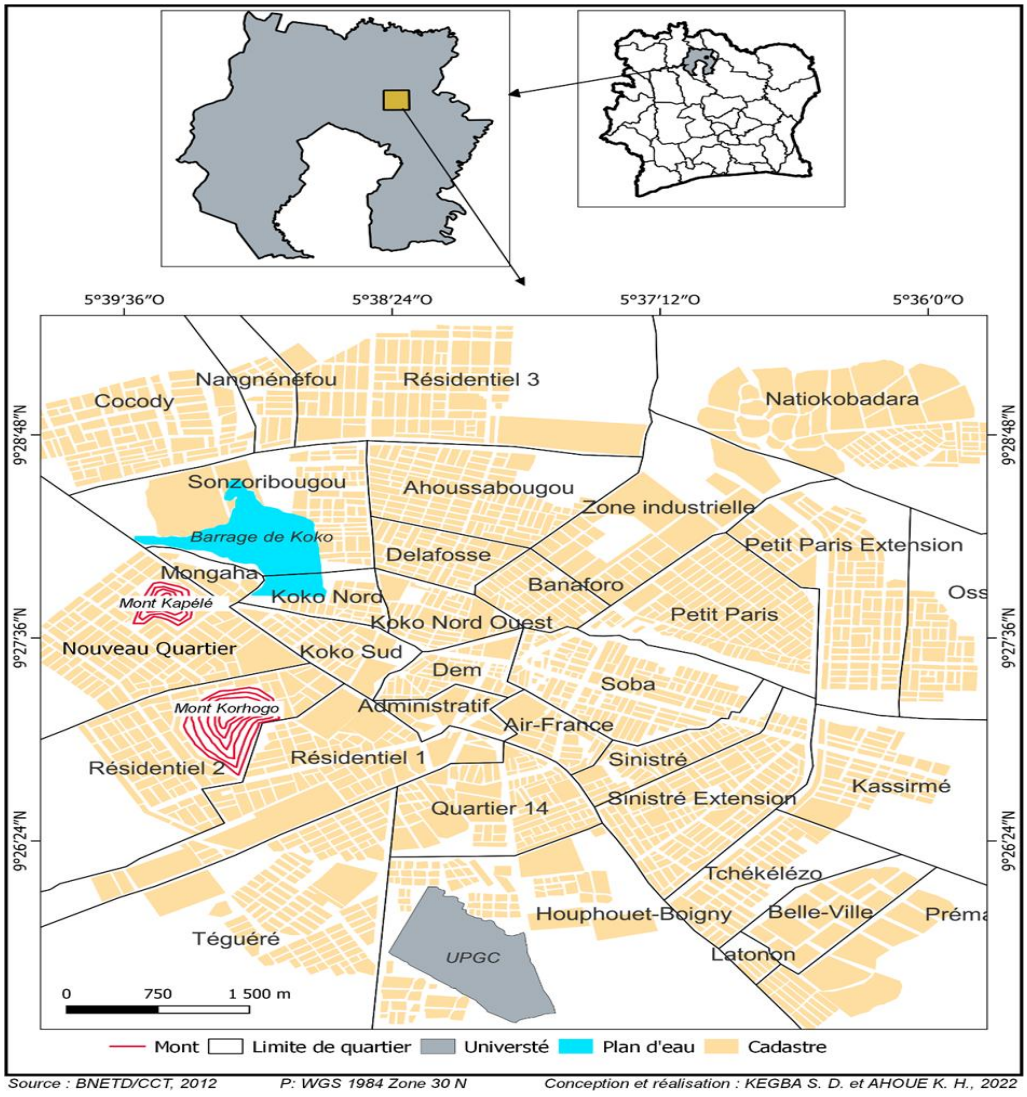

Figure 1: Map of Korhogo town (North of Ivory Coast)

