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Microbiological Quality Assessment of Mutton in the Saaba District in Ouagadougou, Burkina Faso

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Abstract

Introduction: This study was carried out to assess the quality of sheep meat sold to consumers in Saaba municipality. **Methods:** A preliminary survey consisted of assessing hygiene and sampling meat in butchers' stores. To achieve this, 100 sales outlets were surveyed for their hygiene conditions. 25 mutton meat samples were sampled in the three villages in Saaba district and analyzed using conventional microbiological techniques. The analysis consisted of determining the microbiological characteristics. **Results:** According to the results of this study, 100% of the butchers surveyed were men of the region. Among these men, 13% had secondary education, 46% had primary education and 41% were illiterate. Of the 100 retail outlets visited, 96% of the sellers were unaware of the hygiene rules and the dangers of microorganisms. The microbiological analysis of the samples revealed that 100% of the meat was of unsatisfactory microbiological quality. The average contamination rate by total aerobic mesophilic flora, total coliforms, *Staphylococcus aureus* and yeasts and molds was 8.93×10^6, 3.12×10^5, 3.69×10^6, and 6.74×10^3 CFU/g respectively. No *Salmonella* strain was detected in any of the samples analyzed. **Conclusion:** Our results pointed out the unsatisfactory safety quality of the sheep meat sold in the sheep meat and good hygiene practices.

Keywords

Sheep Meat, Microbiological Analyses, Ouagadougou, Fecal Coliforms,

Mesophilic Flora

1. Introduction

Burkina Faso is a Sahelian country in which the main activities are agriculture and livestock farming. Livestock is the country's third-largest export, after gold and cotton. It contributes almost 18% to the national gross domestic product (GDP), with a population of livestock estimated at 9,091,000 head in 2014, according to data from the livestock statistics yearbook [1].

Meat consumption is high and was estimated to be around 25,468 tonnes in 2010 and 30,137 tonnes in 2014 [2]. Meat contains large quantities of high-quality proteins, which, in their amino acid composition, meet the needs of the human body. The protein content of fresh meat is approximately 20 g per 100 g of meat [3]. In addition, proteins of animal origin are mainly rich in essential amino acids, particularly lysine and histidine, and have a balance of essential amino acids close to human requirements. Due to its exceptional nutritional qualities, meat is also a highly favorable environment for microbial proliferation, as microorganisms find the nutrients they need to thrive. Meat is a highly perishable foodtuff whose hygienic quality depends, on contamination during slaughter and cutting as well as the development and growth of contaminating flora during cooling, storage, and distribution [4] [5]. The slaughterhouse is one of the major critical points for meat hygiene and is considered the stage with the greatest risks [4] [6]-[9].

According to Jouve [10], 80% - 90% of the microflora in meat that reaches consumers is the result of contamination at the slaughterhouse. The way in which mutton meat is transported to sales outlets and the conditions under which it is kept once in butchers' shops or sales outlets in Burkina Faso raise suspicions that the meat leaving slaughterhouses may be recontaminated, raises doubts about the health quality of these products. Despite this situation, there is no data on the hygienic quality of the meat sold in most informal butchers' shops in rural districts of Ouagadougou. This study, which aims to assess the microbiological quality of the mutton meat sold in the Saaba district of Ouagadougou in Burkina Faso, a meat that is greatly appreciated by the local population, was started to determine hygienic quality of this foodtuff.

2. Methods

2.1. Study Site

The study was carried out in the Saaba district in Burkina Faso from August 1, to October 31, 2023. Saaba is one of six rural municipalities of Ouagadougou. It is located in the north east of Kadiogo province. It is bounded by the parallel 12˚2'37" north latitude and the meridians 1˚25'15" west longitude.

Sheep meat sales sites were assessed in the Saaba municipality. The samples were located in three villages: Borgo, Nioko 1, and Wamtenga (Dapoya) (**Figure 1**).

