Scientific Research Publishing

Food and Nutrition Sciences, 2022, 13, 986-1000
https://www.scirp.org/journal/fns
ISSN Online: 2157-9458
ISSN Print: 2157-944X

# Microbiological Quality of Fresh and Grilled Mutton Sold in Ouagadougou, Burkina Faso

**Zoénabo Douamba[1], Abel Tankoano[2], Donatien Kaboré[1], Diarra Compaore-Sereme[1], Mahamoudou Ouédraogo[3], Pingdwindé Marie Judith Samadoulougou-Kafando[1], Adama Paré[1], Mamadou Hama Dicko[3], Hagrétou Sawadogo/Lingani[1]**

[1]Institut de Recherche en Sciences Appliquées et Technologies (IRSAT)/Centre National de la Recherche Scientifique et Technologique (CNRST), Ouagadougou, Burkina Faso
[2]Institut de Recherche en Sciences Appliquées et Technologies (IRSAT)/Centre National de la Recherche Scientifique et Technologique (CNRST), Bobo-Dioulasso, Burkina Faso
[3]Laboratoire de Biochimie, Biotechnologie, Technologie Alimentaire et Nutrition (LABIOTAN), UFR/SVT, Université Joseph KI-ZERBO, Ouagadougou, Burkina Faso
Email: kaboredonatien74@yahoo.fr

**How to cite this paper:** Douamba, Z., Tankoano, A., Kaboré, D., Compaore-Sereme, D., Ouédraogo, M., Samadoulougou-Kafando, P.M.J., Paré, A., Dicko, M.H. and Sawadogo/Lingani, H. (2022) Microbiological Quality of Fresh and Grilled Mutton Sold in Ouagadougou, Burkina Faso. *Food and Nutrition Sciences*, **13**, 986-1000.
https://doi.org/10.4236/fns.2022.1312069

**Received:** September 22, 2022
**Accepted:** December 27, 2022
**Published:** December 30, 2022



## Abstract

In Ouagadougou, grilled meats in the form of pieces and brochettes are very popular and well-known to consumers. The aim of this study was to assess the microbial quality of mutton meat sold in Ouagadougou, Burkina Faso. A total of 120 samples were collected from 20 meat grillers 60 samples of fresh meat and 60 samples of grilled meat. The sampling was done between the month of August 2018 and the month of February 2019. The samples were analyzed according to standard methods. The test performed were counts of Aerobic Mesophilic Bacteria (AMB), yeasts and molds, enterobacteria, *Campylobacter* spp, *Staphylococcus aureus*, *Bacillus cereus*, *Brucella* spp, *Pseudomonas aeruginosa*, the search for salmonella, and the detection of antibiotics residues. Results showed a high count of AMB (8.77 and 6.78 log UFC/g); enterobacteria (6.58 and 3.05 log UFC/g), *Staphylococcus aureus* (6.45 and 4.35 log UFC/g), *Bacillus cereus* (6.98 and 4.52 log UFC/g), *Campylobacter* (6.03 and 3.86 log UFC/g), yeasts and molds (4.80 and 3.26 log UFC/g) and *Pseudomonas aeruginosa* (0.45 and 0.15 log UFC/g), respectively in fresh meat and grilled meat. Presumptive *Salmonella* was found in 95% of fresh meat samples and in 75% of grilled meat samples. In the tested samples, no *Brucella* spp were detected. However, residues of antibiotics were found in 5% of fresh meat samples and 5% of grilled meat samples. Means of moisture and pH were respectively 74.91% and 6.05% for fresh meat and 53.21% and 6.06% for grilled meat. The average microbial counts recorded in fresh and grilled meat are significantly high and indicate poor hygiene in the raw ma-

terial and ready-to-eat meat. Good practices of hygiene and processing guides should be developed for the meat grilling value chain actors to reduce contamination risks.

## Keywords

Meat, Mutton, Grilling, Microbial Quality

## 1. Introduction

Meat plays an important role in people's diets due to its nutritional richness. It is a valuable source of protein (19 - 23 g/100g), iron (2.2 - 7 mg/100g), vitamin B12 (1 - 5 µg/100g), vitamin B6 (0.3 - 0.5 mg/100g), zinc (3.3 - 6.8 mg/100g), selenium (10 - 12 µg/100g), and phosphorus (250 mg/100g), etc. [1]. Moreover, proteins of animal origin are particularly rich in essential amino acids, especially lysine and histidine, and they provide a balance of essential amino acids close to the needs of humans [2]. Burkina Faso is a Sahelian country with a large livestock population estimated at 7,609,000 head of cattle, 10,589,000 head of sheep and 12,956,000 head of goats [3]. Most of the livestock is exported as live animals with a small part that is processed locally [4]. Slaughtering for meat production is the primary process activity. Secondary processing consists mainly of grilling and drying, and a small part is processed into sausages for the urban market [4]. Due to the lack of adequate processing and/or preservation methods such as refrigeration and freezing, the meat from local processing is mostly obtained under conditions that do not guarantee its quality [5]. However, meat is a very favorable product for microbial proliferation.

