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REGULAR ARTICLE

HYGIENIC QUALITY ASSESSMENT OF FRESH BEEF MEAT IN BUKAVU URBAN SLAUGHTERHOUSES, SOUTH KIVU PROVINCE OF THE LONG SALE CHAIN: POTENTIAL HEALTH RISKS FOR CONSUMERS EASTERN D.R. CONGO

*Theophiline Babe[1], Theodore Munyuli[1, 2], Justin Ombeni[*1, 4], Theophile Kashosi[3], , Tresor Mwangi[4]*

Address (es): Ing.Nut. Theophiline Babe,
[1] Bukavu Institute of Higher Education in Medical Techniques, ISTM/Bukavu, Department of Nutrition and Dietetics, Eastern DR Congo.
[2] National Center for Research in Natural Sciences, CRSN-Lwiro, D.S., Departments of Agriculture, Biology and Environment, Bukavu, South-Kivu Province, Eastern DR Congo.
[3] Bukavu Institute of Higher Education in Medical Techniques, ISTM/Bukavu, Department of Laboratory Techniques, P.O Box. 3036/Bukavu, South Kivu province, eastern DR Congo.
[4] Jomo Kenyatta University of Agriculture and Technology, Faculty of Food Science and Nutrition, Department of Food Science and Technology, Nairobi, Kenya.

*Corresponding author: justinombeni12@gmail.com

ABSTRACT

Meat is generally subject to multiple sources of microbial contamination related to the length and complexity of their journey from farm to consumer's table. The purpose of this study is to assess the current hygienic quality level of fresh beef slaughtered in Bukavu urban slaughterhouses, South Kivu to identify the health dangers to consumers. The meat samples were taken from 78 carcasses into three periods: at the slaughterhouse, to the market at the end of the transport position of sale and butchery. Microorganisms were sought following appropriate ISO standards. Total Aerobic *Mesophilic* Flora (FAMT), total *coliforms*, *staphylococcus* and other *enterobacteria* were counted more ($p<0.001$) at the slaughterhouse and the market at the end of transportation to butchery Chi^2: 64.90; 82.91 and 176.5, respectively; $p<0.001$). Hygienic quality of beef meat is poor, this study revealed a very high level of contamination of the collar and shoulder of beef carcass analyzed from slaughterhouse to distribution location ($p<0.001$). The very high bacterial load of these products is observed at the slaughterhouse and the public market during carcasses transport, the lesser butchery. This charge varies as well according to the slaughterhouse where the sampling took place, site and date of collection, including public slaughterhouse, most visited by distributors and that of suburban is the most famous. Beef carcasses are contaminated almost at the end of the week (thursday) by pathogenic bacteria such as; *Staphylococcus aureus*, *Salmonella* ssp., *E. coli*, *coliforms* and other *Enterobacteriaceae* represent a great danger of food poisoning to consumers, hence the need to implement an effective program against beef contamination, veal and respect for hygiene breeding farm, slaughterhouses, slaughter procedures, method of handling meat, and transport to the sale to consumer.

Keywords: consumption, meat, contamination, bacteria, human health risk, Bukavu

INTRODUCTION

The recent crises that have shaken and still shake food sector and particularly meat, suggest that the quality of it is constantly deteriorating and that it is better to turn to alternative sources of protein **(Dennaï *et al.*, 2001)**. Meat is the muscle of the transformation products after animal death. It is traditionally considered to be the vehicle for many food borne diseases in humans because of health defects **(Dennaï *et al.*, 2001; Fosse, 2003; Vaillant *et al.*, 2004; Fosse *et al.*, 2006)**. It is a highly perishable foodstuff and whose hygienic quality depends, first of contamination during slaughtering and cutting operations and secondly, the development and growth of flora contaminants during cooling, storage and distribution **(Dennaï *et al.*, 2001; El Hadef *et al.*, 2005)**. If meats are subject to multiple sources of contamination linked to the length and complexity of their journey from the farm to the consumer's table, these potential hazards need to be considered in terms of real health risk.
To do this, we must weigh each of these hazards in terms of frequency or probability of occurrence, and in terms of severity. This dimension called risk analysis has long been neglected, but it is the basis of all public health recent policy **(Fosse, 2003; El-Hadef *et al.*, 2005)**.
While many studies have been made on hygienic and microbiological quality of meat in most continents **(Collobert *et al.*, 2002, 2007; Herau *et al.*, 2007)**, few studies are listed in the countries of the Sub-Saharan Africa **(Wade, 1992)**. In DR Congo, the little work done on the meat quality cover microbiology and the bacteriological quality of meat, internal organs of pigs and cattle for human consumption **(Krubwa, 2002)**. From these studies, it appears that the analysis of the microbiological quality of meat has revealed that the internal organs of the animal are the busiest in bacteria and were the source of *salmonella* infections more dangerous. They exhibit more than pork liver is five times more contaminated than beef liver **(Krubwa, 2002)**. Similarly, current production practices carcasses can cause contamination of carcasses with pathogens such as pathogenic E. *coli*, *Salmonella enterica*, *Bacillus cereus*, *Clostridium botulinum*, *Clostridium perfringens*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Mycobacterium bovis*, *Mycobacterium tuberculosis* **(Fosse *et al.*, 2006; Salifou *et al.*, 2010; Laila *et al.*, 2016)**. These microbiological germs are mostly responsible for food poisoning in consumers **(Fosse *et al.*, 2006, Vaillant *et al.*, 2004; El ham and Nahla, 2011)**.
In South Kivu between 2012 and 2014, tons of meats were destroyed by the state veterinary service as suspected to be unfit for human consumption. Formally, it was announced that the meat were destroyed as obtained by applying bad felling techniques (bad bleeding) and/or diseases such as tuberculosis, local tuberculosis, fluke, liver abscess, tapeworms and localized tuberculosis. These few statistics provide information instead of providing pleasure and joy; the meats available in the markets of Bukavu city constitute a health risk for South Kivu consumers. Hence the need to identify pathogenic bacteria in beef and to estimate the risk to consumers often persists in the consumption of meat, without checking the source and mode production or retention by the seller. To do this, it is necessary to continue work to better assess the hygienic quality of the beef carcasses meat in the distribution chain.
The main purpose of this study is to contribute to the knowledge of hygienic quality of food of animal origin to assess their risk to the health of consumers, by i) assessing the bacteriological quality of cattle meat of slaughterhouse to the point of sale and the change in the amount of microbiological germs of beef carcasses meat after transport to sales positions, 2i) counting the total load aerobic mesophilic flora from the same carcasses and 3i) the identification and isolation of pathogenic bacteria of beef and identifying potential health risks to humans eating them.

