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Bacteriological Quality of Meat Sold in Markets and Kiosks before and after Cooking in Bamako

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Abstract The bacterial loads of meat sold in markets and kiosks in Bamako before and after cooking have been determined. In these meats, total aerobic mesophilic flora, fecal coliforms, sulphate-reducing anaerobic germs, staphylococci and *Salmonella* were searched and counted. In market, raw meats, concentrations of total aerobic mesophilic flora, fecal coliforms, sulphate-reducing anaerobic germs and staphylococci were above the set limits. In raw meats from markets, the initial average concentrations determined were $21.67.10^5$CFU/g; $6.30.10^2$CFU/g; $4.36.10^2$CFU/g and $3.90.10^2$CFU/g respectively for total aerobic mesophilic flora, fecal coliforms, staphylococci and sulphate-reducing anaerobic germs. *Salmonella* was found in 66.67% of raw meat samples. However, after cooking, the average loads of all bacteria were below the limit values. In raw meat samples from kiosks, the average concentrations determined were $2.95.10^5$CFU/g; $3.45.10^2$CFU/g; $2.30.10^2$CFU/g and $4.70.10^2$CFU/g respectively for total aerobic mesophilic flora, fecal coliforms, staphylococci and sulphate-reducing anaerobic germs. *Salmonella* was found in 33.33% of these meats samples. After cooking meat from kiosks, the average concentrations were $0.45.10^5$CFU/g; $0.87.10^2$CFU/g and $0.83.10^2$CFU/g respectively for total aerobic mesophilic flora, staphylococci and sulfito-reducing anaerobic germs. Fecal coliforms and *Salmonella* were not found after cooked meats from the kiosks. The loads of bacteria from the meat samples from the kiosks were greatly reduced by cooking more than those of meat taken at the market level. Cooking reduced microbial loads to acceptable values. The bacterial load of meat from the markets in Bamako is very high, so it is wise and much preferable to buy the meats in safe places such as kiosks and eat them only after a very good cooking in order to guarantee the good health of consumers in Bamako.

Keywords: *quality, Bacteriology, meat, market, kiosk, cooking, Bamako*

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1. Introduction

Meat is consumed by many people around the world because of its nutritional composition. It is an important source of valuable protein for different populations around the world. However, it is an important vehicle for microbial pathogens responsible for foodborne infections in humans, as its composition and physical characteristics are conducive to the growth of a wide range of microorganisms, including pathogens [1,2].

Contamination of meat by foodborne pathogens is a major public health problem. Among bacteria, *Salmonella* has been frequently associated with gastroenteritis worldwide [3]. *Salmonella* causes salmonellosis, characterized by nausea, abdominal pain, diarrhea and sometimes fever resulting in morbidity and, in some cases, mortality in animals and humans [4]. A study by Majowicz & *al.* [5] found that, worldwide, Salmonella infection is responsible for approximately 93.8 million cases of human gastroenteritis and 155,000 deaths per year.

The microbiological quality of the meat depends on the physical condition of the animal at slaughter place, the spread of contamination during slaughter and processing, temperature and other storage and distribution conditions [6]. The assessment of the microbial quality of raw meats is then preferred and recommended to reduce possible contamination [7].

In Mali in 2007, the average consumption of beef was estimated at 8.9 kg/staff/year with an average daily protein intake of 5% and an average daily intake

of 1.5% in calories [8]. The sanitary quality of meat is now a major issue for all sector players in Mali, as the sector is neither sufficiently organized nor effectively controlled. Apart from health control, no other approach to quality assurance has been undertaken to date. The actual production line begins at the slaughterhouse/slaughter place and ends on the butcher's table [9].

The meat consumed in and around Bamako comes from slaughterhouses that supply the markets. These slaughterhouses do not have refrigerated vehicles, the transport of meat is provided by means that could promote the contamination of meat by biological, chemical and even physical agents.

The transport of meat from slaughterhouses to butchers is carried out with dump trucks, carts, tricycle motorcycles, two-wheeled motorcycles, bicycles, taxis and other inappropriate means of transport. All these means of transport are far from complying with national and international regulations in terms of transporting products such as meat.

In butcher shops, meat is served to customers after many manipulations. However, despite these nutritional qualities, meat is a very favorable environment for microbial proliferation.

In Bamako, some butchers sell meat under sheds without protection from flies and other insects. In others, meats are exposed in the open air and in poor storage conditions [10].

The tripe and offal mixed with the carcasses are usually sold on the same stands. The same material is used for cutting meat without being washed and disinfected.

DNPIA [8] confirms that equipment and worktops are rarely washed with simple water and soap.