In Burkina Faso, grilled meat in the form of pieces and brochettes is particularly appreciated by the population. In the places where meat is grilled, it is manually handled before human consumption. The lack of knowledge of certain hazards and the non-respect of elementary hygiene rules can be the source of microbial contamination and constitute a threat to consumers. In addition, a high microbial load can alter the quality, causing economic losses. A study conducted in 2018 on samples of fresh and grilled beef taken in Ouagadougou revealed high microbial counts [6]. With regards to high microbial counts in these beef samples, further investigation can be extended to other types of meat such as grilled mutton which is highly appreciated by consumers. It is in this context that the current study is undertaken with the aim to contribute to improving the sanitary quality of fresh and grilled mutton sold in Ouagadougou.

## 2. Material and Methods

### 2.1. Sampling

A total of 120 meat samples were collected, including 60 samples of fresh meat and 60 samples of grilled meat. The samples were randomly collected in eight of

the thirteen districts of Ouagadougou city (Table 1). The sampling consisted of aseptically collecting three (03) fresh meat samples and three (03) grilled meat samples from each of the twenty (20) meat grillers selected for the study (Figure 1). The sampling was done between August 2018 and February 2019. The samples were packaged in sterile polyethylene airtight bags and then transported to the laboratory in cooler containing ice packs to avoid temperature variation that could alter the microbial count.

## 2.2. Methods for Microbiological Analysis

The collected samples were tested following ISO 7218 standards [7]. The aerobic mesophilic bacteria (AMB), yeasts and molds, enterobacteria, *Campylobacter* spp, *Staphylococcus aureus*, *Bacillus cereus*, *Brucella* spp, and *Pseudomonas aeruginosa* were counted on samples of fresh and grilled meat. Ten (10) grams of each sample were weighted into sterile stomacher bags with 90 mL of sterile

Table 1. Sampling site and sample count.

| Arrondissements (N = 8) | Sectors (N = 14) | Meat grillers Count (N = 20) | Sample count | |
|---|---|---|---|---|
| | | | Fresh meat (N = 60) | Grilled meat (N = 60) |
| 1 | 2 | 1 | 3 | 3 |
| | 3 | 1 | 3 | 3 |
| 2 | 8 | 2 | 6 | 6 |
| | 9 | 1 | 3 | 3 |
| | 11 | 2 | 6 | 6 |
| 3 | 15 | 2 | 6 | 6 |
| | 16 | 2 | 6 | 6 |
| 4 | 17 | 2 | 6 | 6 |
| 5 | 22 | 2 | 6 | 6 |
| | 23 | 1 | 3 | 3 |
| | 24 | 1 | 3 | 3 |
| 6 | 26 | 1 | 3 | 3 |
| 9 | 35 | 1 | 3 | 3 |
| 10 | 43 | 1 | 3 | 3 |


Figure 1. Fresh meat and grilled meat ((a): fresh meat; (b): meat grilling; (c): grilled meat).

water. The bags were homogenized for 2 min at the normal speed of 230 rpm in the stomacher (Laboratory Blender, Model stomacher 400, London, England). From these homogenized bags dilutions of ten folds were pour plated following standards [8]. The enumeration of the different microorganisms was done following the methods described in **Table 2**. For presumptive salmonella following the standard [9] for (4) main steps were followed: pre-enrichment in buffered peptone water (BPW), enrichment in Rappaport-Vassiliadis Soy (RVS) broth and Muller Kaufman with Tetrathionate novobiochine (MKTTn) medium, isolation on *Salmonella-Shigella* (SS) and Xylose Lysine Desoxycholate (XLD) agar.

#### 2.2.1. Microorganisms Enumeration

Petri dishes containing 4 - 300 colonies for AMB , and 4 - 150 colonies for enterobacteria, *Campylobacter*, *Brucella*, *Staphylococcus aureus*, yeast and mold, *Bacillus cereus* were counted to determine the number (N) of microorganisms present in the sample and expressed in CFU/g following the standard [7]:

$$N = \frac{\sum C}{1.1 \times d \times v}$$

$\sum C$ is the sum of the colonies counted on the 2 retained plates of two successive dilutions;

$v$ is the volume of inoculum applied to each petri dish, in milliliters;

$d$ is the dilution corresponding to the first selected dilution.