MATERIALS AND METHODS

South-Kivu province and study sites

South Kivu is located in the eastern Democratic Republic of Congo, approximately 1°36' and 5°51' South latitude on the one hand and 26°47' and 29°20' longitude East of somewhere else. The province is limited to the East by the Republic of Rwanda, which it is separated by Ruzizi River and Lake Kivu, Burundi and Tanzania, which it is separated by Lake Tanganyika. The study has been carried out in the provincial capital of Bukavu, specifically in each slaughterhouse three

communes to the city, including the commune of Bagira, Kadutu and Ibanda (Figure 1).
Meat samples were collected in slaughterhouses, butcher shops and other places of distributions available in the middle.
The public slaughterhouse of Bukavu/Elakat located in Ibanda commune, precisely to Ruzizi II border to the east, separating province of the Republic of Rwanda; is the most slaughterhouse visited by the sellers. CIRIRI suburban abattoir is built opposite the first road to Walungu territory, on the hill overlooking Bukavu town between Mulwa and Ciriri neighborhoods in Bagira town. The Brasserie slaughterhouse built in front of Brasserie Bralima on leading road to Pharmakina society, commune Kadutu. And Bagira slaughterhouse is located in the area A just below Bagira central market in Bagira town are of beef production reference sites before sampling.

Materials

The appreciation of hygienic quality of fresh beef along the sales chain was conducted from January 1st to June 28, 2015 on 78 meat samples from 26 animals (i.e. 3 sites sampling per carcass/animal) slaughtered in Bukavu abattoirs, South Kivu province. After weighing and stamping, half carcasses were packed in jute bags before being transported outside the slaughterhouse, on foot, by bike or in a taxi to sales positions. Sometimes, some butchers (sellers) carried the naked carcasses and does not packed up. Once the position of sale, carcasses were unpacked and placed on tables where they were fragmented bone and gradually to room temperature, to be sold by the kilogram in Butchery shops or sold by estimating the amount in others local urban markets. They were well kept at that temperature all day or until their complete sale. The investigation of hygienic quality appreciation of meat was designed according to the approaches described by **Abbey Avery and Borlaug-Ruan (2004)**.

Methodology

Sampling of beef carcass meat

The samples were taken two days a week for 6 weeks because of the slaughter by slaughterhouse days per week. The day of sampling varied every Monday and Thursday of the week so that the results are representative of the whole week. The sampling periods were: (1) to slaughterhouse after the post mortem inspection, (2) the sales positions just after the transportation and installation of meat on the stalls, (3) and at mid-day selling around 15 hours, eight hours after slaughter. The sampling technique was identical for all samples and was made according to **ISO 17604 (2003)**. Many sample copies were made per site each day on field visit.
Four samples of 5 cm and a maximum thickness of 1 cm each were made by half-carcass. The destructive method was performed using a punch of 2.5 cm in diameter to define the surface to be sampled. This sampling was done using a clamp and a blade mounted single use of a scalpel handle. The day before, the sampling equipment was sterilized pastor oven and the day of sampling, the punch was sterilized with the flame from the alcohol burnt before each operation. The samples at the slaughterhouse were carried out after post-mortem inspection on five different half-carcasses. The carcasses were randomly selected (beginning, middle and end of slaughter chain) and alternated so as to have a carcass right and a left half carcass. The sampling sites were respectively: the collar, the shoulder and the side (Figure 1).
Once installed on the table in butcher shops or sales positions, new samples were immediately carried out on the same carcasses after transport; but this time on neighborhoods (1/4 carcass) carcasses previously taken to slaughterhouses. The samples were taken right next to the previous locations. A third sample was taken on the remains of neighborhoods that made the second sample objects, time after 8 hours am sales operations and handling of meat. This time, the levy sites varied from one district to another made of the latter are gradually broken up for sale. A total of four samples were collected by half-carcass including two by neighborhood. Samples taken by carcasses were deposited together aseptically in a pre-identified bag, closed and placed in a cooler where the temperature was maintained between 0 and 4 °C. After the samples at slaughterhouses and those just after the transportation, the samples collected were immediately brought back to the microbiology laboratory of Bukavu Institute of Higher Education in Medical Techniques “ISTM-Bukavu" for possible bacteriological analysis. The last samples were also reduced in the same laboratory at about 15 hours. Before analysis, the samples were kept at 4°C in the laboratory. Bacteriological analyzes were performed within 24 hours after collection. For these analyzes, a volume of 100 ml of previously sterilized peptone water was introduced into each stomacher bag containing the total sample size of 20 cm^2. The whole was milled for 2 to 3 minutes in the Stomacher. The supernatant was collected in a sterile bottle and was the stock solution 100. The different dilutions were made from the stock solution. Counting the isolation and identification of germs sought were well done and in accordance with ISO 6887-2 **(ISO, 2004)**.
The germs were sought total mesophilic aerobic flora (FAMT), *Enterobacteriaceae* and *salmonella* that are the three indicators of the health of the slaughter process **(European Commission, 2005)**, *Pseudomonas* which are indicators of psychotropic spoilage of meat and organisms that can grow on the meat stored at room temperature (0°C to 30°C), *Escherichia coli* providing information on the conditions of slaughter **(Cartier, 1990)** and the enumeration of pathogens such as *Staphylococcus* and *Clostridium perfringens*. Samples taken in the morning were always stocked in the afternoon of the collection day. The FMAT was seeded, incubated at 30°C and refined in accordance with ISO 4833 **(ISO, 2003)**; the *Enterobacteriaceae* sought in accordance with ISO 21528-2 **(ISO, 2004)**; *Salmonella* sought in accordance with ISO 6579 **(ISO, 2002)**; Suspected pathogenic staphylococci in accordance with ISO 6888-1 **(ISO, 2003)**, *Clostridium perfringens* in accordance with the ISO 7937 standard **(ISO, 2005)** and finally *Escherichia coli* in accordance with ISO 7251 **(ISO, 2005)**. These different methods of microbiological analysis of bovine animals’ meat presented above are already used by **Salifou *et al.* (2013), Laila *et al.* (2016) and Dennai *et al.* (2001)**.
For each microorganism being sought, the results were expressed as colony forming unit (CFU) to 10g of carcasses and sampled in accordance with specific ISO standard every germ for quantitative research and in the absence or presence of germs for qualitative research. The average costs were calculated daily, sampling period and each germ.