However, there is a growing number of kiosks in neighborhoods and markets in the city that sell meat. These kiosks are designed to provide the necessary hygiene conditions to ensure the safety and health of meat consumers. However, they are few in number and are mostly located in affluent neighbourhoods. Their multiplication can be a mean of reducing against various diseases caused by the consumption of contaminated meat in the capital and even in the rest of the country.

The biggest problem with meat conservation is microbial development. In fact, the meat consumed is a growing environment conducive to the spread and multiplication of a multitude of microbial contamination [11].

Different cooking techniques cannot guarantee the safety of meat if they originally have a high load of pathogenic microorganisms. The presence of pathogenic germs such as *Salmonella*, *Staphylococcus*, clostridiums, can probably lead to food poisoning.

In light of all these problems related to the consumption of meat sold in markets and elsewhere under the wrong conditions, it is necessary to control the microbiological quality of meats in Bamako.

The objective of this study is to determine the bacterial loads of meat sold in a few markets and kiosks in Bamako before and after cooking in order to contribute to improve the health of consumers in the city of Bamako.

2. Materials and Methods

2.1. Sampling

The samples were carried out in the six (6) municipalities of Bamako in Mali. At the level of each municipality a place of sale of meat (market) in a market and a kiosk selling meat (off-market or in the market) were randomly targeted for sampling.

At the market level and in the kiosks, the samples were taken by the butchers under the same conditions of sale to consumers. Twenty-four (24) samples were analyzed. Samples taken are placed in sterile bags and transported in a cooler. At the kiosks, the samples were taken under the same conditions as those of the markets at the stall.

As a result of the sampling, the meats were divided into two sub seeds for each batch (Kiosk and market). The first part was microwaved in meat cooking mode to form the cooked subsampling. The second part remained in the state to form the raw subsamples. Both batches were used for bacteriological analysis.

2.2. Bacteriological Analysis of Samples

Total Mesophilic Aerobic Flora (TMAF) research and count: Total mesophilic aerobic forest (TMAF) was counted on PCA agar (Flat Count Agar) (ISO: 4833).

Search and count fecal or thermotolerant Coliforms:

Fecal Coliforms were counted on deoxycholate-lacto agar at 0.5% (NF V 08-060 44 C).

Research and counting of staphylococci coagulase positive: Positive coagulase staphylococci was found on the Chapman medium (ISO 6888).

Research and counting of sulphate-reducing anaerobic germs: sulphate-reducing anaerobic germs (SRA) were counted on TSN agar (NF V-08061).

Salmonella research: *Salmonella* was searched on the SS medium (*Salmonella/Shigella*) (ISO 6579).

3. Results

3.1. Concentration of Bacteria in Raw Meats in Markets

The concentration of bacteria in raw meats from Bamako markets has been determined. The results show that concentrations of total aerobic mesophilic flora, fecal coliforms, sulphate-reducing anaerobic germs and staphylococci are higher than the limit values set by the standards. The average concentrations determined were $21.67.10^5$UFC/g; $6.30.10^2$UFC/g; $4.36.10^2$UFC/g and $3.90.10^2$UFC/g respectively for total aerobic mesophilic flora, fecal coliforms, staphylococci and sulphate-reducing anaerobic germs. *Salmonella* was found in 66.67% of raw meat samples from markets (Table 1).

3.2. Concentration of Bacteria in Raw Meats at Kiosks

Concentration of total aerobic mesophilic flora, fecal coliforms, sulphate-reducing anaerobic germs and

staphylococci in raw meats from Bamako kiosks were determined. The results show that concentrations of total aerobic mesophilic flora are all below the limit values set by the standards. On the other hand, fecal coliforms and sulphate-reducing anaerobic germs have concentrations above the limit values set by the standards. Staphylococci was found in 50% of raw meat samples from kiosks (Table 2). The average concentrations determined were $2.95.10^5$CFU/g; $3.45.10^2$CFU/g; $2.30.10^2$CFU/g and $4.70.10^2$CFU/g respectively for total aerobic mesophilic flora, fecal coliforms, staphylococci and sulphate-reducing anaerobic germs. *Salmonella* was found in 33.33% of raw meat samples from markets (Table 2).

3.4. Concentration of Bacteria in Meats Purchased from Kiosks then Cooked

Previous microbiological parameters have been researched and counted in meat samples from post-cooking kiosks. The results reveal that cooking significantly reduced the microbial load of the meat. The average loads of all microorganisms sought are below the set limits. The average concentrations determined were $0.45.10^5$CFU/g; $0.87.10^2$CFU/g and $0.83.10^2$CFU/g respectively for total aerobic mesophilic flora, staphylococci and sulfito-reducing anaerobic germs. Fecal coliforms and *Salmonella* were not found in samples of cooked meat from kiosks (Table 3).

