



# Hygienic condition of beef meat sold in the markets of the city of Man (Côte d'Ivoire)

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**Abstract**— Food-borne illnesses represent a real public health problem, due to their severity and frequency. These are common pathologies that can be dangerous and sometimes fatal, due to the consumption of food contaminated by pathogenic microorganisms or toxic substances such as pesticides. The risk of poisoning increases when the most elementary rules of hygiene are not respected. Among the foods often affected is meat, which is an extremely perishable commodity. The objective of this study was to show, through a survey of beef sellers in three markets in the city of Man (Côte d'Ivoire) as well as consumers and, through microbiological tests, the danger that consumption of beef sold in these informal markets can represent. The surveys carried out showed that the most basic hygiene rules were not respected by the beef meat sellers. And even, for the sellers who say they respect them, that leaves something to be desired. As for the microbiological tests which consisted in determining the presence of contaminating germs on pieces of meat taken during the investigation, they revealed the presence of germs such as total aerobic mesophilic flora (TAMF), *Escherichia coli* and *Salmonella* spp. The bacterial load of *E. coli* varied between 4.105 CFU/g and 15.105 CFU/g depending on the market and *Salmonella* spp. was present in all meat samples taken from the three markets. These results suggest that the meat sold in the markets of Man is indeed a risk factor for food poisoning for the populations that consume it.

**Keywords**— Beef meat, food poisoning, informal markets, Microbiology quality, city of Man

## I. INTRODUCTION

Throughout the world, food poisoning remains a real public health problem. Their impact on health and the global economy is increasingly recognized (WHO, 2002). Particularly susceptible populations are young children, the elderly, pregnant women and immunocompromised people (Kouamé-Sina, 2013). The quality of food hygiene is essential for human health, it is an important index to assess the socio-economic performance of a country. Therefore, food safety becomes a necessity for human surveillance (WHO, 2002).

In Côte d'Ivoire, we are witnessing a resurgence of food poisoning and the emergence of certain diseases such as digestive disorders and especially cholera. In 2011, the country experienced several cholera outbreaks that caused 22 deaths out of a total of 933 recorded cases (Tra and Konan, 2018). In the Department of Yakassé-Attobrou, in 2018, 12 people died of food poisoning. Recently, in the Department of Vavoua, in september 2021, nine people died of food poisoning. The recrudescence of these diseases is the majority of the consequent cases of the extreme unhealthiness of the environment of production and sale of products intended for human consumption. The

sale of food in an unsanitary environment is the first element of microbiological transmission, which can lead to health risks for consumers (Tra and Konan, 2018). According to the official health control services, germs of the genus *Salmonella*, *Clostridium*, *Staphylococcus*, coliforms, yeasts and molds have been identified in foodstuffs intended for human consumption. These potentially pathogenic germs are involved in most of the poisonings encountered (Michel *et al.*, 2005). In Abidjan, for example, between 2006 and 2008, the prevalence of *Salmonella typhi* increased from 3% to 22% and the microorganism was responsible for the death of 13 people following the consumption of contaminated maize porridge in Bongouanou. In the same year, nine people fell ill in Alépé after eating cassava contaminated with three types of dangerous microbes: *Salmonella*, *Staphylococcus* and *Clostridium perfringens* (Roesel and Grace, 2016). These species, namely: *Salmonella* spp, *Staphylococcus* spp and *Clostridium* spp are bacteria responsible for zoonoses, i.e., diseases present in animal hosts and which can be transmitted naturally to humans (Roesel and Grace, 2016).

However, in sub-saharan Africa, animal products are an essential component of the food and the means of subsistence of the populations, in addition to the fact that these animal products and in particular beef are extremely perishable and contaminate foodstuffs, several different pathogens along the production chain (Hajaniaina, 2017). In addition, the contamination of beef is accentuated by the lack of and non-compliance with hygiene conditions in the markets. In fact, in developing countries, and particularly in sub-saharan Africa, meat is most often sold on informal markets, which are traditional markets with infrastructures that escape any food safety regulations and controls. (Roesel and Grace, 2016). In Man, a town located in the mountainous west of Côte d'Ivoire, as everywhere else on ivoirien territory, beef is sold in informal markets. The assessment of the health risks associated with the consumption of this food is limited because there is little information on the epidemiology of the contamination of the ivoirien territory and more particularly of the city of Man (Côte d'Ivoire).