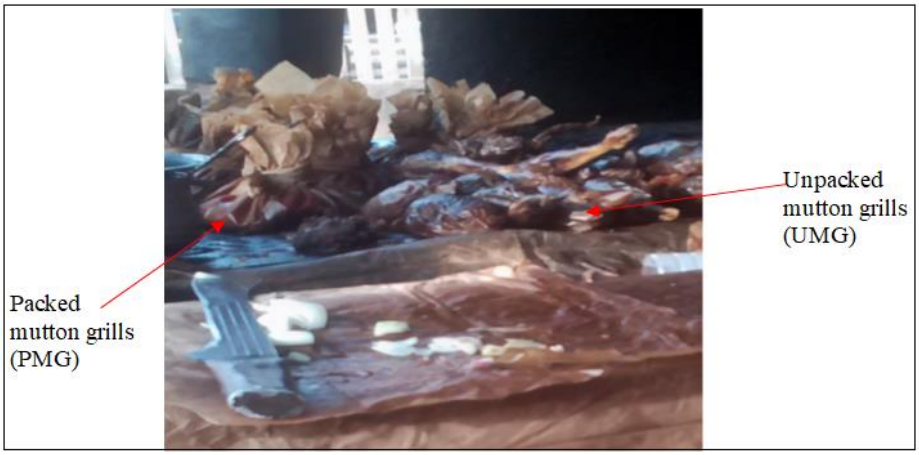

Figure 2: Mutton grills

2.6 Cooking test for the determination of Benzo(a)pyrene (BaP)

The cooking test consisted in estimating the BaP content of mutton grills according to the cooking conditions (fire intensity; cooking time) usually used by sellers. It was made at the sale point of a randomly chosen seller. The cooking conditions were defined according to the information collected from the sellers during the survey. First, six small pieces of mutton were cooked on a grill placed above the flames. Three pieces were removed from the grill after 15 min of cooking, and the other three after 30 min of cooking. In a second step, six other small pieces of mutton were braised on a grill placed above the embers. Three pieces were removed from the grill after 40 min of cooking, and the other three after 60 min of cooking. For each type of cooking, the samples, after cooling in a container, were wrapped in aluminum foil, then locked in an amber glass jar to avoid their exposure to all sources of light during storage. Finally, the samples were placed in a cooler at around 4°C, and then transferred to the laboratory where they were stored in the refrigerator at 4°C waiting for the BaP assay.

2.7 Microbiological analysis of mutton grills

The stock suspensions and the decimal dilutions were prepared according to standard ISO 6887-2 (2003). The Total Mesophilic Aerobic Flora (TMAF) was counted on Plate Count Agar (PCA) according to standard NF V 08-051 (1999). The enumeration of faecal coliforms was carried out on VRBL agar according to standard NF V 08-017 (1980). That of *Staphylococcus aureus* was made on Baird-Parker agar according to standard NF V 08-057-1 (2004). The average count of each microorganism was calculated according to the recommendations of the standard ISO 7218 (2007). The search for Salmonella was carried out on Hektoen agar according to standard ISO 6579 (2002).

2.8 Assessment of the microbiological quality of mutton grills

The microbiological quality of the mutton grills was judged according to the microbiological criteria applicable to foodstuffs "meals prepared at the retail stage sold hot or cooked on site", defined by the European Commission (Table 1). For TMAF, faecal coliforms and *S. aureus*, the sample was qualified:

- "satisfactory" when the value of N was less than m;
- "acceptable" when the value of N was between m and M;
- "unsatisfactory" when the value of N was greater than M.

N: number of microorganisms present in a sample expressed in CFU/g; m: limit number of microorganisms below which the microbiological quality of a sample is considered “satisfactory”; M = 10 x m: limit number of microorganisms beyond which the microbiological quality of a sample is considered "unsatisfactory".

Regarding *Salmonella spp*, the sample was considered "satisfactory" when there was no *Salmonella*; otherwise, it was qualified as “unsatisfactory”.

Then, the overall quality of the mutton grills was assessed by considering the microbiological results of the four germs sought. The overall quality of a sample was judged:

- "satisfactory", when the sample was deemed "satisfactory" for all four germs;
- "acceptable", when the sample was deemed "acceptable" for one of the germs and "satisfactory" for the other three germs;
- "unsatisfactory", when the sample was deemed "unsatisfactory" for at least one of the four germs.