#### 2.2.2. Coagulase Production Test for *Staphylococcus aureus*

To confirm *Staplylococcus aureus* count, presumptive *S. aureus* colonies were transferred to test tubes containing 5 mL of Brain Heart Infusion (BHI) broth

**Table 2.** Microorganism growth conditions.

| Parameters | Reference | Culture medium | T˚C/incubation |
|---|---|---|---|
| AMB | [10] | PCA (Plate Count Agar) | 30˚C/48 - 72h |
| Enterobacteria | [11] | EMB (Eosin Methylene Blue) | 37˚C/24h |
| Yeast and mold | [12] | Sabouraud Chloramphenicol Agar | 25˚C/120h |
| *S. aureus* | [13] | Mannitol Salt Agar | 37˚C/48h |
| *P. aeruginosa* | [14] | Cetrimide Agar | 42˚C/24h |
| *Campylobacter* spp | [15] | *Campylobacter* Agar | 42˚C/24 - 72h |
| *B. cereus* | [16] | Brain Heart Infusion Agar | 30˚C/18 - 48h |
| *Brucella* spp | [17] | *Brucella* Agar | 37˚C/24 - 72h |
| *Salmonella* spp | [9] | BPW | 37˚C/18h |
| | | RVS | 41˚C/24h |
| | | MKTTn | 37˚C/24h |
| | | SS Agar | 37˚C/24h |
| | | XLD Agar | 37˚C/24h |

and incubated for 24 hours at 37˚C. After incubation, 0.5 mL of the new culture was added to 0.5 mL of disinfected rabbit plasma in hemolysis tubes and incubated at 37˚C. The tubes were then checked after 1 h-2 h-3 h-4 h-8 h-24 h to determine clot formation which is the evidence of coagulase activity [18].

### 2.3. Detection of Antibiotics Residues

The presence of antibiotic residues was detected in the different meat samples according to the method based on the growth inhibition reaction of tests bacteria [19]. *Bacillus subtilis* est sentitive to antibiotics of aminosids family, des quinolons and macrolids; *Geobacillus stearothermophilus* is sensitive to beta-lactamins, sulfamids and tetracyclins. For this purpose, reference strains of *Geobacillus stearothermophilus* ATCC 10149 and *Bacillus subtilus* ATCC 6633 were each enriched in Mueller Hinton broth (MH) (Liofilchem, Italie) and incubated respectiveley at 55˚C and 30˚C. After 24 h of incubation, 0.1 mL of *G. stearothermophilus* and *B. subtilis* suspensions were plated on MH agar and incubated at 55˚C and 30˚C respectively for 24 h. Suspensions of the strains were prepared by homogenizing the well-distinct pure colonies in physiological water (NaCl 9 g/L water) and then adjusted to optical density 0.08 - 0.1 using a spectrophotometer at 625 nm (equivalent to McFarland standard 0.5). The resulting suspensions were plated on MH agar. The fresh and grilled meat samples were ground and heated at 80˚C for 5 - 10 minutes to inactivate the lyzozyme and destroy probable germs. Sterile wattman paper discs of 6.13 mm diameter were impregnated and placed on the previously inoculated Petri dishes. The plates were incubated at 55˚C and 30˚C for *G. stearothermophilus* and *B. subtilis*, respectively. After 24 h of incubation, the clear areas around the discs of each positive sample were measured with an electronic caliper. The analyzed sample is considered positive if the radius of the inhibition zone is greater than or equal to 2 mm.

### 2.4. Interpretation Criteria of the Microbial Load According to Microbiological Standards

The Results were interpreted following standards presented **Table 3**. This interpretation was done according to a 3-class plan for AMB, enterobacteria, yeasts and molds, *Staphylococcus aureus*, *Pseudomonas aeruginosa*, *Brucella* spp. and *Bacillus cereus*. Thus, a sample is said to be:

- satisfactory (S): if the determined values are less than m;
- acceptable (A): if the determined values are between m and M;
- unsatisfactory (NS): if values above M are observed.

A 2 two-class plan was used for the interpretation of *Salmonella* and antibiotic residue results. A sample is considered satisfactory if there is an absence and not satisfactory if there is the presence of *Salmonella* in 25 g of the sample. It is also considered satisfactory if there is no antibiotic residue in 5 g of the sample and unsatisfactory if it is present.