Statistical analysis

The procedure of Generalized Linear Models (Proc GLM) of SAS (Statistical Analysis System, version11 (2013) USA was used for analysis of variance. The sampling period (abattoir, transport and butchery shop), the sampling day (Monday and Thursday) and the position of the carcasses (beginning, middle and end) were used as a source of variation. The significance of the effect sampling period or day effect sampling position or effect slaughter chain was determined by *F*-test. The position of the carcasses on the slaughter chain was not significant and therefore was not considered in the analysis model. The mean and standard deviations of counted nuclei were calculated and compared in pairs by the Student *t*-test. The chi-square, X^2-test was used to know the difference in the distribution of different frequencies or bacterial loads in different sampled carcasses.
To this end, the chi-square test (in MINITAB ver.17) was applied in order to want to know if there was a significant association between the frequency of observations (counts) of microorganisms and different sampling sites samples of meat. The *Z*-tailed test was used to compare the frequencies in pairs.

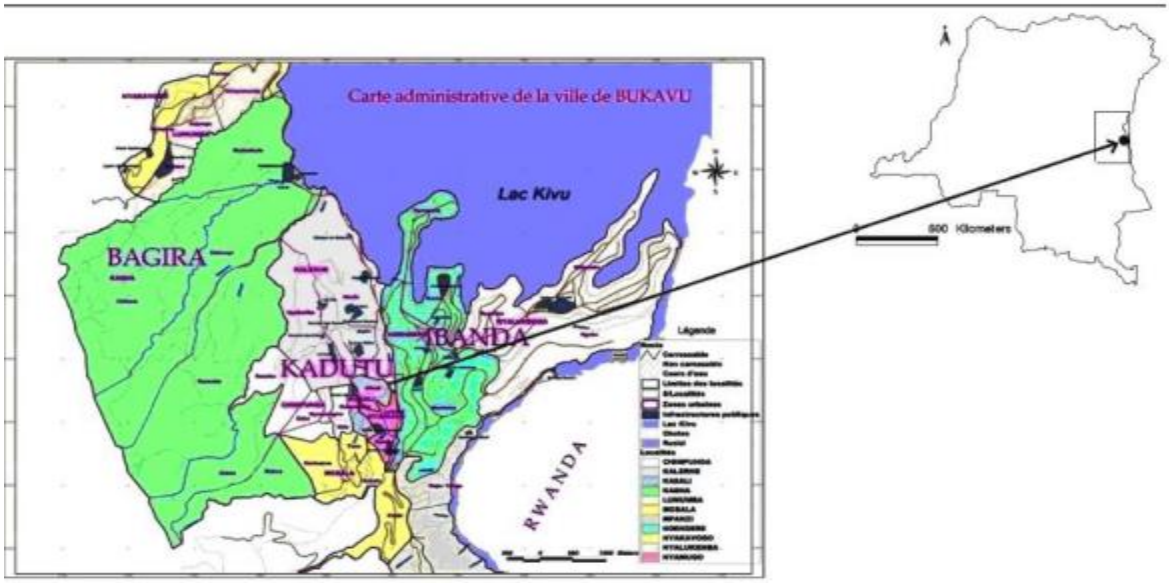

Figure 1 Map showing the administrative division of Bukavu town: the study sites are successively represented

RESULTS AND DISCUSSION

The results of this investigation show off the sanitary quality of fresh meat from bovine animals slaughtered in Bukavu urban slaughterhouses, South Kivu along sales chain is poor and the degree of contamination by pathogenic bacteria is a potential risk of exposure to diseases among consumers.