Table 1. Concentration of Bacteria in Raw Meats in Markets

Samples	TAMF (10^5CFU/g)	FC (10^2CFU/g)	Staph. (10^2CFU/g)	SRA (10^2CFU/g)	*Salmonella*
E_1	58	17	9	0,3	+
E_2	54	1	1,2	8	-
E_3	56	6	0,9	2	-
E_4	4,6	4,5	1,03	9,6	+
E_5	5,6	8	13	0,8	+
E_6	4,9	1,3	1,02	2,7	+
Average	**21,67**	**6,30**	**4,36**	**3,90**	**+**
Limit	m= 5.10^5 M= 5.10^6	m= 10^2 M= 10^3	m= 10^2 M= 10^3	m= 30 M= 3.10^2	M=m=0/10g

Table 2. Concentration of Bacteria in Raw Meats in Kiosks

Samples	TAMF (105CFU/g)	FC (10^2CFU/g)	Staph. (10^2CFU/g)	SRA (10^2CFU/g)	*Salmonella*
E_1	3,2	60	1	0,6	+
E_2	4,2	0	2	0,3	-
E_3	0,31	0	0,8	0,2	-
E_4	0,94	0	18	0	-
E_5	0,29	40	14	0	-
E_6	0,4	0	0,9	0,8	+
Average	**1,56**	**16,67**	**6,12**	**0,32**	**+**
Limit	m= 5.10^5 M= 5.10^6	m= 10^2 M= 10^3	m= 10^2 M= 10^3	m= 30 M= 3.10^2	M=m=0/10g

Table 3. Concentration of bacteria in meat cooked for kiosks

Samples	TAMF (10^5CFU/g)	FC (10^2CFU/g)	Staph. (10^2CFU/g)	SRA (10^2CFU/g)	*Salmonella*
E_1	0,08	0	0	0	-
E_2	0,92	0	0	0	-
E_3	0,53	0	0	0	-
E_4	0,34	0	1,5	1,3	-
E_5	0,41	0	1,6	1,5	-
E_6	0,41	0	2,1	2,2	-
Average	**0,45**	**0,00**	**0,87**	**0,83**	**-**
Limit	m= 5.10^5 M= 5.10^6	m= 10^2 M= 10^3	m= 10^2 M= 10^3	m= 30 M= 3.10^2	M=m=0/10g

4. Discussion

The main critical points in the meat production chain in Bamako are the slaughter sites, the transport chain, sales point and the butchers. Unfortunately, at all these points, hygiene measures are often not respected and anyone can see the conditions under which the meat is transported to consumers [12].

The average loads of total aerobic mesophilic flora, fecal coliforms, staphylococci and anaerobic sulphite-reducing germs determined in samples of raw meat from markets are significantly higher than those determined in samples of raw meat from kiosks.

The aerobic mesophilic count is one of the microbiological indicators of food quality and the presence of aerobic organisms reflects the existence of conditions favorable to the multiplication of microorganisms.

The presence of high loads of total aerobic mesophilic flora in especially raw meats could be explained on one hand by a lack of hygiene in the handling of sales at markets and kiosks.

On the other hand, it may also be due to contamination while slaughtering, transport of carcasses, the environment and personnel. According to ANSSA [11], 95% of mesophilic aerobic germs identified in raw beef from slaughterhouses come from the slaughter environment: air, soil, and cutting tools. The results of this study are comparable to the results of previous work [13,14,15,16].

Raw meats bought in stall markets are more loaded with bacteria from the total mesophilic aerobic flora than raw meats bought at meat stands. However, cooking has reduced many of the bacteria in the meat samples. The total flora loads of the samples taken at the kiosks were significantly reduced by cooking more than those of the meats taken at the markets. This could be explained on one hand by the fact that the initial (pre-cooking) bacterial loads of the meats purchased at the kiosks were lower. It could also be due to differences in study areas, temperature and suppliers' personal hygiene practices.

Good hygiene practices reduce the risk of contamination. Mapeyi's studies [17] confirm the importance of hygiene practices. He found that 55% of the cooked game meats marketed in restaurants in Libreville, Gabon were unsatisfactory because of their high TAMF load. The poor quality of the premises and working equipment of butcher shops is a significant source of contamination of meat by TAMF [18].