**Table 3.** Results interpretation criteria.

| Microorganisms | Product quantity (g) | Nature | m | M | References |
|---|---|---|---|---|---|
| Aerobic Mesophilic Bacteria | 10 | Fresh | $10^6$ | $10^7$ | [20] |
| | | Grilled | $3 \times 10^4$ | $3 \times 10^5$ | [21] |
| *Enterobacteria* | 10 | Fresh | $10^4$ | $10^5$ | [21] |
| | | Grilled | $10^3$ | $10^4$ | |
| Yeast and molds | 10 | Fresh | $10^4$ | $10^5$ | [20] |
| | | Grilled | $10^3$ | $10^4$ | [21] |
| *Staphylococcus aureus* | 10 | Fresh | $5 \times 10^2$ | $5 \times 10^3$ | [20] |
| | | Grilled | $10^2$ | $10^3$ | |
| *Pseudomonas aeruginosa* | 10 | Fresh | $10^5$ | $10^6$ | [21] |
| | | Grilled | $10^2$ | $10^3$ | |
| *Bacillus cereus* | 10 | Fresh | $10^3$ | $10^4$ | [20] |
| | | Fresh | $10^3$ | $10^4$ | [21] |
| *Campylobacter spp* | 10 | Fresh | $10^3$ | | [22] |
| | | Grilled | $10^2$ | | [23] |
| *Salmonella spp* | 25 | Fresh | Absence | Presence | [21] |
| | | Grilled | | | |

m: acceptable log CFU/g microorganism concentrations, M: unacceptable log CFU/g microorganism concentrations.

### 2.5. Physico-Chemical Analysis (pH and Water Content)

The physicochemical analyses including pH and water content were performed on fresh and grilled meats. The pH was measured at 25˚C using a pH meter (CONSORT P901). Moisture content was determined by weighing the sample before and after oven drying according to the international standard [24].

### 2.6. Data Analysis

Moisture content and pH were expressed as mean values for three measures ± the standard deviation. These results and microbiological data collected were processed with Excel spreadsheet and XLSTAT Pro 7.5.2 statistical software (for comparison of means). The means of the variables were compared using the Newman-Keuls test at the probability threshold of p = 5%.

## 3. Results

### 3.1. Water Content and pH

The pH of fresh meat varies from 5.95 to 6.14 with an average of 6.04. The pH of the grilled meat varies between 5.2 and 6.9 with an average of 6.05. The two types of meat do not differ in this parameter (p = 0.8683). As for the water content, it varies from 73.35% to 76.47% with an average of 74.91% for the fresh

meat samples against a variation of 32.02 to 74.91 ($p < 0.001$) with an average of 53.21 for the grilled meat samples.

### 3.2. Microorganisms Isolated from Fresh and Grilled Meats

Aerobic Mesophilic bacteria, enterobacteria, *B. cereus*, *S. aureus*, *Campylobacter spp* and *P. aeruginosa* counts varies according to the nature of meat. The values of these germs are higher in fresh meat than in grilled meat. Both types of meat have the same count of yeasts and molds ($p = 0.061$) and *Brucella* (absence). The results of the microorganism count of the fresh and grilled meat samples are reported in Table 4. *Samonella* were detected in 95% of fresh meat samples against 75 of grilled meat samples. Antibiotic residues were also detected in 5% of fresh meat samples and in 5% of grilled meat samples.

### 3.3. Assessment of Fresh and Grilled Meats Quality

The assessment of the results at the thresholds accepted by the microbiological criteria is shown in Figure 2 and Figure 3. High AMB count was responsible for the rejection of 70% of fresh meat samples compared to the 56.67% of grilled meat samples. Similarly, 71.67% of the fresh meat samples had a *S. aureus* load above the threshold compared to 50% of the grilled meat samples. Rejection rates of 95% of fresh meat samples and 75% of grilled meat samples were related to *Salmonella* spp. contamination. Enterobacteria and *Campylobacter* contributed more to the rejection of fresh meat samples than grilled meat samples. Taking into account all the parameters of the study, 91.66% of the fresh and grilled meat samples were not suitable for human consumption.

## 4. Discussion

The water content of fresh meat samples presented a small variation with an

Table 4. Microbial count of fresh and grilled meats (log CFU/g).

| Microbiological parameters | Products | | P-value |
|---|---|---|---|
| | Fresh meat (n = 60) | Grilled meat (n = 60) | |
| AMB | 8.77[a] | 6.78[b] | 0.012 |
| Enterobacteria | 6.58[a] | 3.05[b] | 0.028 |
| Yeast and Mold | 4.80[a] | 3.26[a] | 0.061 |
| *Bacillus cereus* | 6.98[a] | 4.52[b] | 0.018 |
| *Staphylococcus aureus* | 6.45[a] | 4.35[b] | 0.001 |
| *Campylobacter spp* | 6.03[a] | 3.86[b] | 0.018 |
| *Pseudomonas aeruginosa* | 0.45[a] | 0.15[b] | 0.006 |
| *Brucella spp* | <1 | <1 | |

Different letters "a, b" on the same line indicate a significant difference for the considered parameter ($p < 0.05$). The letter n represents the total of tested samples.