At the end of bacteriological analyzes of 78 meat samples from 26 animals (carcasses) slaughtered in the slaughterhouses of Bukavu town, South Kivu province, various pathogenic bacteria were identified present in half-carcasses of fresh meat from cattle collected by slaughterhouse, where the variation of bacterial load is a slaughterhouse function of where took sample place in the distribution and sampling day.

Bacteriological quality of beef carcass meat sold in slaughterhouses, butchery shops and on the shelves of Bukavu markets

At the end of bacteriological analyzes performed on the half-carcasses of fresh cattle meats, different pathogenic bacteria have been identified in samples of beef collected by slaughterhouse, where the variation of bacterial load is a function of the slaughterhouse and from where took place the sample in the distribution ($p<0.001$).

It is apparent five groups of bacteria isolated in beef carcass meat, distributed according to slaughterhouse and the sampling period, including: Flora Mesophilic Aerobic Total (FMAT), total coliforms with the species identified and isolated *Escherichia coli* and other Enterobacteriaceae, Pseudomonas with the species *Pseudomonas aeruginosa*, staphylococci (micrococcaceae) with *Staphylococcus aureus*, Negative Staphylococcus Coagulase (NSC) and Salmonella (Enterobacteriaceae) with two important pathogenic species identified; *Salmonella typhimurium* and *Salmonella enterica*. There is also the presence of other unspecified Salmonella and Enterobacteriaceae. Table 1-4 shows the different identified bacteria and charge along the three periods of samples.

The charge in bacterial load periods following meat samples in urban slaughterhouses Bukavu South Kivu are not surprising; they have been highlighted repeatedly in different African slaughterhouses by **Kebede in (1986)** and **Ibrahim (1992)** for Dakar, Senegal; **Krubwa (2002)** to DR Congo; **Bouchra *et al.* (1998)** for Rabat, Morocco; **Dennaï *et al.* (2001)** for Kenitra in Morocco; **Sallam and Samejima (2004)** for Egypt; **El Hadef *et al.* (2005)** for Algerian urban slaughterhouses; **ANSSA, (2007)** for Mali; **Mbawala et al. (2010)** for Ngaoundere city slaughterhouses in Cameroon**; Salifou *et al.* (2010, 2013)** and **Agossa (2010)** for Cotonou-Porto-Novo slaughterhouses in Benin; **Arua Odwar *et al.* (2014)** in their microbiological quality study of chicken meat in Nairobi, Kenya and recently **Laila *et al.* (2016)** for Fez city of Morocco slaughterhouses.

After counting, isolation and identification of germs, it is clear from these study five groups of bacteria contaminating the beef urban slaughterhouses in the sales chain. These bacteria are distributed according to the slaughterhouse, the sampling period and the sampling days are: Flora Mesophilic Aerobic Total (FMAT), total coliforms with the species identified and isolated *Escherichia coli* and other Enterobacteriaceae, *Pseudomonas* with *Pseudomonas aeruginosa* species, staphylococci *(micrococcaceae)* with *Staphylococcus aureus* and other Negative Staphylococci Coagulase (NSC) and Salmonella *(Enterobacteriaceae)* with two important pathogenic species identified; *Salmonella typhimurium* and *Salmonella enterica*. There is also the presence of other unspecified Salmonella and Enterobacteriaceae in this study. Table 1-4 shows various identified bacteria and charge along the three periods of samples.

In the following paragraphs, we will consider successively these various pathogenic microbial species affecting the hygienic quality (microbiological) meat and assess their potential health risks to consumers, by comparison of our results with that of the available literature.

The charge in *Pseudomonas* (*Pseudomonas aeruginosa*) is important in meat produced at Ciriri and Bagira slaughterhouse. This charge amounted to the market at the end of transportation to butchery shop ($p<0.001$). Furthermore, this bacterial species was not identified in the meat produced in Elakat slaughterhouse, reason for which daily variation of the analysis of their office in carcasses slaughterhouse was not performed. But it is present in beef meat of Brasserie slaughterhouse and of local butcheries selling during transport of the carcass Chi^{2}: 300; $p<0.001$).

This lack of *Pseudomonas* in the samples is explained by the made the slaughter of an animal in good conditions (absence of stress in animals) causes glycogenolysis which subsequently produced lactic acid inhibitory effect on the development of spoilage bacteria *(Clostridium* and *Pseudomonas)* **(Mbawala *et al.*, 2010;. Varnam and Sutherland, 1995)**. The *Pseudomonas* is a Gram-negative bacilli localized to the skin of the animal and facilitating the surface putrefaction of fresh meat stored in a humid atmosphere **(Laila *et al.*, 2016)**. According **Sallam and Samejima (2004)**, P. *aeruginosa* are loads of carcasses at slaughterhouses in Egypt and during transport have been low compared to that enumerated in the butchery. *Pseudomonas* observed carcasses to the butchery denotes a secondary contamination that may be disfavor good preservation of meat in time and therefore to changes in organoleptic characteristics.