Table 1: Microbiological criteria (CE n° 02073/ 2005)

Microorganisms	**Criteria UFC/g**
Total Mesophilic Aerobic Flora (TMAF)	3×10^5
Faecal coliforms at 44°C	10^2
Coagulase positive Staphylococci at 37°C	10^2
Salmonella spp	Absence in 25 g

2.9 Determination of Benzo(a)pyrene (BaP) content in grilled mutton

BaP is a particularly carcinogenic Polycyclic Aromatic Hydrocarbon (PAH) used as a marker of PAH contamination. The BaP assay was done according to the chromatographic method proposed by standard ISO 15753 (2006). After grinding the samples, the PAHs were extracted with a mixture acetonitrile/acetone (v/v: 60/40), then purified on C18 bonded phase cartridges (LRC Bond Elut 500 mg, 10 ml type) using the previous mixture as eluent. Then, a 20 µl extract was injected into the column (250 mm x 4.6 mm x 5 µm) of HPLC equipped with a UV-visible fluorescence detector. The solvent mixture acetonitrile/acetone (v/v: 60/40) and acetonitrile/water (v/v: 50/50) were used as mobile phase at a flow rate of 0.6 ml/min. Finally, the quantification of BaP was made from the calibration curve previously established by considering 5 calibration points (0 µg/l, 2.5 µg/l, 5 µg/l, 7.5 µg/l and 10 µg/l).

2.10 Statistical treatment of data

Data from the field survey were processed and presented in the form of numbers using Excel 2013 software. For the cooking and storage methods, and the

hygiene of mutton grills preparation, the proportion of sellers (PS_1), expressed in %, was calculated as follows:

$$PS_1(\%) = \frac{\text{Number of sellers corresponding to X}}{\text{Total number of sellers surveyed}} \times 100 \text{ …….. (1)}$$

For a quality microorganism Q, the proportion of samples (PS_2), expressed in %, was calculated as follows:

$$PS_2(\%) = \frac{\text{Number of samples judged Q}}{\text{Total number of samples analyzed}} \times 100 \text{ …… (2)}$$

For a germ (G), its contribution (CG), expressed in %, in the unsatisfactory quality of mutton grills was calculated according to the formula below:

$$CG(\%) = \frac{\text{Number of samples unsatisfactory at the level of G}}{\text{Total number of samples unsatisfactory}} \times 100$$
…… (3)

Chi-square ($\chi 2$) test was then applied to assess the significance of the difference between the calculated proportions. Student's *t*-test was used to compare the average microbial loads of the two types of mutton grill. Analysis of variance (ANOVA) was applied to the data from the BaP assay, followed by Tukey's test for the classification of means. All statistical tests were performed using XLSTAT 2015 software, and statistical significance was set at $p < 0.05$.

III. RESULTS

3.1 Mutton grills preparation

Table 2 summarizes the preparation steps of mutton grills sold on the outskirts of the streets of Korhogo town. All the interviewed sellers used two preparation processes (M1 and M2) which follow almost the same steps; but have some differences. In the M1 process, the meat is cut into small pieces before being braised, while in the M2 process, it is braised in large pieces, then cut at the request of customers.

The combustible source used by these sellers was firewood. More than half of them (60%) cooked the meat over ember fire for 40 min to 60 min, while the others (40%) used flame fire for 15 min to 30 min (Table 3).

Table 2: Methods of preparing mutton grills

Method M1	**Method M2**
Mutton	
Cut into small pieces	Cut into large pieces
Add oil, maggi-cube and salt, and mix	Sprinkle a mixture of oil, maggi-cube and salt
Braise until fully cooked on a grill placed over a wood fire	
Remove from fire and season with chilli, pepper, mustard, etc.	Remove from fire and cut into small pieces, at the request of customers
	Season with chilli, pepper, mustard, etc.
Pack in recovery paper, which served as a cement bag, waiting for customers	Pack in recovery paper, which served as a cement bag

Table 3: Distribution of sellers according to the method of cooking mutton

Combustibles source	**Type of fire**	**Cooking time**	**Proportion of sellers**	**Statistics**
				P
Firewood	Ember fire	40 à 60 min	60 %	0.028
	Flame fire	15 à 30 min	40 %	

3.2. Mutton grills storage

The distributions of sellers according to the storage means of leftover meat and unsold grills are recorded in Table 4. A minority of surveyed sellers (10%) managed to sell all the meat every day; while the majority (90%) kept leftover meats and unsold grills for the next day. The most used storage means of leftover meat was freezer (53.34%), followed by refrigerator (26.66%); while cooler (6.66%) and cold room (3.34%) were used by a minority of sellers. Regarding unsold grills, basin or basket was the storage method most used by the surveyed sellers (60%); while 30% of them used the refrigerator or cooler.