Thus, one could ask the question: is the beef produced and sold on the Man market safe for consumers of this commodity?

Controlling beef contamination is now a major concern for actors in the production to consumption chain (Koffi-Nevry *et al.*, 2012). This study is, to our knowledge, the first carried out in the city of Man. The objective of this study is therefore to contribute to the improvement of the hygienic quality of foodstuffs: the case of meat, sold on the

markets of the city of Man. The answer to our hypothesis will consist of:

- carry out a survey of beef sellers and consumers to get an idea of their opinion on the health risks associated with the marketing of beef;
- determine the presence of any contaminating germs in beef from pieces of meat taken from the market.

## II. MATERIAL AND METHODS

### 2.1. Study area

This study was carried out in the city of Man, about 578 km from the Autonomous District of Abidjan. Man is the regional capital of the Tonkpi Region. Tonkpi Region is located in the mountainous west of Côte d'Ivoire between 07°20 and 07°35 North latitude and 07°25 and 07°45 West longitude. This Region is bordered to the West by the State of Liberia and to the North-East by the State of Guinea. In Côte d'Ivoire, it admits as administrative limits, the Bafing Region in the North, the Woroba Region in the North-East, the Guémon and Haut-Sassandra Regions in the East and in the South, it admits as limits the Cavally Region and the western part of the Guémon Region. Tonkpi Region constitutes with the regions of Cavally and Guémon, the District of the Mountains. It brings together five departments and thirty-three sub-prefectures. The five departments are: the Departments of Biankouma, Danané, Sipilou, Zouan-Hounien and the Department of Man (Figure 1).

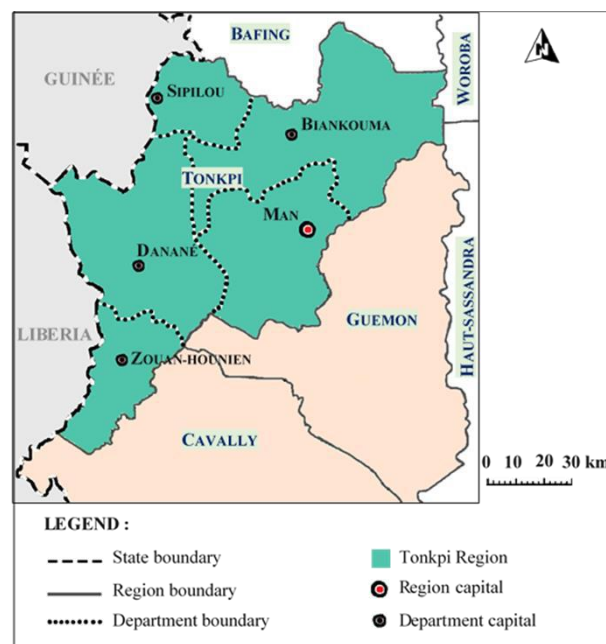


Fig.1: Administrative map of the Tonkpi Region (Source : INS, 2016)

The region covers 14,540 km<sup>2</sup> and has a population of 1,047,769 according to the last population census carried out in 2014. The lowlands have the highest rural population densities in the region, with many localities having more of 200 inhabitants per km<sup>2</sup>. The Dan or Yacouba are the dominant indigenous ethnic group in the territory, which is also home to several non-indigenous ivoirien populations as well as foreigners of african origin, notably guineans, malians and Burkinabe people. Non-africans constitute a marginal population (RGPH, 2014).

## 2.2. Survey of beef sellers and consumers on the health status of beef

Three markets were randomly selected to conduct the surveys. First of all, there is the big market of Man in addition to neighborhood markets of Doyaguiné and Cacasport. The survey was carried out in april 2021. Two questionnaires intended for meat sellers and one for meat consumers were developed and administered in the form of interviews to these different actors. The sellers are questioned stand by stand while the consumers were questioned on the place of sale of the meat or taken randomly on the market. The information sought concerning beef sellers related, among other things, to socio-demographic status (sex, age and level of education) and their knowledge of the rules of good hygiene practices. It was also necessary to know whether the beef sellers cleaned their working premises daily and what was the method of preserving the meat that had not been purchased. Among meat consumers, the information sought was to know, on the one hand, the reason for which they consumed beef despite the health risks incurred, and on the other hand, whether they had suffered from digestive disorders after meat consumption and possibly the various symptoms.