In view of the results, the meats collected from the markets had a high concentration of fecal coliforms compared to the meats sold in the kiosks even after cooking. Fecal coliforms are fecal contamination germs that are pathogenic to humans; they mainly come from the digestive tract of animals and humans. Meat receives its first load of fecal contaminants in slaughterhouses. The ANSSA [12], counted fecal coliforms in 53.3% of meat samples from slaughterhouses in Bamako. Their research is essential in slaughterhouses in order to control contamination. In the United States, fecal coliforms are regularly counted on beef carcasses in slaughterhouses [19]. Mapeyi [17] reported in its study that 64% of its game meat samples analyzed after cooking were found to be unsatisfactory with respect to their coliform load.

Raw meat samples from markets and kiosks have very high staphylococcus loads. Staphylococci come from air, water and soil. Individuals carry these germs at different levels of the body. However, its presence in food does not mean fecal contamination [19]. In kiosks, meat is protected from external environmental elements, bioaerosols and especially from frequent human contact, which is a source of contamination. These results are lower than those of Meftah [20] who found up to 3.104 CFU/g of Staphylococcus aureus germs in fresh beef. Even if Staphylococcus aureus is removed during cooking, its toxins can withstand the temperature of the cooking process, thus creating the risk of food poisoning.

Compared to the loadings of the SRP sprout samples, the results show that meat taken at markets is less loaded in contrast to raw meat samples taken at kiosks. The reason for this is that although meat is kept away from the outside air and the microbes it carries, meat can be contaminated at slaughter. Basett, [18] found a low presence of RSA in his samples and stated that meat contamination is more frequent at slaughter because species such as C. perfringens are hosts in the animals' digestive tract. Our results are comparable to those of Donald [21] who found average levels of RSA contamination in these samples from Malika (1,024.102 CFU/g) and Keur Massar (0.100.102 CFU/g).

The salmonella count in samples of meat from the markets after cooking revealed a high contamination (66.66%). A study revealed that 15% of samples of buffalo meat imported into Senegal were contaminated with Salmonella due to questionable hygienic conditions [22]. Hygienic practices have a significant impact on Salmonella contamination of meat, confirmed in poultry by Fatou [23]. The high post-cooking load of meat is thought to be explained by the efficiency of cooking and the level of the initial load. On the other hand, none of the meat samples taken from the kiosks and cooked contained salmonella. Since the initial load of meat from the kiosks was low, it was totally eliminated by the heat during cooking. Salmonella germs are dangerous and can induce very serious foodborne illness (FBT). They infest meat through contact with polluted environments, soiled hands, all along the slaughter line [18].

Overall, to promote the quality and safety of a food such as meat and ensure the protection of health of consumers of Bamako, the implementation of certain sectoral strategies of the National Food Safety Policy is necessary.

Sanitary control and monitoring, which are not applied today by the technicians of the State services, must be re-established and carried out frequently in the markets and other meat sales outlets.

The staff supervising slaughtering activities in the slaughterhouses in Bamako is made up solely of veterinarians who only ensure veterinary control of production. The recruitment of a hygienist specialized in environmental hygiene and product safety will improve the quality of the production environment.

The authorities must ensure that slaughterhouses are equipped with refrigerated vehicles fitted with hooks for suspending carcasses. The use of inappropriate means of transporting meat must be prohibited.

To prevent the risk of contamination of meat by contamination vectors and bioaerosols in sales premises, traditional facilities must be replaced by glassed-in and maintained kiosks.

Good hygienic practice in meat sales points must be systematically and regularly observed. This involves applying gestures, practices and conduct to preserve and improve the hygienic and sanitary qualities of the meat consumed. The personal and clothing hygiene of the personnel is part of these behaviors. Awareness raising and training of meat sellers at the markets in Bamako will be an asset to strengthen their knowledge in terms of sanitation and food hygiene.

5. Conclusion

The results of the bacteriological analyses of meat samples taken at the markets and kiosks in the various communes of the district revealed that among the bacteria there are those that are indicative of fecal contamination and those whose presence confirms the poor hygienic quality of the meat.

Meat sold in the markets before and after cooking is more loaded with bacteria than meat sold in the kiosks.

Cooked meat certainly allows for a strong reduction in the bacterial load but is not sufficient to ensure total safety in the event of contamination by pathogens whose initial loads were high before cooking.

Since cooking does not remedy the problem of contamination of meat sold in Bamako, it is essential to comply with a number of measures included in the strategic documents on food safety in Mali. These include the respect of good hygienic practices from meat production in slaughterhouses to sales point in markets and kiosks. Good gestures or practices during the sale of meat are also necessary.

The contamination of meat sold in Bamako can undoubtedly be eradicated thanks to the commitment of the local authorities in charge of market management and the political will of the State.

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