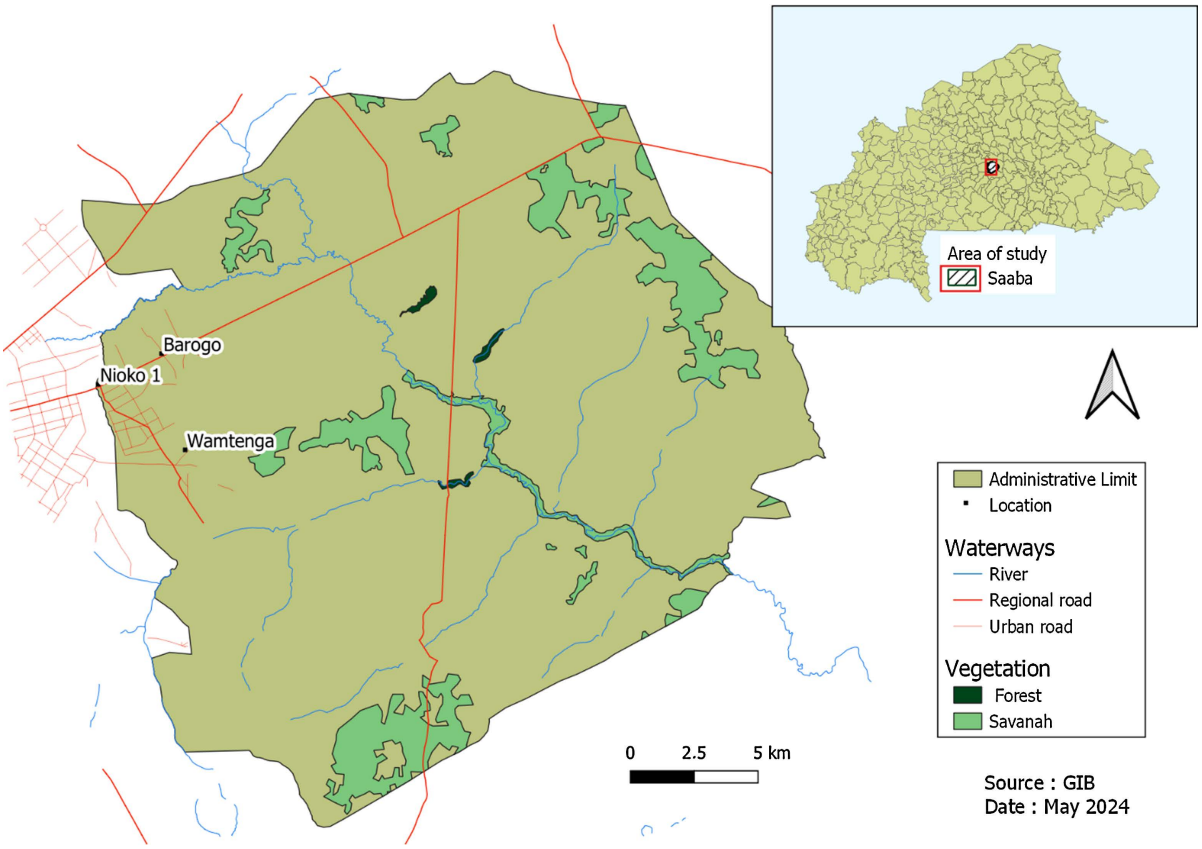


Figure 1. Map showing the Saaba location of the commune and the villages surveyed (BNDT, 2014).

Microbiological analyzes were carried out at the Laboratory of the "Ecole Nationale de l'Elevage et de la Santé Animale (ENESA)" in the Food Microbiology Section in Ouagadougou.

2.2. Survey

A survey was carried out among 100 meat sellers in Saaba, which were selected according to a randomized process. During this survey, a standardized questionnaire was administered. It included an interview with sellers and a visual observation of the cleanliness of the butchers. The parameters considered during the survey were: preservation methods, species marketed, meat sellers' knowledge of good hygiene practices, premises hygiene, equipment hygiene, and staff hygiene and the working conditions of this staff.