## 2.3. Microbiological analyzes

Three markets in order to carry out the analyses, samples of pieces of meat were taken beforehand. Samples were taken from randomly selected outlets in these markets. The sample was taken by the sellers under the same purchasing conditions as the consumers. After purchase, the samples are put in stomacher bags and then transported as quickly as possible to the laboratory using a cooler for microbiological analyses. A total of thirty (30) meat samples were taken: fifteen (15) samples from the Man market, nine (9) from the market in the Cacasport neighborhood and six (6) from the market in the Doyaguiné neighborhood. For the enumeration of each type of microorganism, one proceeds by the method of inoculation by incorporation into the agar which consists in counting the viable microorganisms present in the sample. And each type of germ is specific to a given agar.

## Preparation of the sample to be analyzed

25 g of each sample was placed in 250 mL of previously sterilized buffered peptone water for the preparation of a 10<sup>-1</sup> stock solution. Everything was stirred in a stomacher to ensure the dispersal of germs. From the solution thus obtained, decimal dilutions were carried out, by aseptically transferring 1 mL of this stock solution into tubes containing 9 mL of sterile physiological water.

## Enumeration of the total aerobic mesophilic flora (TAMF)

The count was carried out by inoculation in the mass. A volume of 1 mL of the stock suspension and its decimal dilutions in duplicate were inoculated into PCA agar (Plate Count Agar) previously maintained under supercooling at 40° C. The incubation was carried out at 30°C for 72 hours, 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 NF V08-051 standard. Only Petri dishes with a number of colonies between 30 and 300 were taken into account for counting.

## Enumeration of total coliforms, thermotolerant coliforms and determination of *Escherichia coli*

The search for these different germs was carried out by sowing streaks for *Escherichia coli*. One (1) mL of the stock suspension and its duplicate dilutions were inoculated into the bile lactose medium with crystal violet and neutral red (VRBL) for the detection of total and thermotolerant coliforms. Tryptone Bile X Glucuronide (TBX) medium was used for the detection of *E. coli*. Incubation was carried out at 30°C for 24 hours for total coliforms, 44°C for thermotolerant coliforms and *E. coli*. The counting and calculation of the average of the 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 standards NF ISO 4831 and NF V 08-060. A qualitative search for *Escherichia coli* was performed. The *Escherichia coli* test was performed using the Leminor reduced rack. After observation of suspicious coliform colonies on VRBL, five colonies are chosen 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.

## Enumeration of staphylococci

The method used is that described by standard NF EN ISO 6888-1. The surface spreading technique of 0.1 mL of

inoculum (samples and decimal dilutions) on complete Baird Parker medium was used. The incubated media were incubated at 37°C for 48 h. 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.

### Salmonella research

Buffered peptone water and Rappaport-Vassiliadis broth were used as the pre-enrichment and enrichment broth, respectively. Xylose-lysine-deoxycholate (XLD) and Hektoen agar served as the isolation medium at 37°C. The method used for this search for salmonella is that specified by standard NF EN ISO 6579. The pre-enrichment is carried out directly from the stock suspension which is incubated at 37°C for 24 hours. It allows the growth of bacteria under 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 dispensed into screw-capped tubes. Into this broth, 0.1 mL of the pre-enrichment solution is added using a sterile pipette. The whole is incubated in an oven at 37° C. for 24 hours. The selectivity of the broth and the relatively high incubation temperature result in the elimination of much of the accompanying flora and promote the growth of salmonella strains. For the isolation of salmonella, the enrichment broth was inoculated onto Hektoen agar by the exhaustion streak technique. The plates are then incubated at 37°C.

### Microbiological criteria for the evaluation of the hygienic quality of meat samples

The criteria for assessing the quality of the samples used are the French standards relating to the criteria which the ready meals must meet (EC regulation, 2005). These criteria are presented in Table 1. The interpretation of the results stems from 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.

<i>Escherichia coli</i>	1.0.10
<i>Staphylocoque spp</i>	1.10 <sup>2</sup>
<i>Salmonella spp</i>	Absence in 25 g

### 2.4. Microbiological analyzes

The analyzes of the data concerning the survey on health conditions among beef sellers and consumers and the microbiological analyses, the construction of tables and the various graphs (histograms and pie charts), were carried out using the EXCEL 2019 software.