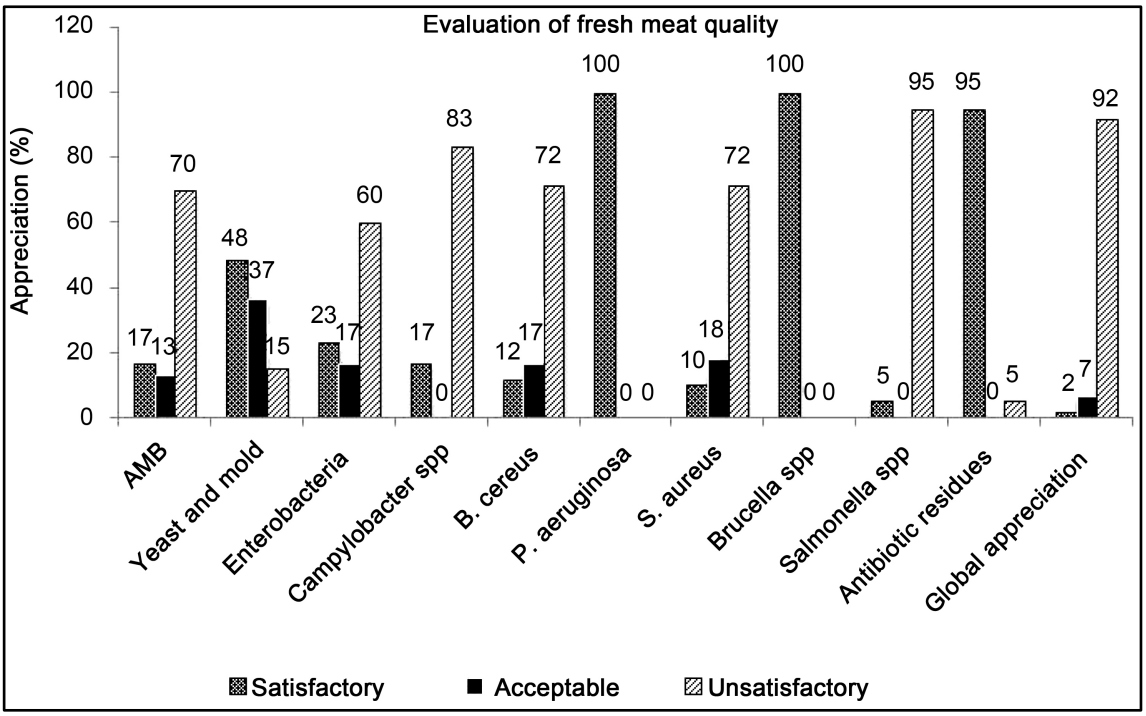


**Figure 2.** Assessment of fresh meat quality according to microbiological interpretation criteria.

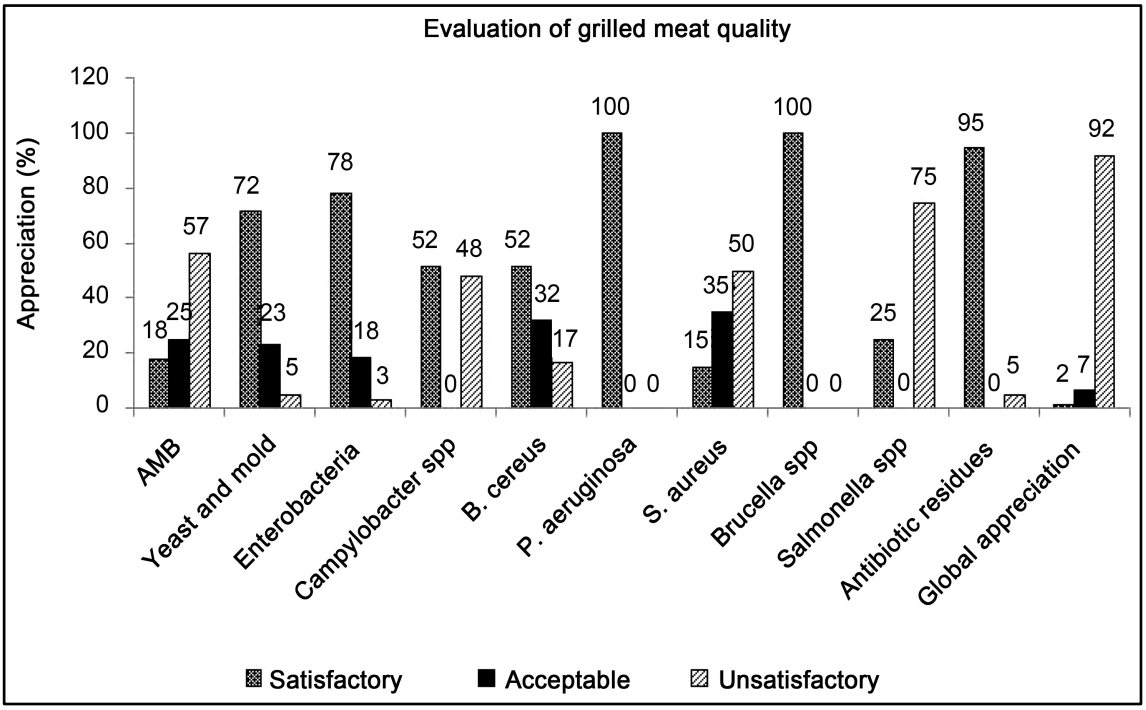


**Figure 3.** Assessment of the quality of grilled meat according to microbiological interpretation criteria.

average content of 74.91%. This content is comparable to the water content of beef, which varies between 65% and 75% [25]. These high water contents promote bacterial growth and limit meat preservation. The lowest contents with the tested samples were obtained with the samples of grilled meat which varied from

32.02% to 74.40% ($p < 0.001$). The high variability in the water content of grilled meat samples is believed to be due to each griller's specific grilling method and the addition of seasonings during grilling. The amounts and consistencies of the seasonings were different from one griller to another.

Ten percent (10%) have pH values between 5.5 and 5.7 considered a "ultimate pH" of the meats. The pH is a chemical parameter that influences the preservation capacity of the meat and its organoleptic quality [26]. Low pH values are known to have a bacteriostatic action that regulates the microbial balance, thus contributing to the preservation of the meat. A high pH (above 5.8) in meat favors the development of microorganisms that could alter the taste, smell and color of the meat, but also favor the growth of pathogenic microorganisms. These "altered" meats will not be suitable for fresh storage. The pH of the meat is also a determining factor for its juiciness; a meat with a low pH tends to lose its water and therefore to be dry whereas a meat with a high pH will have a very good water retention and will present a good juiciness [27].

The microbial load of grilled meat is lower than that of fresh meat. The average AMB count of fresh mutton samples was 8.77 log CFU/g versus 6.78 log CFU/g for grilled meat samples. Seventy percent (70%) of the fresh meat samples and 56.67% of the grilled meat samples had an AMB count superior to the accepted thresholds [20] [21]. These results confirm the