2.3. Sampling Method

A two-stage random sampling method was used. The first stage involved the identification of the sales outlets, while the second involved the actual sampling of the meat. Due to the absence of an exhaustive list of meat sales outlets in the study area, the procedure adopted was first a preliminary survey consisting of an assessment of hygiene and the sampling of meat in butcher shops. This survey allowed us to identify a total of 100 butchers in the district who met the criteria based on

the regularity of their slaughterings and their willingness to participate in the study. The study involved 25 samples of sheep meat sampled from 25 butchers in three villages in the municipality of Saaba (Borgo, 10 samples; Nioko 1, 10 samples, and Wemtenga, 05 samples). All parts of the carcass were sampled. Once the meat had been sampled, they were placed in sterile ziplock bags, kept in a cooler containing carbohydrate ice, and finally sent to the laboratory (ENESA) for microbiological analysis.

2.4. Microbiological Analysis Method

The meat samples were analyzed immediately after collection and arrival at the laboratory. Stock suspension was obtained by weighing 10 g of sample in a sterile stomacher bag and adding 90 g of sterile peptone water. The whole mixture was stomached for 2 minutes, followed by serial decimal dilutions. The mass inoculation method was used for inoculation. The groups of microorganisms tested were: total aerobic mesophilic flora (TAMF), total coliforms (TCB), thermotolerant coliforms (TTCB), presumed pathogenic *Staphylococci* (PPS), yeasts and molds (Y/M) and *Salmonella*. Parameters analyzed, culture media used, and the incubation conditions are as indicated in Table 1.

Table 1. Culture media, analysis methods, and incubation conditions according to microbiological parameters.

Microbiological parameters	Media	Incubation temperature/duration	Method References
TAMF	PCA	30˚C/48 - 72 hours	ISO 4833-2:2013(F)
TCB	EMB	37˚C/24 hours	ISO 4832:2006(F)
TTCB	VRBL	44˚C/24 hours	NFV08-060(2009)
Yeasts and moulds	Sabouraud + Chlramphenicol	25˚C/72 - 96 hours	NF ISO 7954
PPS	Baird-Parker	37˚C, 24 hours	ISO 6888-1:2021(F)
Salmonella	EPT	37˚C/24 hours	ISO 6579-1:2017(F)
	RVS	41.5˚C/24 hours	
	MKTTn	37˚C/24 hours	
	XLD	37˚C/24 hours	
	SS	37˚C/24 hours	

2.5. Method for Interpreting the Results

The results were interpreted according to a 3-class plan for TAMF, TTCB, PPS, and yeast and molds, taking into account the criteria. A sample was considered satisfactory microbiological quality (SMQ) if the flora (F) was less than or equal to m; acceptable microbiological quality (AMQ) if F was between m and 10 m, and unsatisfactory microbiological quality (USQ) if F was greater than 10 m; m being the numerical value representing satisfactory concentrations of microorganisms

per gram of meat (Table 2).

Table 2. Average values of microbiological parameters in raw meat.

Microbiological parameters	Average flora (m UFC/g)	Contamination level		
		Satisfactory	Acceptable	Unsatisfactory
TAMF	8.93×10^6	$F < 5 \times 10^6$	$5.10^6 < F < 5 \times 10^7$	$F > 5.10^7$
TCB	3.12×10^5	$F < 10^2$	$10^2 < F < 10^3$	$F > 10^3$
TTCB	3.12×10^5	$F < 10^2$	$10^2 < F < 10^3$	$F > 10^3$
Yeasts and moulds	6.74×10^3	$F < 10^5$	$10^5 < F < 10^6$	$F < 10^6$
PPS	3.69×10^6	$F < 10^3$	$10^3 < F < 10^4$	$F > 10^4$
Salmonella/25 g	0	Absence	-	Presence

Legend: TAMF: Total Aerobic Mesophilic Flora; TCB: Total Coliform Bacteria; TTCB: Thermotolerant coliform bacteria; PPS: Presumed Pathogenic *Staphylococci.*

For *Salmonella*, the interpretation was based on a two-class plan. The presence of *Salmonella* indicated that the sample was QMNS. The sample was QMS if they were absent.