## III. RESULTS AND DISCUSSION

### 3.1. Results

#### Results of survey of beef meat sellers and consumers

A total of 37 beef meat sellers and 101 beef consumers were interviewed. Concerning the meat sellers, the socio-demographic characteristics showed that the interviewed beef sellers are all men (Figure 2). Figure 3, which presents the age range of sellers, shows that 10.9% of them are between 18 and 24 years old, 37.8% are between 25 and 34 years old, 37.8% are also between 35 and 49 years old; sellers aged 50 to 64 are present with a percentage of 13.5%. Figure 3 also shows that no seller is over 64 years old. The analysis of this figure shows us that in Man, beef sellers are mostly young people. The level of education of beef sellers is shown in Figure 4. In this figure, we note that no seller has reached the higher level, 27.0% have reached secondary level, 10.8% have at the primary level, 48.7% have rather made Koranic studies while 13.5% are illiterate. After this analysis, we can deduce that the beef is sold by men, young in age and not having done the conventional school.

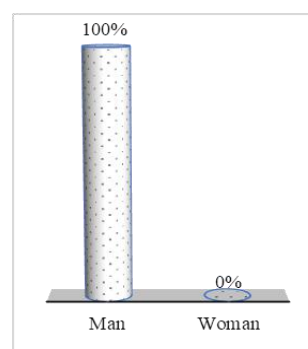


Fig.2: Distribution of beef meat sellers by sex

Table 1: Microbiological criteria (EC Regulation, 2005)

Microorganisms	Criteria CFU/g
TAMF	3.10 <sup>5</sup>



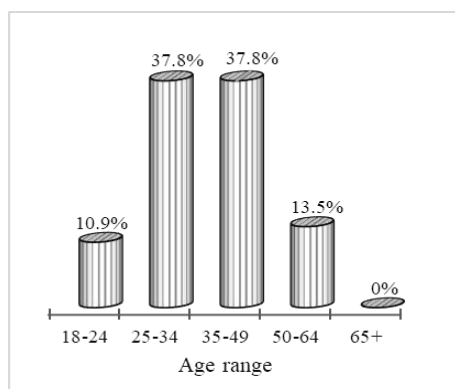


Fig.3: Distribution of beef meat sellers by age range

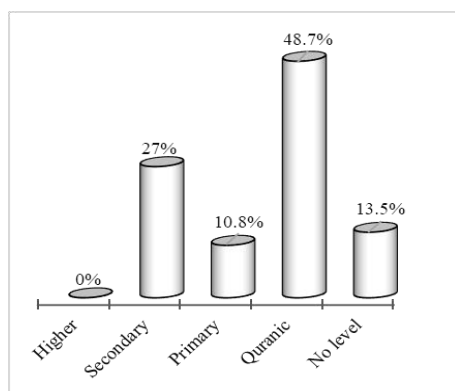


Fig.3: Distribution of beef meat sellers by education level

The results of the survey on the knowledge or not of beef sellers good hygiene practices are presented in Figure 5. In this figure, we can see that of the 37 sellers questioned, 59.5% received a training on hygiene rules while the remaining 40.5% received none. Also, according to Figure 6, the majority of sellers, approximately 83.8%, believe that they take care of the cleaning of points of sale on a daily basis and only 16.2% do not do it daily. The results obtained also show that all sellers without exception declare sending the rest of their meat to cold rooms or, failing that, to freezers for post-sale storage (Figure 7).