Table 1 Quantity variation of microbiological germs carcasses according to the sampling period of Elakat slaughterhouse

	Bacteria (CFU/10g of meat)	**Movement levied meat**					***X²*-test**
		After slaughter	**Transport**		**Mi-sales**		
		Collection sites					
Groups	**Species**	**Abat.**	**Buch.**	**Markt.**	**Buch.**	**Markt.**	***X²***
FMAT	-	192	90	102	92	100	64.90**
Total Coliforms	*Escherichia coli*	134	66	68	60	74	45.91**
	Other *enterobacteria*	134	66	68	60	74	45.91**
Staphylococci (Micrococaceaea)	NSC	210	92	100	141	51	121.87**
	Staphylococcus aureus	91	61	164	132	141	57.88**
Salmonella (Enterobacteriaceae)	*Salmonella typhimurium*	240	100	140	160	168	64.67**
	Salmonella enterica	283	159	138	162	182	70.49**
	Others *Salmonella*	216	264	210	199	170	21.98**

Legend: *FMAT: Flora Mesophilic Aerobic Total; NSC: Negative Staphylococci Coagulase; CFU: Colony Forming Units, DF= 4; different significance levels of the X²-test variable association *p<0.05; **p<0.001; otherwise it is not significant when the value obtained in X² is followed by no asterisk (p>0.05). Other: undetermined species; Abat. : Abattoir/slaughterhouse; Buch. : Butchery; Markt. : Market*

Table 2 Quantity variation of microbiological germs carcasses according to the sampling period of Ciriri slaughterhouse

	Bacteria (CFU/10g meat)	**Movement levied meat**					***x²*-test**
		After slaughter	**Transport**		**Mi-sales**		
		Collection sites					
Groups	**Species**	**Abat.**	**Buch.**	**Markt.**	**Buch.**	**Markt.**	***x²***
FMAT	-	160	142	118	136	130	7032
	Coliforms	582	144	138	140	142	678.9**
Total coliforms	*Escherichia coli*	160	66	166	138	124	48.84**
	Other *enterobacteria*	222	82	132	120	118	80.87**
Pseudomonas	*Pseudomonas aeruginosa*	220	100	120	60	120	112.3**
Staphylococci	NSC	140	130	144	98	30	82.91**
(Micrococaceaea)	*Staphylococcus aureus*	240	180	92	130	47	164.2**
Salmonella	*Salmonella enterica*	120	128	1136	144	148	2393**
(Enterobacteriaceae)	Other *Salmonella*	800	162	226	442	226	740.3**

Table 3 Quantity variation of microbiological germs carcasses according to the sampling period of Brasserie slaughterhouse

	Bacteria (CFU/10g of meat)	**Movement levied meat**					***x²*-test**
		After slaughter	**Transport**		**Mi-sales**		
		Collection sites					
Groups	**Species**	**Abat.**	**Buch.**	**Markt.**	**Buch.**	**Markt.**	***x²***
FMAT	-	186	70	116	189	197	82.91**
	Coliforms	200	199	101	164	136	44.96**
Total coliforms	*Escherichia coli*	100	144	182	134	192	37.1**
	Other *enterobacteria*	100	58	70	68	60	16.02*
Pseudomonas	*Pseudomonas aeruginosa*	100	100	0	0	0	300**
Staphylacocci	NSC	343	166	194	152	70	214.7**
(Micrococaceaea)	*Staphylococcus aureus*	120	56	154	152	170	63.15**
Salmonella	*Salmonella enterica*	160	210	150	120	140	28.97**
(Enterobacteriaceae)	Other *Salmonella*	100	140	160	150	150	15.71*

Table 4 Quantity variation of microbiological germs carcasses according to the sampling period of Bagira slaughterhouse

	Bacteria (CFU/10 g of meat)	**Movement levied meat**					**X²-test**
		After slaughter	**Transport**		**Mi-sales**		
		Collection sites					
Groups	**Species**	**Abat.**	**Buch.**	**Markt.**	**Buch.**	**Markt.**	***X²***
FMAT	-	403	152	251	150	253	176.5**
	Coliforms	245	100	145	99	146	96.07**
Total coliforms	*Escherichia coli*	100	60	140	142	158	52.73**
	Other *enterobacteria*	214	60	140	58	56	186.9**
Pseudomonas	*Pseudomonas aeruginosa*	140	91	93	62	182	78.99**
Staphylococci	NSC	252	101	142	126	42	177.9**
(Micrococaceaea)	*Staphylococcus aureus*	188	130	58	133	55	112.6**
Salmonella	*Salmonella enterica*	160	120	140	50	110	59.66**
(Enterobacteriaceae)	Other *Salmonella*	146	142	142	126	144	1829**

Level contamination of beef depending on the sampling day, type of identified bacteria and samples from the sites on carcass distributed in slaughterhouses

In the sample set, the charge in Flora Mesophilic Aerobic Total (FMAT) has varied according to the slaughterhouse and periods of samples (p<0.001). The meat taken to the slaughterhouse, immediately after slaughter to the point of sale is much more loaded in aerobic mesophilic flora in the slaughterhouse and the market at the end of transportation to butchery shop Chi²: 64.90; 82.91 and 176.5; p<0.001) for meat produced at Elakat, Brasserie and Bagira slaughterhouse respectively. By cons, to Ciriri slaughterhouse the FMAT load amounted is more to the slaughterhouse and butchery shop that market, but this change is not significant in terms of sampling period's Chi²: 7.032, p>0.05). Charge in FMAT also varied depending on the sampling date, sampling sites on the carcass of cattle and the slaughterhouse where the removal occurred (p<0.0001). In all slaughterhouses, the highest contamination were obtained on Thursday with a significant variation as slaughterhouses and analyzed portions (p<0.001). Except for the collar when the low contamination level was obtained on Monday, but no significant association with the slaughterhouse where the sampling took place Chi²: 8.78; p=0.032) (Table 5).