Table 4: Distribution of sellers according to the storage means of leftover meats and unsold grills

Objets	**Storing means**	**Proportion of sellers (%)**	**Statistics**
			P
Leftover meats	Cold room	3.34	< 0.0001
	Deep freezer	53.34	
	Refrigerator	26.66	
	Cooler	6.66	
	No storage	10	
Unsold grills	Refrigerator ou Cooler	30	< 0.0001
	Basin or basket	60	
	No storage	10	

3.3. Hygiene of mutton grill preparation

Table 5 presents the summary of observations made in places where mutton grills are prepared and sold.

3.3.1 Environment hygiene

Observations revealed that most of the selected places (83.33%) did not comply with the principle of separating "clean" and "dirty" areas. In addition, the majority of the places visited (70%) were located near often unsanitary gutters. Most of the sales premises (76.66%) were sheds designed from wood and sheet metal. Finally, for the majority of premises (90%), the floor surface was not tiled and was difficult to clean and disinfect.

3.3.2 Equipment hygiene

The work equipment consisted of tables, benches, knives, machetes, axes, grills, cooking pots. In most places of sale, cooking grills (80%) and storage appliances (66.66%) and other tools used (86.66%) were poorly maintained and dirty. In addition, in the majority of sale places (93.33%), the trash cans had no lid and gave off foul odors.

3.3.3 Raw material (mutton) hygiene

The observations showed that, in most of the places visited (80%), the meat was in contact with other food or non-food products in storage appliances. Meat intended for preparation remained exposed to the ambient air for several hours, in the majority of sale places (63.33%). In addition, the prepared grills were packaged in recovery paper, which served as a cement bag.

3.3.4 Method hygiene

In the majority of sale places visited (76.66%), grill sellers slaughtered their animals themselves. In more than half of the sale places (53.34%), the sellers cleaned the premises and the equipment the next day against 46.66% of the places where they do it the day of their use.

3.3.5 Workforce hygiene

In most of the places visited (93.33%), the workforce consisted of people belonging to the same family or ethnic group. Sellers wore ordinary and dirty clothes in the majority of sale places (80%). In some places (20%), they used blouses that were also dirty. For most places of sale (86.66%), sellers did not comply with food hygiene rules.

Table 5: Summary of observations made in places where mutton grills are sold

Observation points	Elements assessed	Assessment criteria	Proportion of sellers (%)	Statistics
				P
Environment	Design material	Wooden and sheet metal hangar	76.66	< 0.0001
		Hard premises	23.34	
	Floor surface	Tiled	10	< 0.0001
		Untiled	90	
	Wastewater drainage gutters	Near	70	< 0.0001
		Far away	30	
	SCD principe	Respect	16.67	< 0.0001
		No respect	83.33	
Equipment	State of cooking grills	Clean	20	< 0.0001
		Dirty	80	
	State of Storage appliances	Clean	33.34	0.0002
		Dirty	66.66	
	State of trash cans	Covered	6.67	< 0.0001
		Opened	93.33	
	State of other tools used	Clean	13.34	< 0.0001
		Dirty	86.66	
Raw material (Meat and grills)	Other FP or NFP	Contact with the RM	80	< 0.0001
		No contact with the RM	20	
	Ambient air	Raw material exposure	63.33	0.003
		No raw material exposure	36.67	
Methods	Sheep slaughter	by the seller	76.66	< 0.0001
		at the slaughterhouse	23.34	
	Period of W&C of equipment and premises	Same day after the SMG	46.66	0.465
		Next day before the SMG	53.34	
Workforce	Type of workforce	Familial or ethnic	93.33	< 0.0001
		Neither familial nor ethnic	6.67	
	Condition of clothes	Dirty blouse	20	< 0.0001
		Ordinary and dirty clothes	80	
	Hygiene requirements	Respect	13.34	< 0.0001
		No respect	86.66	

SCD: Separation of Clean and Dirty areas; FP: Food Products; NFP: Non-Food Products; RM: Raw Material; W & C: Washing and Cleaning; SMG: Sale of Mutton Grills.