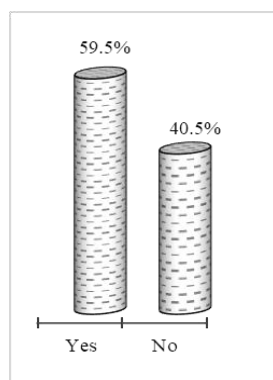


Fig.5: Proportion of beef meat sellers knowing or not the rules of hygiene

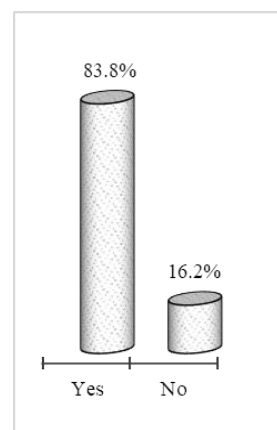


Fig.6: Proportion of beef meat sellers cleaning or not their place of sale

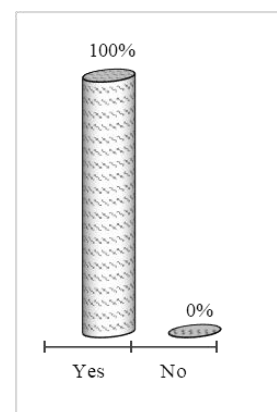


Fig.7: Proportion of beef meat sellers keeping or not the rest of the meat after sale

With consumers, the survey carried out aimed to find out the main reasons that led them to consume beef, whether there were any digestive disorders after eating meat and the main symptoms when they were having trouble. The results showed that the main reason for consuming beef in the city of Man was for its good taste, i.e., 43.9% of the people interviewed, then followed by those who consume it for simple pleasure (26.2%), followed by people who eat meat because it is nutritious (25.2%). Finally, only 3.9% of people interviewed believe that the cost of meat is cheaper and very few people, i.e., 0.9%, believe they buy meat from sellers because it is hygienic (Figure 8). Of all the consumers, 28.7% said they had gotten digestive problems after eating meat and 71.3% said they had no problems (Figure 9). Among the people who presented with a disorder, 44.7% revealed that they had gotten diarrhea as symptoms and 55.3% had stomach aches as symptoms (Figure 10).

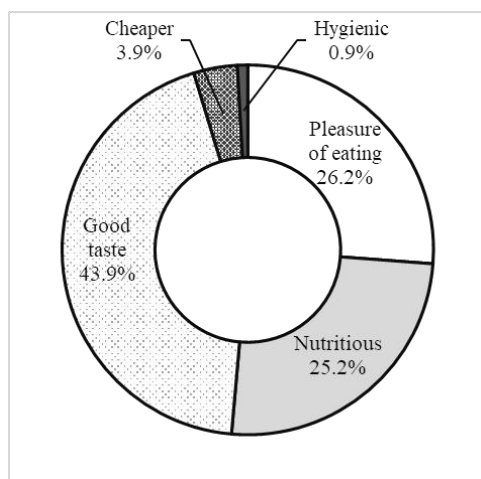


Fig.8: Reasons for beef meat consumption in the city of Man

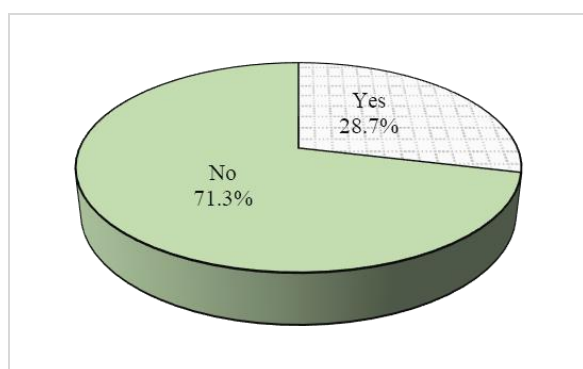


Fig.9: Proportion of people having had or not digestive disorder after eating beef meat

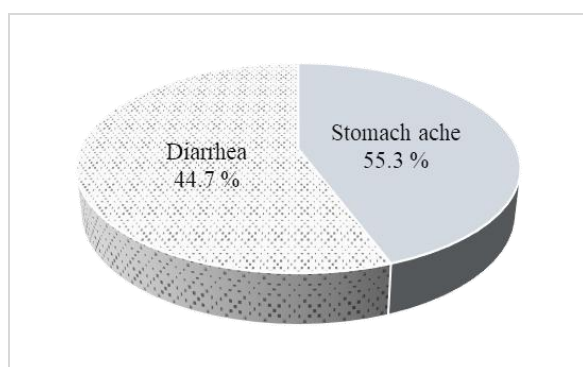


Fig.10: Symptoms presented in people with a digestive disorder

### Results of microbiological analyzes

The microbiological analysis carried out on the meat samples from the markets of Doyaguiné, Cacasport and the large market of Man gave the results recorded in Table 2.