The **Salifou *et al.* (2013)** study on bacteriological quality of fresh beef meat from slaughtered in Cotonou-Porto-Novo abattoirs, Benin during distribution chain exhibited as compared to the sampling period, FAM identified in half-carcasses of fresh beef meat was counted more butchery shop and end transportation than to the slaughterhouse. Its results expressed as log CFU/g or log CFU/cm², indicate that the average values found in the slaughterhouse together spread a fairly high degree of contamination of the sampled carcasses. Loads Carcass aerobic mesophilic flora found in this research are slightly higher than that found in the municipal slaughterhouse of Kenitra in Morocco on 32 sampled carcasses (5.15 log CFU/g) by **Dennaï *et al.* (2001)** and lower than that registered by **Oumokhtar *et al.* (1998)** on 20 samples of meat from the slaughterhouse Rabat (8.109 CFU/g). The work of **Salifou *et al.* (2012)** on the hygiene of slaughter process in the Cotonou-Porto-Novo slaughterhouses gave an average disburden of 3.0 ± 0.12 log CFU/cm² November-December 2009 and 5.09 ± 0.16 log CFU/cm² November-December 2010 for mesophilic aerobic flora. The results obtained by **Salifou *et al.* (2012)** are lower than those obtained in this study.

According to Regulation No. 2073/2005 of the European Union **(Commission EU, 2005)**, these results are not satisfactory and sign of poor hygiene of sampled cattle carcasses. The high load FMA observed at slaughterhouse, during transport and slaughter indicates both a defective general hygiene carcass involving non-compliance and secondly the effectiveness of sanitary measures seem not satisfactory in the slaughterhouse and in the distribution chain.

In fact, the slaughterhouse is one of the major critical points of Meat Hygiene and slaughter is considered the stage where the greatest opportunities for contamination exist (80 to 90% of micro-flora meat reaching the consumers result of contamination occurring at the slaughterhouse) **(Jouve, 1990)**. FMAT among the microorganisms that can affect the health of consumers by causing food borne poisoning and may alter the organoleptic characteristics of the carcasses **(valiant *et al.*, 2004; Fosse *et al.*, 2006; Laila *et al.*, 2016)**.

Gradual increase in average microbial load observed by sampling period shows the effectiveness of further contamination of carcasses at their exit from the slaughterhouse on the one hand and contamination related to transportation, the conservation mode (no cold) and manipulations (cuts, etc.) on the other. The significant difference observed between the charge raised for slaughterhouse and that recorded the butchery shop shows that the sanitary quality of meat available to consumers, even if it is not already acceptable to the release of slaughterhouse is much influenced by the steps downstream of the carcass production chain. This increased load microorganism is due to the operations of cutting and sales that contribute (through the tools used, the type of packaging and labor) to the contamination of new surfaces such as bare. These findings are consistent with observations made by other authors in their old notes **(Bryan *et al.*, 1988; Ekanem , 1985)**, they have noticed that in developing countries, the lack of hygiene producers and distributors of meat, the exposure of food to dust and flies promotes contamination by pathogenic microorganisms. Moreover, the first food material can be contaminated from the start or during processing by pathogenic bacteria and thus present a risk to the consumers health **(Bryan, 1988).**

A high content FMAT may be accompanied by an early spoilage of the meat. However, unlike **Letouze *et al.*, (1986)**, which notes the lack of relationship between the load FMAT and probable time of occurrence of alteration phenomenon, by an assumption that it is the result of specific bacterial proliferation germs showing a part of the total flora.

The high loads FMAT in urban slaughterhouse cattle meat Bukavu-South Kivu can also be explained by the fact that the slaughterhouse of Bukavu are part of non-mechanized slaughterhouses and fixed phones, where the realization of bleeding and all animal carcass transformations and fifth district are in the same location following a handcrafted model. It is likely that corrective/preventive measures such as the introduction of chain and rigorous cleaning work system of the equipment used will lower sensibly the total bacterial load.

The charge in load FMAT depending on the day of sampling shows instability in the working method. The highest rates recorded almost on weekends (Thursday) confirm the hypothesis of **Salifou *et al.* (2010)**; assumption that the hygienic quality of slaughter process on the last day of the week is influenced by the number of animals slaughtered that day and that is almost double the usual slaughter capacity of slaughterhouses; these are not functional on Sundays and other days of the week not presented in this study.

Table 5 Charge in Aerobic Mesophilic Flora (CFU/10g) of carcasses slaughterhouse where sampling took place

Day and websites taken	Names of slaughterhouse where sampling took place				Statistics *Chi*²-test)		
	Elakat	Ciriri	Brasserie	Bagira	*DF*	X^2	*P*
1. Flank	Total Aerobic Mesophilic per abat./day						
Monday	100	148	140	100	3	16131	0.001
Thursday	103	166	230	267	3	81802	<0.0001
2. Shoulder							
Monday	194	242	306	280	3	27847	<0.0002
Thursday	298	220	230	184	3	29202	<0.0003
3. Necklace							
Monday	191	250	230	240	3	8.7849	0.032
Thursday	290	160	226	232	3	37374	<0.0001

Loads of total coliforms in meat (*Escherichia coli* and other Enterobacteriaceae) are as high as for FMAT to abattoir and the market at the end of transportation to butchery (p<0.001). E. *coli* is the most dominant of all slaughterhouses and significantly varied in all periods of samples (p<0.001; Table 1-4 above). For meat taken at shoulder and collar of the carcass of cattle slaughter, the high contamination was obtained on Monday and is associated with the four slaughterhouses samples (p<0.0001). By cons, there is a contamination of carcasses taken sides, but there is no association between variation in the bacterial load of the carcass flanks and sampling slaughterhouse (Monday X^2: 3.351, p=0.341 and Thursday X^2: 9.047; p=0.029) (Table 6).