high AMB count obtained from samples of fresh and grilled beef sold in Ouagadougou [6] (9.23 log CFU/g and 6.66 log CFU/g) as well as those obtained in samples of raw and grilled small ruminant meat from slaughterhouses and meat grillers at Dakar, Senegal, which were 6.83 log CFU/g and 7.85 log CFU/g respectively [28]. Lower loads (5.33 log CFU/g) were obtained by [29] from N'Djamena grilled meat samples. Fresh meat high microbial load in AMB could be explained by a lack of hygiene in the production and preservation processes of meat [30]. In facts, according to [31], poor hygiene practices in the slaughtering, storage and preservation process, as well as cross-contamination, are practices that strongly influence meat quality among many meat grillers and brochettes grillers in Ouagadougou. The same tools (cutting table, knives) are used for the finished products (grilled meat) and the raw material (fresh meat). Also, this contamination could be related to transport conditions that constitute a factor of contamination of these types of products. Investigations in Ouagadougou showed that meat marketed in the streets of often transported from slaughterhouses to grilling points on two-wheeled vehicles without adequate protection [31].

Enterobacteria had an average load of 6.58 log CFU/g in fresh meat and 3.05 log CFU/g in grilled meat samples. According to the microbiological criteria on the presence of enterobacteria in fresh and cooked meat [21], 23.33% of the fresh meat samples were of satisfactory quality, 16.67% of acceptable quality and 60.0% of unsatisfactory quality. For grilled meat samples, 78.34% were of satisfactory quality, 18.33% of acceptable quality and 3.33% of unsatisfactory quality. Results indicating similar enterobacteria loads were obtained in Ouagadougou

by [6] with 6.86 log CFU/g and 2.05 log CFU/g in fresh and grilled beef respectively. Enterobacteria are control germs and indicate a lack of hygiene. Their presence in meat is indicative of direct or indirect fecal contamination due to poor hygienic practices during slaughter, sale, transport or preparation [30].