This table shows the average bacterial load in CFU/g of the different germs tested for on the meat samples taken from the three markets. The germs which were sought are the total aerobic mesophilic flora (TAMF), *Escherichia coli*, *Staphylococcus aureus* and *Salmonella* spp.

Concerning the TAMF, the microbiological analysis showed the presence of this germ on the meat samples taken from the three markets. The values of the bacterial load observed for this germ are  $2.65.10^6$  CFU/g,  $2.76.10^6$  CFU/g and  $2.1.10^6$  CFU/g respectively for the large market of Man, the market of Cacasport and the market of Doyaguiné. The comparison of the different bacterial loads obtained for this germ with the reference microbiological load ( $3.10^5$ ) could lead to the conclusion that the samples taken were of acceptable microbiological quality. Indeed, the bacterial loads obtained are between three (3) and ten (10) times the reference criterion.

For *E. coli*, the analysis also showed its presence in all the samples taken. The very high bacterial loads were  $1.5.10^6$  CFU/g on average for the samples from the large market in Man,  $3.42.10^5$  CFU/g for those from the Cacasport market and  $4.10^5$  CFU/g for the samples from Doyaguiné. Regarding *E. coli*, the reference microbiological criterion is  $10^2$ . The values obtained are well above (10) times the reference criterion. The meat samples analyzed on these three markets are therefore of unsatisfactory microbiological quality.

As for the *S. aureus*, the analysis of meat samples taken from the three markets showed a total absence of this germ. The microbiological quality of the samples with regard to *S. aureus* is therefore satisfactory.

For *Salmonella* spp. germ, the microbiological analyzes showed that it was present in all the samples taken. The very high bacterial loads observed are  $7.13.10^5$  CFU/g for samples from the big Man market,  $1.12.10^6$  CFU/g for the Cacasport market and  $6.45.10^5$  CFU/g for the Doyaguiné market. The presence of this germ on the meat samples taken shows that these samples have an unsatisfactory microbiological quality. Indeed, according to the reference microbiological criterion relating to this germ, a sample is of satisfactory microbiological quality when this germ is absent from 25 g of this sample.

Overall, the microbiological quality of the meat samples taken from the three Man markets is unsatisfactory given the presence of salmonella and the high bacterial load of *Escherichia coli* detected without exception in all the samples analyzed.

Table 2: Microbiological quality of meat samples taken from the three markets

Germs studied		Samples taken from the markets			Microbiological criteria
		Large market of Man	Cacasport market	Doyaguiné Market	
TAMF	Load in CFU/g	$26,5.10^5 \pm 6,4$	$27,6.10^5 \pm 0,6$	$21.10^5 \pm 1,0$	$3.10^5$
	Quality	AMQ	AMQ	AMQ	
<i>Escherichia coli</i>	Load in CFU/g	$15.10^5 \pm 1,35$	$3,42.10^5 \pm 0,74$	$4.10^5 \pm 0,8$	$10^2$
	Quality	UMQ	UMQ	UMQ	
<i>Staphylococcus aureus</i>	Load in CFU/g	Absent	Absent	Absent	$10^2$
	Quality	SMQ	SMQ	SMQ	
<i>Salmonella</i> spp	Load in CFU/g	$7,13.10^5 \pm 8,5$	$11,19.10^5 \pm 7,78$	$6,45.10^5 \pm 0,85$	Absent/25g
	Quality	UMQ	UMQ	UMQ	

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

### 3.2. Discussion

This study was first conducted to get an idea of the opinion of beef sellers and consumers regarding the health risks around the marketing of this food. It appears from this survey that these actors are well and truly aware of the risks incurred for the consumer. Regarding meat sellers, the socio-demographic characteristics show that the sellers surveyed are all men and mostly young (86.4%). This result was expected, because cutting and processing beef carcasses requires a lot of physical effort, which a young man can easily do. According to the results observed, the majority of meat sellers believe that they clean their work environment daily and have even received training on the rules and respect for good hygiene practices. However, this does not reflect the observation made during the surveys. This paradox is explained by the negligence of these sellers as to the practice and respect of hygiene rules. To this end, according to Tra and Konan (2018), in a study conducted on the environment and sanitary awareness of traders and consumers from Wassakara to Yopougon (Côte d'Ivoire), these actors are aware of the health risk of food sold in such an environment but they mobilize the ideology of habit and social obligation to stay in this market and exercise their economic activity there. As for the survey carried out among consumers, to find out their appreciation of the hygienic quality of the meat made available to them on the markets, it appears that the real