Like FMAT, loads of total coliforms in meat (*Escherichia coli* and other *Enterobacteriaceae*) are as high and vary from period to period (p<0.001). Total *coliforms* and others *enterobacteria* were counted more for slaughterhouse and the market at the end of transmission and the lowest load were obtained at butchery shop. These germs respectively provide information about the state of freshness of meat and on the conditions of slaughter **(Cartier, 1990)**. Fecal coliforms other categories of coliform live in the intestines of humans and animals, their presence result of bad conditions during the slaughter process **(Collobert *et al.*, 2002)**. In four abattoirs in the Calvados department, **Collobert *et al.* (2002)** reported an average contamination of 1.42 logs CFU/cm² for *Enterobacteriaceae* of 233 slaughtered cattle carcasses. Similarly, **Vallotton (2004)** reports that 70% of carcasses have load total coliforms below 1.5 log CFU/cm² and 30% have a load of between 1.5 and 4 log CFU/cm².

Variation charges in total coliform fillers and other enterobacteria obtained in this study according to the sampling periods is different from that obtained by **Salifou *et al.* (2013)** who discovers in slaughterhouses Cotonou-Porto-Novo, Benin that the charges in enterobacteria were least counted for slaughterhouse than at the end of transport, while the load in the highest enterobacteria was obtained at the butcher shop.

The charges in enterobacteria observed in this study are largely above those obtained by **Collobert *et al.* (2002)** and **Vallotton (2004)** after conversion of CFU/10g values in log CFU/g or log CFU/cm². According to Regulation No. 2073/2005 of the European Union **(European Commission, 2005)**, charges coliform and other enterobacteria exceed the maximum threshold allowed (2.5 log CFU/cm²) for that quality is satisfactory. Although the majority of these germs are considered non-pathogenic, they can in some cases be responsible for gastroenteritis disorders in humans, such as E. *coli* 0157: H7 **(Levine *et al.*, 1991)**.

Escherichia coli (coliform) specie is the most dominant of all slaughterhouses and studied varied significantly in all periods of samples (p<0.001). These results are contradictory to those of **Salifou *et al.* (2013)**, which indicate in his study that the average load of E. *coli* has not changed a sampling period the other, however, it notes a trend, the charge in E. *coli* increases to abattoir for butchery without, however, significant differences.

Presence of coliform bacteria in all samples taken at the slaughterhouse shows a poor condition slaughter. The mean values obtained in this study are much higher than that found by **Sumner *et al.* (2003)** in South Australia. In 1268 carcasses examined, E. *coli* is observed in 10% in Australia **(Phillips *et al.*, 2001)**. In the United States, 44% of beef carcasses meat examined were positive for E. *coli* **(Siragusa et al., 1998)**.

For meat taken at shoulder and necklace carcass cattle slaughterhouse where sampling has taken place, the high contamination was obtained on Monday and is associated with the four slaughterhouses samples (p<0.0001). By cons, there is a contamination of carcasses taken sides, but there is no association between variation in the bacterial load of the carcass flanks and sampling slaughterhouse (Monday $X^{2:}$ 3.3515, p=0.341 and Thursday $X^{2:}$ 9.0473; p=0.029). For cons, the outcomes of the study **Salifou *et al.* (2013)** reveal daily loads *Enterobacteriaceae* that have not varied from one day to the other at the slaughterhouse and during transport.

If at butchery, charging in total *coliforms* varied significantly from one day to another, it is because hygiene conditions fluctuate from day to day. According **Collobert *et al.* (2007)**, high loads in mesophilic aerobic flora and total *coliforms* and others *enterobacteria* are due to a failure of cleaning and disinfection of equipment cutting cycle. In most of our butchers, hardware is just flushed at the end of the day. If we should note the absence of period effect coupled with the presence of day effect to the butchery would prove that the biggest in total *coliform* contaminations are brought to slaughterhouse. Their presence attests contamination from the poor condition of slaughter definitely associated with poor post-slaughter handling. The hygiene risks associated with the presence of *Escherichia coli* in the meat and meat products are a public health problem with serious **(Cohen and Karib, 2006; Dennaï *et al.*, 2001)**. Coliforms are a considerable portion in the FMAT in this study.

Table 6 Load Variation total coliforms and other enterobacteria (CFU/10g) of carcasses by slaughterhouse which took place the taking

Day and websites taken	Names of slaughterhouse where sampling took place				Statistics Chi²-test		
	Elakat	Ciriri	Brasserie	Bagira	*DF*	X^2	*P*
1. Flank	Total Aerobic Mesophilic per abat./day						
Monday	136	152	136	162	3	3.3515	0.341
Thursday	130	147	130	100	3	9.0473	0.029
2. Shoulder							
Monday	140	148	128	300	3	110.19	<0.0001
Thursday	130	150	124	200	3	23,656	<0.0001
3. Necklace							
Monday	230	143	240	250	3	33,635	<0.0001
Thursday	164	242	242	110	3	65873	<0.0001

Staphylococci also exhibit great variability in the slaughterhouse that in mid-sale (p<0.001). The distribution is significantly varied according to the three periods of samples. Negative Staphylococci Coagulase dominate position in the contamination of cattle carcasses meat followed by *Staphylococcus aureus*, ranging according to the slaughterhouse and periods of samples (p<0.001). Loads counted staphylococci isolated and identified in each of the parts analyzed and the sampling date have varied from the slaughterhouse where the sample held in the other (p<0.0001). Null charge in staphylococci were obtained daily samples and are based on sampling sites on the carcass at Elakat slaughterhouse and the highest load was obtained on Monday and Thursday during transport (Table 7).