*Bacillus cereus* averaged 6.98 log CFU/g in fresh meat samples and 4.52 log CFU/g in grilled meat samples. According to the standards for raw and cooked beef and sheep meat [20]), 11.66% of the fresh meat samples quality were satisfactory; 16.67% were acceptable and 71.67% have *B cereus* loads exceeded the infecting or toxigenic dose which is 5 log CFU/g. About grilled meat, 51.67% of the samples were satisfactory; 31.67% acceptable and 16.66% have a *B cereus* count higher than the infecting or toxigenic dose. Similar *B cereus* counts were observed in fresh meat samples (6.61 log CFU/g) and in grilled beef (4.42 log CFU/g) in Ouagadougou [6]. *B. cereus* can be considered as indicators of a telluric or environmental contamination not controlled by technological treatments. Indeed, this contamination could be due to the presence of *B. cereus* as spores in the soil and the presence of these spores in the digestive tract of warm-blooded animals. *B. cereus* spores have a strong ability to stick to stainless steel surfaces and pile up in processing equipment, which can then become reservoirs of spores. The lack of fencing at the meat grilling sales places could explain dust contamination of the handled meat. Also, given the nature of the grilling material (very often iron and rarely steel), it could allow spores to adhere and contaminate the meat after grilling. The presence of *B. cereus* in the grilled meat could also be explained by these two main reasons: keeping the meat at ambient temperatures that allows the growth of *B. cereus* (temperatures between 4˚C and 55˚C), delayed transformation of the fresh meat, the non-respect of the cold chain and or a cross-contamination.

The average coagulase-positive *Staphylococcus aureus* count was 6.45 log CFU/g in fresh meat samples and 4.35 log CFU/g in grilled meat samples. According to the criteria [20] on the presence of coagulase positive *S. aureus* in fresh and cooked meat, 71.67% of the fresh meat samples are of unsatisfactory quality with 53.33% of the samples with counts of coagulase positive *S. aureus* exceeding the infecting or toxigenic dose of $10^5$ CFU/g. As for grilled meat, 50% of the samples are of unsatisfactory quality with 6.67% of the samples with loads exceeding the infecting or toxigenic dose. [6] found similar loads in fresh (6.36 log CFU/g) and grilled beef (4.42 log CFU/g) with 100% of unsatisfactory samples in fresh meat and 85% of unsatisfactory grilled meat samples. In Benin, [32] found 4.38 log CFU/g *S. aureus* in samples of grilled mutton meat. [28] obtained lower loads in meat samples collected from slaughterhouses and slaughter areas (1.53 log CFU/g) and in samples of grilled meat (0.43 log CFU/g) in Senegal. *S. aureus* grows at temperatures above 7˚C and its development on raw products is limited by competition with other bacteria [20]. The high number of staphylococci in the tested samples may be related to the non-respect of the cold chain or to a human post-contamination during handling [33]. In addition, the misuse of

antibiotics could be a source of health problems for consumers even when microorganism's counts are relatively low. Indeed, investigations on the microbiological quality of brochettes sold in Ouagadougou revealed that 91.67% of *S. aureus* strains were resistant to ceftazidime and aztre [34].

The average *Pseudomonas aeruginosa* count is 0.45 log CFU/g in fresh meat samples and 0.15 log CFU/g in grilled meat samples. All fresh and grilled meat samples were of satisfactory quality according to the criteria for *P. aeruginosa* in raw and cooked meat, which are 6 log CFU/g and 3 log CFU/g respectively [21]. For *P. aeruginosa* count [6] obtained samples of fresh and grilled beef of satisfactory quality in Ouagadougou while Somda *et al*. (2021) found counts of 10 to 25 CFU/g of grilled brochettes sold in Ouagadougou. *Pseudomonas* are the main psychrotrophic bacteria found in meats and are responsible for spoilage. Their presence at the level of the slaughter lines and in particular in the cold rooms constitutes a source of contamination of meats. *Pseudomonas* is mainly used as an indicator of spoilage in fresh meat and milk [30]. The low presence of *Pseudomonas* in the samples would reflect the freshness of the meat. These microorganisms are also very sensitive to heat and their low counts in fresh meat ensures of the efficiency of heat treatments during grilling.