2.6. Statistical Analysis

Data were entered using Epidata® software and processed using Epidata Analysis® software. Interest variables, coded as presence/absence, were the presence of the microorganisms investigated. Excel version 2016 was used to draw tables and figures.

Version 4.4.1 of R was used to determine the principal component analysis and draw figures. Fisher's exact test with Chi-square tests was used to evaluate significant differences with 95% as the confidence interval between microorganism contamination.

3. Results

3.1. Surveys

For the survey results, 100% of our respondents were men from all over the city. Of these men, 13% had attended secondary school, 46% had attended primary school, and 41% were illiterate. Of the total, only 7% received hygiene training, compared to 93% who were not trained. As for the premises, 1/4 or 25 premises comply with hygiene standards. This gives us a total of 96% of our respondents who have not received hygiene training. The meat commonly sold in these butchers' shops in Saaba is either beef or sheep. Some other categories of meat are not commonly available and can only be ordered as, for example, donkey and horse meat.

3.2. Microbiological Analysis

Samples, stock suspension, and serial decimal dilutions were prepared according to the instructions in international standard ISO 6887-1 (1997). Samples were

analyzed immediately after collection. The stock suspension was obtained by weighing 10 g of sample in a sterile stomacher bag, topped up to 100 g with sterile peptone water. The entire mixture was stomached for 2 minutes, followed by a series of successive decimal dilutions. The mass inoculation method was used for inoculation. The parameters analyzed, the culture medium used, and the incubation conditions are indicated in Table 1.

3.2.1. Total Aerobic Mesophilic Flora (TAMF)

One hundred percent (100%) of the raw sheep were of unsatisfactory quality for TAMF, with an average of 8.93×10^6 microorganisms per gram (Table 2 and Table 3).

3.2.2. Total Coliform Bacteria (TCB)

The average contamination of the products by TCB was 3.12×10^5 microorganisms per gram of the product for raw sheep with a 100% unsatisfactory quality of 100% (Table 2 and Table 3).

3.2.3. Thermotolerant Coliform Bacteria (TTCB)

The average contamination of the products by TLC was 3.12×10^5 microorganisms per gram of product for raw sheep with a 100% unsatisfactory quality of 100% (Table 2 and Table 3).

Table 3. Percentage (%) of satisfactory, acceptable, and unsatisfactory quality of the raw meat sample.

Microbiological parameters	Raw meat		
	Satisfactory	Acceptable	Unsatisfactory
TAMF	0	0	100
TCB	0	0	100
TTCB	0	0	100
Yeasts and moulds	100	100	0
PPS	0	0	100
Salmonella	100	100	0

Legend: TAMF: Total Aerobic Mesophilic Flora; TCB: Total Coliform Bacteria; TTCB: Thermotolerant Coliform Bacteria; PPS: Presumed Pathogenic *Staphylococci*.

3.2.4. Presumed Pathogenic *Staphylococci* (PPS)

The average contamination of the products by presumed pathogenic *staphylococci* was 3.69×10^6 microorganisms per gram for raw sheep, with a percentage of unsatisfactory quality of 100% (Table 2 and Table 3).