3.4 Count of microorganisms present in mutton grills

Table 6 presents the average microbial loads (CFU/g) of the two types of mutton grills samples. The average microbial load of each germ sought in PMG did not differ significantly ($p > 0.05$) from that quantified in UMG. The average loads of TMAF, faecal coliforms and *S. aureus* were respectively 5.69×10^6, 4.09×10^3 and 4.86×10^3 CFU/g for PMG, and respectively 2.6×10^6, 2.88×10^3 and 1.16×10^3 CFU/g for UMG.

The proportions of grills samples contaminated by the germs sought are summarized in Table 7. At the level of TMAF and *Salmonella spp*, the proportions of contaminated PMG and UMG were not significantly different ($p > 0.05$), with percentages of (100 and 93.33%) and (13.33 and 8.89%). On the other hand, for faecal coliforms and *S. aureus*, the proportions of contaminated PMG (respectively 91.11 and 75.56%) were significantly higher ($p < 0.05$) than that of contaminated PMG (73.33 and 64.44%, respectively). This observation suggests that PMG was the type of grill most prone to microbial contamination.

Table 6: Average microbial loads of the two types of mutton grills samples

Microorganisms	Type of sample		Statistics
	PMG (N = 45)	UMG (N = 45)	*P*
TMAF (CFU/g)	$5.69\times10^6 \pm 5.81\times10^6$	$2.6\times10^6 \pm 2.65\times10^6$	0.545
Faecal coliforms (CFU/g)	$4.09\times10^3 \pm 4.17\times10^3$	$2.88\times10^3 \pm 2.94\times10^3$	0.755
Staphylococcus aureus (CFU/g)	$4.86\times10^3 \pm 4.92\times10^3$	$1.16\times10^3 \pm 1.19\times10^3$	0.281

Table 7: Proportion of mutton grills samples contaminated with germs

Microorganisms	Type of sample		Statistics
	PMG (N = 45)	UMG (N = 45)	*P*
TMAF	100 % (45)	93.33 % (42)	0.078
Faecal coliforms	91.11 % (41)	73.33 % (33)	0.027
Staphylococcus aureus	75.56 % (39)	64.44 % (29)	0.014
Salmonella spp	13.33 % (6)	8.89 % (4)	0.502

3.5 Microbiological quality of mutton grills

Table 8 summarizes the distribution of mutton grills according to microbiological quality, i.e. considering the four germs (TMAF, faecal coliforms, *S. aureus* and *Salmonella spp*) concomitantly. At the PMG level, the "unsatisfactory" samples were in the majority (75.56%). In addition, there were no "satisfactory" samples. Concerning the UMG, the "non-satisfactory" samples were a little more than half of the samples analyzed (57.78%); in addition, the cumulative proportion of "acceptable" and "satisfactory" samples (42.22%) was almost double that of PMG (24.44%). This demonstrates that the microbiological quality of UMG was better than that of PMG. However, overall, the mutton grill samples were mostly "unsatisfactory" (66.67%). In addition, according to Table 9, the unsatisfactory grill quality was largely due to *S. aureus* (53.67%) and faecal coliforms (51.67%).

Table 8: Distribution of mutton grills samples according to microbiological quality

Type of grilling	Assessment of quality			Statistics
	Unsatisfactory	Acceptable	Satisfactory	*P*
PMG (N = 45)	75.56 % (34)	24.44 % (11)	0 %	< 0.0001
UMG (N = 45)	57.78 % (26)	37.78 % (17)	4.44 % (2)	< 0.0001
PMG + UMG (N = 90)	66.67 % (60)	31.11 % (28)	2.22 % (2)	< 0.0001

Table 9: Contribution of microbial germs in the unsatisfactory quality of mutton grills

Microorganisms	Contribution rate	*P*
TMAF	35 % (21)	< 0.0001
Faecal coliforms	51.67 % (31)	
Staphylococcus aureus	53.67 % (32)	
Salmonella spp	16.67 % (10)	

3.6 Toxicological quality of mutton grills

The benzo[a]pyrene (BaP) content in mutton grills according to the cooking method is shown in Table 10. Overall, the results indicated that the cooking method (fire intensity – cooking time) had a significant effect ($p < 0.01$) on the BaP content of mutton grills. Indeed, mutton grills cooked over an ember fire for 60 min had the highest BaP content (5.13 ± 0.35 µg/kg); followed by those prepared over an ember fire for 40 min, with a content of 2.52 ± 0.33 µg/kg. On the other hand, those prepared over flame fire for 15 min had the lowest content (0.65 ± 0.05 µg/kg). In addition, the

concentrations of BaP present in mutton grills cooked over an ember fire were greater than 2 µg/kg, which is the limit value for BaP set by the European Commission. On the other hand, those present in mutton grills cooked over flame fire were lower than this value.