Yeasts and molds averaged 4.80 log CFU/g in the fresh meat samples and 3.26 log CFU/g in the grilled meat samples. According to the standards applicable to raw and cooked beef and mutton meat [20] for Yeast and molds, 85% of fresh meat samples were of satisfactory quality compared to 95% of grilled meat samples. Lower yeast and mold counts were obtained in fresh (3.42 log CFU/g) and grilled (0.97 log CFU/g) [6]. Yeasts and molds are widely distributed in the environment. When they proliferate in food, they can cause product spoilage and significant economic losses [30].

The average number of *Campylobacter* spp. in fresh and grilled meat samples was 6.03 log CFU/g and 3.86 log CFU/g, respectively. According to the food acceptance criteria for the presence of *Campylobacter* [22]; ANSES, 2021), 16.67% of fresh meat samples were of satisfactory quality compared to 51.67% of grilled meat samples. Similar counts were obtained in fresh (5.02 log CFU/g) and grilled (2.32 log CFU/g) beef samples for *Campylobacter* spp [6]. *Campylobacter* are bacteria found in the digestive tract of mainly poultry and beef animals (pigs, cattle, sheep) [33]. *Campylobacter* are micro-aerophilic, heat-sensitive bacteria that rarely multiply in food. Their presence in these samples would be due to the non-respect of good slaughtering practices, to a lack of hygiene in the preparation of meat or to a cross-contamination. According to [35], *Campylobacter* infection symptoms are similar to those of salmonellosis including profuse, watery or slimy diarrhea, sometimes containing blood, associated with abdominal pain, vomiting, nausea and headache. The presence of Campylobacter mainly in grilled meats could therefore constitute a risk for consumers.

Presumptive *Salmonella* spp were found in 95% of the fresh meat samples and 75% of the grilled meat samples. [6] detected *Salmonella* in all samples of raw

and grilled beef sold in Ouagadougou. Lower counts were observed in raw meat samples (6.6%) collected from three university restaurants in Ouagadougou [36] and in samples collected in butcheries (7.5%) in Ethiopia [37]. [38] reported the absence of *Salmonella* in bovine carcass samples from Ouagadougou slaughterhouse. The high prevalence of *Salmonella* in the sample tested in this study could be due to either poor hygiene and sanitation practices throughout the meat supply value chain. Salmonella infections continue to be a major public health problem in Burkina Faso and the presence of *Salmonella* therefore constitutes a potential risk to consumers.

No *Brucella* spp. strains were detected in the fresh and grilled meat samples. All samples therefore met the microbiological standards for *Brucella* in the meat samples in this study. These results corroborate those of [6] and confirm the low prevalence of *Brucella* in meat in sold in Ouagadougou.

Antibiotic residues were detected in 5% of fresh meat samples and 5% of grilled meat samples. These results are lower compared to a similar study by [39] that found antibiotic residues in 31% samples of beef meat samples in Ouagadougou. The result in this study could be explained by the positive impact of sensitizations on the presence of antibiotic residues to the actors of the animal production chain.

Microbiological analysis showed that fresh meat is more contaminated than grilled meat ($p < 0.05$). Grilling is a cooking technique that significantly decreased the microbial count of grilled meat. However, according to the microbiological criteria for meat, 1.67% (1/60) of the fresh meat samples and 1.67% (1/60) of the grilled meat samples were of satisfactory quality compared to 6.67% of acceptable quality and 91.66% of poor quality. The high microbiological contamination of meat in this study is believed to be due to poor hygienic and sanitary practices across the meat supply value chains, including unhygienic carcass transport, unhygienic handling, equipment and personnel for grilling meat, and poor cooking of grilled meat.

This study has some limitations such as the sample size and lack of confirmation of suspected Salmonella. However, the sampling was done in eight of the thirteen districts of Ouagadougou city and the majority of the samples are of unsuitable quality for consumption on several counted microorganisms.

## 5. Conclusion

The study found that fresh mutton was more contaminated than grilled meat and exceeded acceptable microbiological standards. In addition, the use of heat reduced the microbial count in meats. However, the presence of pathogenic microorganisms in the grilled meat indicates that the samples are unsatisfactory in terms of food hygiene. These germs could be a source of toxi-infection and therefore a source of public health problems. It would therefore be essential to raise awareness among actors in the meat value chain on the risks of consuming contaminated meat and to provide them with adequate training on good hygiene

practices and meat processing. Finally, rigorous and regular sanitary control must be set up to ensure compliance with these hygiene measures.

## Acknowledgements

The authors would like to thank the WAAPP-FCN-viande project.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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