3.2.5. Yeasts and Molds

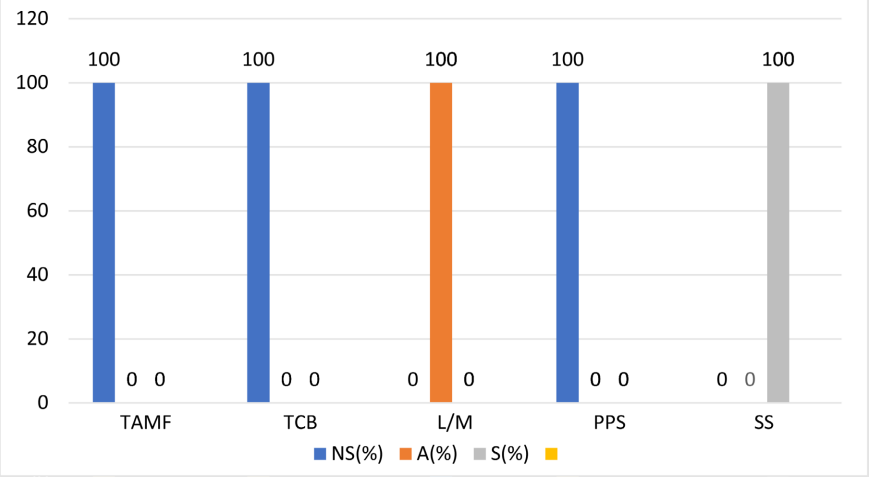
The average contamination of the products by yeast and molds was 6.74×10^3 CFU microorganisms per gram for raw sheep with a 100% satisfactory quality (Table 2 and Table 3).

3.2.6. *Salmonella*

The average *Salmonella* contamination of the products was 0 microorganisms per gram for the raw sheep with a satisfactory quality of 100% (Table 2 and Table 3).

3.2.7. Microbiological Quality of Raw Meat According to Microorganisms

One hundred percent (100%) of the raw meat analyzed was of unsatisfactory microbiological quality for all parameters studied (Figure 2).



Legend: S: Satisfactory; A: Acceptable; NS: Non Satisfactory; TAMF: Total Aerobic Mesophilic Flora; TCB: (Total Coliform Bacteria); L/M: Levures/Moisissures((Yeast/Molds); PPS: Presumed Pathogenic *Staphylococci*; SS: Stock Solution.

Figure 2. Level of microbial contamination of products by different microorganisms.

3.2.8. Characteristics of Microorganisms from the 3 Locations

The principal component analysis (PCA) showed that the microorganisms isolated from meat taken from the 3 localities (Borgo, Nioko 1 and Wentenga) (Figure 3) have similar characteristics, *i.e.* the microbiological concentrations of meat from the 3 localities are not very different.

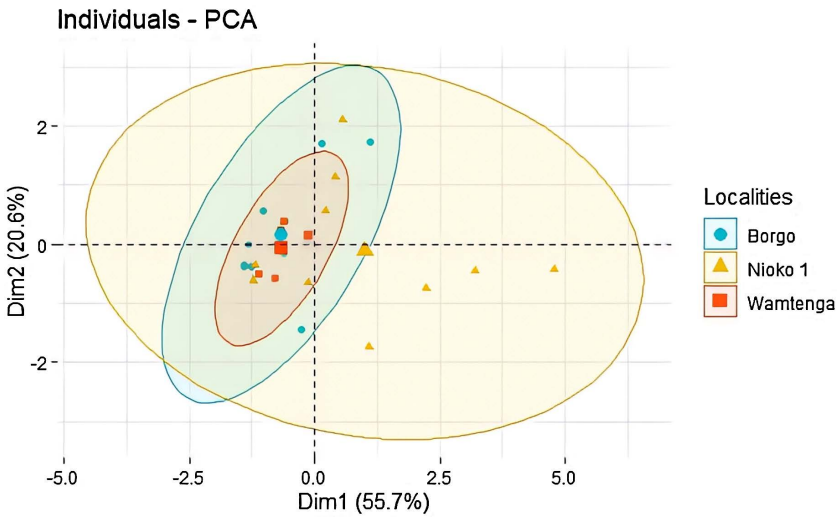


Figure 3. Visualization of sampling locations according to their microbial characteristics.

ANOVA analysis (Fisher (LSD)) of the differences between the modalities with a 95% confidence interval showed that there was a statistically significant difference between TAMF, TCB isolated from Nioko 1 and Borgo mutton meat, and Nioko 1 and Wemtenga mutton meat. Regarding PPS and the yeasts and molds, no statistically significant difference was observed (Table 4).