Table 10: Benzo(a)pyrene (BaP) content in mutton grills according to cooking method

Fire intensity	Cooking time	BaP content (µg/kg)	*P*
Ember fire	60 min	5.13 ± 0.35^{a}	< 0.0001
	40 min	2.52 ± 0.33^{b}	
Flame fire	30 min	1.39 ± 0.26^{c}	
	15 min	0.65 ± 0.05^{d}	

IV. DISCUSSION

During the survey, the combustible source used by mutton grill sellers was firewood. The majority of sellers (60%) cooked mutton over an ember fire. The choice of this cooking method is explained by the good cooking it gives to the meat. Indeed, according to Harivola (2019), this cooking method allows meat to be well cooked. Most sellers (60%) kept unsold grills at room temperature in basins or baskets; while 30% used the Refrigerator or cooler. The storage of unsold grills in basins or baskets would be due to the fact that the sellers met believe that it is not necessary to keep cold cooked foods. This result is different from that of Harivola (2019) who, in a study of beef and chicken grills in Madagascar, found that the majority of sellers (56.33%) kept their unsold grills cold (refrigerator or cooler), while 11.26% did not use cold storage.

The hygiene evaluation of mutton grills preparation showed in the majority of sale places: non-compliance with the principle of separating "clean" areas from "dirty" areas; poorly designed premises; poorly maintained equipment; meat improperly stored or exposed to ambient air; inappropriate programs for cleaning premises and equipment. In addition, in these places (86.66%), sellers did not comply with food hygiene rules. All these observations suggest the existence of potential sources (environment, equipment, material, method and workforce) of food contamination. These work conditions could promote the proliferation of microorganisms in sale places and the contamination of mutton grills. These results are consistent with those of Kouassi *et al*., (2012) who claimed that the diversity of microorganisms present in grilled meats is due to non-compliance with hygiene, poor sanitary conditions observed at sale places, frequent unhygienic handling of meat and cross-contamination with soiled materials and packaging.

The results of the microbiological analyzes showed that TMAF was the most widespread germ with the highest proportions of contaminated samples (100 and 93.33%). The average TMAF loads in PMG and UMG were 5.69×10^{6} CFU/g and 2.6×10^{6} CFU/g, respectively. These results are relatively different from those found by Adama (1996) who reported in a study an average TMAF load of 5.2×10^{5} CFU/g in 100 grilled meat samples. This difference would be due to the fact that the sale places visited are insufficiently clean and the mutton grills exposed to the ambient air are contaminated by bacteria. The count showed that the average faecal coliforms loads were 4.09×10^{3} CFU/g and 2.88×10^{3} CFU/g for PMG and UMG, respectively. The comparison of these results with microbiological criteria shows that the samples analyzed do not meet food safety standards. This can be explained by the fact that the mutton grills have been contaminated by faecal coliforms during the improper slaughtering of animals, the transport of meat and by workforce. *S. aureus* concentrations averaged 4.86×10^{3} CFU/g and 1.16×10^{3} CFU/g for PMG and UMG, respectively. The presence of *S. aureus* in the mutton grills could be explained by the hygiene lack of the workforce in the sale places. Indeed, this lack of hygiene is demonstrated by inappropriate movements favoring cross-contamination, the wearing of rings or bracelets during work, undesirable gestures, such as putting fingers in the nostrils, sneezing using the hands, using dirty rags for cleaning hands etc. These results are lower than those of Adama (1996) who found an average *S. aureus* load of 6.15×10^{3} CFU/g in a study on the quality of grilled meats prepared in "Dibiteries" in the Dakar region. The results obtained by the microbiological analyzes showed that *Salmonella spp* was the least widespread germ with the lowest proportions of contaminated samples (13.33 and 8.89%). These results confirm those of Kebede (1986) who also demonstrated the low presence of salmonella in grilled meats. Indeed, this author was able to highlight Salmonella in only one sample out of 100 samples analyzed. This low presence could be explained by the fact that salmonella, being thermosensitive, are destroyed by the heat applied during the preparation of the mutton grills.