reasons which lead them to consume meat are the good taste of the meat and also for the simple pleasure, but not because the meat sold is hygienically clean. This attitude is reflected in the fact that, despite the social realities of the markets in terms of food hygiene, these actors (traders and consumers) develop a capacity to adapt to the environmental conditions imposed on them, even if health risks may result (Tra and Konan, 2018). Some consumers surveyed (28.7%) claimed to have had digestive problems following the consumption of purchased beef, and the main symptoms were diarrhea and stomach aches. However, according to Farthing (2000), the presence of such disorders is generally attributed to the ingestion of undercooked foods, especially beef. These diarrheas and stomach aches are most often characteristic of toxoinfections caused by pathogenic microorganisms (Cassin *et al.*, 1998).

The study on the determination of possible contaminating germs of meat intended for consumption by human populations has only confirmed our concerns. Indeed, the microbiological analyzes carried out showed the presence of total aerobic mesophilic flora (TAMF), *Escherichia coli* and above all, the presence of *Salmonella* spp in all the meat samples taken from the three markets in the city of Man selected. However, among the germs sought, the absence of the *Staphylococcus aureus* germ was observed.

Concerning the detected TAMF, although this germ is not dangerous for health, its detection in the meat can however reflect an alteration of this foodstuff. According to Kneifel *et al.* (2002), this flora reduces the intrinsic quality (taste, smell, physical aspect) of the food. And for the WHO (2002), a high bacterial load of TAMF in the samples may indicate that the meats have been exposed to poor handling, inadequate processing methods and inappropriate storage conditions.

For contamination of meat samples with *Escherichia coli*, this is confirmation of fecal soiling, which is directly associated with unsanitary conditions. This bacterium comes exclusively from the intestines of humans and animals. Some serotypes can cause gastrointestinal illnesses. Infections with this microorganism are most often caused by eating contaminated, undercooked beef. In such a context, the education of meat sellers and consumers is essential to prevent foodborne illnesses through the application of good hygiene practices in the markets.

As for *Salmonella* spp., a highly pathogenic germ, a high bacterial load was observed in all the meat samples taken. However, the presence of this contaminating agent stipulates that the microbiological quality of a food is not satisfactory. According to Bornert (2000), the main reservoir in which salmonella actively multiply is the digestive tract of their potential hosts, to the point that they are considered normal hosts of the digestive tract and their only natural habitat. Thus, all animals including cattle are potential carriers of salmonella in the digestive tract (Peter *et al.*, 2010). Thus, the presence of these bacteria elsewhere in the environment or in water would only be due to fecal contamination. The presence of this microorganism is most of the time associated with the existence of food poisoning. Indeed, the main strains of salmonella are responsible for typhoid fevers but also paratyphoid fevers (Euzeby, 2007). These fevers are serious, often fatal if left untreated. This illustrates the need for good hygienic practices when slaughtering, processing, storing, cutting, marketing and even preserving beef.

However, according to Roesel and Grace (2016), in the informal markets of most african countries, dangers are frequent but they do not necessarily turn into risks. Even if the dangers are often present, the risk for human health is not necessarily high. The danger is that contaminating germs are present on the food. However, the risks may be lower due to african consumption practices such as boiling meat long before human consumption, which effectively reduces the danger.

#### IV. CONCLUSION

Around the world, food-borne illnesses have a serious impact on the health of populations. They are of increasing concern to consumers, producers and policy makers. The study on the hygienic conditions of the meat sold on the market of the city of Man showed that this locality is not immune to this health problem. Indeed, the results of the survey conducted among beef sellers and consumers of this foodstuff as well as the microbiological tests carried out revealed that the populations of the city of Man are exposed to real dangers. The determination of contaminating germs such as *Escherichia coli* and *Salmonella* spp incriminated in several cases of toxoinfection justifies this assertion. Even if it is difficult to control the epidemiology and the frequency of contamination of these affections, it would be interesting to sensitize the actors of the beef production chain to the respect of the elementary rules of hygiene in order to reduce health risks incurred by the people.

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