Table 4. Analysis of differences between modalities with a 95% confidence interval.

	TAMF	PPS	Yeast and moulds	TCB
Nioko 1	13,795,100.000[a]	4,394,630.000[a]	870.500[a]	6,886,000.000[a]
Borgo	4,576,700.000[b]	1,760,060.000[a]	750.600[a]	209,517.000[b]
Wamtenga	3,628,200.000[b]	1,952,000.000[a]	639.200[a]	1,474,000.000[ab]

Legend: TAMF: Total Aerobic Mesophilic Flora; TCB: Total Coliform Bacteria; TTCB: Thermotolerant Coliform Bacteria; PPS: Presumed pathogenic *Staphylococci*. Values with different letter indices are significantly different (Fisher LSD). Values in the same column with the same letter indices are not statistically different at the p = 0.05 confidence level (Fisher LSD).

4. Discussion

This study has certain limitations:

- Small meat sample size,
- The non-characterization of the specific bacterial species present in the meat samples, including their potential pathogenicity and antibiotic resistance profiles due to the lack of fund.

4.1. Assessment of the Survey Results

The results of the study revealed many shortcomings in the construction of the premises as well as the equipment used.

This could be due to the poor management of equipment and premises, and similarly inadequate knowledge on the rules of hygiene among the meat sellers could be a potential source of contamination. In terms of working methods, the good hygiene practices recommended by the committee [11] were not applied properly. This poor hygiene could be related to illiteracy, lack of training, and lack of awareness among staff. Contamination depends on several factors: 1) the animal's state of health and fatigue [12], 2) the animal's cleanliness, and 3) compliance with slaughtering procedures [4] (e.g., compliance with the waiting time between the last administration of a veterinary medicine and the slaughter of an animal for consumption).

4.2. Assessing the Microbiological Quality of Meat

The percentage of meat contaminated with TAMF was 100%, with an average of 8.93×10^6 CFU/g. This result was significantly higher than the standard value of 5×10^6 CFU/g. These average values found in the present study showed a fairly high degree of contamination in the carcasses sampled. They were higher than

those found at the Constantine abattoir by Denna *et al.* [4], who worked on 30 sheep carcasses [5]. The relatively high figure found in the present study could be explained by the poor state of the premises, poor handling, and lack of compliance with hygiene conditions.

Compared to CTBs (bacterial species belonging to the *Enterobacteria* or optional anaerobic family), they are microorganisms indicating the microbial quality of the water because it contains bacteria of fecal origin. Their presence on carcasses indicates poor hygiene during slaughtering operations and recent fecal contamination. These bacteria were present in the meat, with an average of 3.12×10^5 CFU/g. These results differed from those of Hamad (2009), who found 13.6 CFU/g at the El-Oued abattoir on sheep carcasses from different regions of Willaya in Morocco. In fact, the high result reported by Hamad [13] could essentially be due to the hygienic behavior of the handlers, since their samples were taken immediately after skinning and before evisceration. Regarding the TTCB, only *Staphylococci*, yeasts, and molds were isolated, with 3.69×10^6 and 6.74×10^3 CFU germs per gram, respectively, in the mutton. Hammoudi *et al.* [14] in Algeria found 1.9 log CFU/cm^2 of thermotolerant coliforms in their study.

The presence of contamination indicators in sheep meat can be explained by: 1) lack of hygiene during handling or poor storage conditions; 2) contamination during slaughter, transport of carcasses, the environment and staff, and washing of the animal. These germs come from a variety of sources: animals, water, and even direct contact through hides, feet, hooves, or the digestive tract.