Regarding the microbiological quality, the results revealed that the microbiological quality of UMGs was better than that of PMGs which were most prone to microbial contamination. This result could be explained by the fact that PMGs were wrapped in paper which was not free of microbial contaminants. In addition, according to Christian (2007), contamination of grilled meats with microbial germs can be due to other sources such as air, soil, handlers and cutting tools that are not well cleaned. In general, the mutton grills overall quality was unsatisfactory in most cases (66.67%). The unsatisfactory quality of the grills observed could be explained by the lack of hygiene and the poor cooking of the meat in these sale places.

Indeed, Yougbare (2014) claimed that cooking food allows a strong reduction in the microbial load, if the core temperature of the food is high, thus promoting the satisfactory quality of the food. Unsatisfactory quality of mutton grills was largely due to *S. aureus* (53.67%) and faecal coliforms (51.67%). Staphylococci are considered commensal bacteria in humans, often found in the nasal cavity, on the skin, in mucous membranes and in areas with high humidity (Costello *et al*., 2009). Rafalimanana (2008) asserted that a high contamination of food by *S. aureus* can be due to improper cooking of this food and non-compliance with hygiene rules from slaughter, washing, transport, preparation until consumption. The strong contribution of faecal coliforms in the unsatisfactory quality of mutton grills would be due in particular to the presence of *Escherichia coli*. Faecal coliforms are indicators of faecal contamination and considered as hygiene germs. According to Eslava *et al*., (2003), their presence indicates a defect in the slaughtering technique, or cross-contamination, but can also be due to contamination by people handling foodstuffs.

The cooking test showed that the cooking method significantly influenced ($p < 0.01$) the BaP content of mutton grills. In addition, BaP contents (2.52 ± 0.33 and 5.13 ± 0.35 µg/kg) in grilled mutton cooked over an ember fire were above the recommended limit value which is 2 µg/kg (EC n° 835/2011). On the other hand, the values (0.65 ± 0.05 and 1.39 ± 0.26 µg/kg) obtained in mutton grills cooked over flame fire complied with the reference criterion. These results are in agreement with those of Harivola (2019) who, in a study on beef skewers and chicken grills, also found that the amount of BaP formed during cooking over an ember fire was higher compared to that formed when cooking over flame fire. In addition, the high BaP content in mutton grills cooked over an ember fire would be due to the sufficiently long cooking time (40 to 60 min). Indeed, in the same study, the previous author demonstrated that the formation of BaP in grilled meat was not related to the fire intensity, but to the cooking time. However, according to Domingo and Nadal (2016), PAHs concentrations in processed meat are dependent on a number of processing parameters including distance to heat source, combustibles, level of processing and cooking time and methods.

V. CONCLUSION

At the end of this study, the results showed that the majority of mutton grills sellers (60%) cooked the meat over an ember fire for 40 to 60 minutes. Most of the sellers surveyed (60%) kept unsold grills at room temperature in basins or baskets, while 30% used the refrigerator and cooler. In most of the sale places visited (83.33%), the sellers did not comply with the principle of separating “clean” and “dirty” areas. Microbiological analyzes showed that the microbiological quality of unpacked mutton grill was better than that of mutton grill packed in recovery paper, which served as a cement bag. However, the mutton grills overall quality was unsatisfactory in most cases (66.67%). The main microorganisms incriminated in the unsatisfactory quality of mutton grills were *S. aureus* and faecal coliforms. In addition, mutton cooked over an ember fire for 40 to 60 min had a higher BaP content (> 2 µg/kg), while meat cooked over flame fire for less than 30 min had a low BaP content (< 2 µg/kg). Ultimately, in view of the above, the mutton grills sold in Korhogo town would present a risk of food toxi-infection and poisoning for consumers. Therefore, sellers must be made aware and trained on good hygiene practices in order to reduce microbial contamination. They must also reduce the cooking time of meat by preferably using flame fire in order to limit the Benzo (a) pyrene level in mutton grills. To deepen this study, it would be interesting to conduct an investigation on a larger sample taking into account other types of meat (beef, goats, chicken, etc.) and do the BaP assay on samples taken from several grill sellers.

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