Microbiological analysis of yeasts and molds showed that the average contamination of the products by microorganisms was 6.74×10^3 CFU/g of meat. These results were lower than those of Saleh *et al.* [15] who found an average of 8.6×10^3 CFU/g on sheep carcasses in Egypt. Regarding the analysis of presumed pathogenic *Staphylococci,* the results obtained showed that the average contamination of the products by these bacteria was 3.69×10^6 CFU/g germs for raw meat. These results were lower than those obtained by Bouzid *et al.* [16] who obtained an average of 4.45×10^6 CFU/g. This high value obtained by Bouzid *et al.* [16] could be explained, on the one hand, by poor handling during analysis and, on the other hand, during the transport of the samples.

Regarding *Salmonella* spp. sought during this study, none were found in our samples. These results were in agreement with those of Ilboudo *et al.* [17] who did not detect *Salmonella* spp. at ovine samples in the same abattoir in Burkina Faso.) The absence of *Salmonella* in this study could be explained by the very low prevalence of this bacteria in the sheep meet. The absence of *Salmonella* spp. in this study does not mean that there was no subsequent contamination at slaughterhouses. In contrast to the AFO results, Salifou *et al.* [18] showed that *Salmonella* spp. is common in carcasses at the Cotonou-Porto-Novo slaughterhouses. These results proved that the carcass surface contains *Salmonella* spp., which may vary depending on the site of contamination or sampling [19].

In our opinion, this difference could be due to transportation to the sales outlets

and the conditions under which it is kept once in the butcher's or sales outlet. In Burkina Faso, some butchers transport meat on motorbikes and even bicycles without any protection. At the point of sale, the meat is not protected against flies and dust, which leads to contamination by microorganisms. These arguments could justify the difference between microbial loads in meat from different localities.

It is strongly recommended to protect meat and thus to decrease the risk of foodborne diseases caused by enteric pathogenic. This also indicates poor hygiene and sanitation practices and fecal contamination during meat transportation, production, and distribution.

5. Conclusions

This study assessed the microbiological quality of the sheep meal sold in butchers' stores in the Saaba district of Ouagadougou. The levels of bacterial contamination found in the raw meat exceeded acceptable limits in relation to recommended microbiological standards. TAMF accounted for 58% of overall contamination, compared with 25% for TCB, 15% for PPS, and 2% for L/M. However, there was a total absence of *Salmonella* spp. in our meat samples.

Analysis of the results suggests that inadequate hygiene at the point of sale and among staff could play a very important role in contaminating meat and endangering consumer health. These shortcomings mainly concern the hygiene of materials, premises, equipment, and staff, as well as working and operating conditions. Then, based on the results of our study, the sheep meat sold at butchers' shops in the Saaba district was not of very good quality.

In view of the risks incurred by the population of this commune in consuming meat, action must be taken by the competent authorities and must take action in the meat industry professionals to improve the microbiological quality of the meat sold in the butcher shops of the Saaba district.

6. Recommendations

Upon concluding this investigation, we recommend the followings:

1) To the Ministry in charge of Animal Resources, establish a threshing site sanitation program and educate and train all staff members on proper hygiene practices;

2) To professionals, to establish standards-compliant facilities, to safeguard these spaces from pests and to routinely disinfect them; to adhere to current legislation controlling the production, handling, and marketing of foodstuffs of animal origin.

Authors' Contributions

Proposal writing—Dissinviel Stéphane. Proposal review—Assiètta OUATTARA, Ange Irénée TOE. Sample collection, laboratory experiments, and data analysis—Dinanibè KAMBIRE, Serge T. BAGRE, Hawa KAGAMBEGA, Illiassou

MOGMENGA, Ibrahim BARRY. Supervision of work—Cheik Amadou Tidiane OUATTARA and Aboubakar Sidiki OUATTARA. Manuscript writing—Dissinviel Stéphane KPODA. Manuscript review by Aboubakar Sidiki OUATTARA.

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The research proposal was approved by Ziniaré, University Center. The samples were collected in the Saaba district in Ouagadougou. The laboratory experiments were performed in National Laboratory of Livestock and Animal Health in Ouagadougou. The authors are thankful to them.

Conflicts of Interest

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

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