These samples could be contaminated with *Staphylococcus aureus* carriers in the various manipulations by distributors. Added to this is the contamination by the animal. The muscle superficially soiled, lets indeed easily penetrate deeply by these microorganisms during cutting. If storage at room temperature is extended, meat and meat products can promote the proliferation of S. *aureus* toxin production then causing poisoning that can be sometimes serious **(Dannai *et al.*, 2001)**.

However, an increasing trend (0.66 germs/g at the slaughterhouse, 5.0 germs/g after transport and 5.66 germs/g butchery) was obtained by **Agossa (2010)** reflecting contamination by man whenever the carcass in contact with the latter in particular during transport and skinning. Research *Staphylococcus aureus* on local beef at retail outlets and Dakar consumption showed that 42% of carcasses were positive **(Wade, 1992)**. But the contamination is often secondary as *Staphylococcus aureus* is a germ of human contamination to the poor hygiene on. **Laila *et al.* (2016)** in his study on the evaluation of the hygienic quality of meat and certain meat products taken from the city of Fez, Morocco concerning *Staphylococcus aureus*, the results show an absence of this bacteria in the pieces of meat beef, liver, poultry and meats. While poultry meat, poultry products and beef liver were contaminated with S. *aureus* and non-compliance rates vary from one category to another and the high percentage is observed in poultry sausages.

Table 7 Load Variation staphylococci (CFU/10g) of carcasses slaughterhouse where sampling took place

Day and websites taken	Names slaughterhouse where sampling took place				Statistics Chi²-test)		
	Elakat	Ciriri	Brasserie	Bagira	*DF*	X^2	*P*
1. Flank	Total Aerobic Mesophilic per abat./day						
Monday	0	253	268	250	3	257.97	<0.0001
Thursday	0	256	300	238	3	274.92	<0.0001
2. Shoulder							
Monday	0	364	254	215	3	335.01	<0.0001
Thursday	0	254	242	99	3	298.32	<0.0001
3. Necklace							
Monday	0	200	243	300	3	274.76	<0.0001
Thursday	0	210	344	236	3	314.47	<0.0001

Loads counted staphylococci isolated and identified in each of the parts analyzed and the sampling date have varied from the slaughterhouse where the sample held in the other (P<0.0001). Null loads staphylococci were obtained daily samples in Elakat slaughterhouse specifically, they are based on samples from the carcass and the highest load sites were obtained on Monday and Thursday during transport in other slaughterhouses. **Salifou *et al.* (2013)** by cons, when it discovers to in his study that the average load staph has not changed a sampling location to another. He adds that no significant difference was observed between the different average loads observed the slaughterhouse staphylococci and at the butchery shop.

Staphylococcus aureus among the microorganisms which can touch consumer health by causing poisoning food-borne and those that can alter organoleptic characteristics of the carcasses. Among bacterial pathogens include *Salmonella spp, Staphylococcus aureus, Listeria monocytogenes, Yersinia enterocolitica* **(Cottin, 1988; Fournaud and Jouve, 200; Dickson and Anderson, 1992)**.

Cases of *Salmonella* have been enumerated, identified and isolated in the beef carcasses meat along periods of samples with a significant variation slaughterhouses during transport in butcheries or for mid-sale (p<0.001). Loads salmonella in parts of the considered frame (flank, shoulder and necklace) are fatal and vary daily sampling according to the slaughterhouse. Although the trend contamination degree of carcass shoulder is increasing day by sampling and varies along the sales chain based on each slaughterhouse, no significant difference was observed between these frequencies (p>0.05; Table 8). Salmonella species

identified were: *Salmonella typhimurium*, *Salmonella enterica* and *Salmonella* spp.
These results demonstrate, contrary to **Salifou et al. (2010)** results, *Salmonella* spp. is common in the beef carcasses meat to Bukavu-South Kivu slaughterhouses. The research results of Laila al., 2016 spread *salmonella* presence in all categories of raw meat. According to **Ghafir and Daube, (2007)**, poultry and especially eggs and beef carcasses meat, is the main source of human cases of salmonellosis. This is in agreement with our results.
In member countries of the **European Union (2004)** and as part of monitoring the product contamination meat with salmonella, many studies have been conducted for the detection of *Salmonella* in beef. The prevalence varied by country: 0.8% in Greece (n=516), 2% in Ireland (n=2176), 3% in Spain (n=233), 3.86% in Hungary (n=1558) and 0.3% in Italy (n=153) **(EFSA, 2006)**.
Loads salmonella in parts of the considered frame (flank, shoulder and necklace) are fatal and vary daily sampling according to the slaughterhouse. Although the trend degree of shoulder carcass contamination is increasing day by sampling and varies along the sales chain based on each slaughterhouse, no significant difference was observed between these frequencies ($p>0.05$). Salmonella species identified were: *Salmonella typhimurium*, *Salmonella enterica* and *Salmonella* spp. These results show that the surface of carcasses does contain salmonella, which can vary depending on the contamination site **(Hinton *et al.*, 1998)** or sampling. **Phillip *et al.* (2001)** detected salmonella in 0.2% of sampled carcasses and 0.1% of boneless beef in Australia.
In another study, **Van *et al.* (2005)** have highlighted the emergence of *Salmonella enteritidis* in industry poultry and the danger for the consumer it may cause. Indeed, All salmonella serotypes may in theory cause a systemic infection in humans to decreased immune status, while most will generate feverish diarrhea, vomiting, abdominal pain and in the elderly or immuno-défiscients bacteraemia, septicemia and extraintestinal maps, in particular vascular **(Baumler *et al.*, 2000)** .The lack of hygiene on farms and in slaughterhouses and the use of broad-spectrum antibiotics are the most important factors contamination **(Korsac *et al.*, 2004)**.
The lack of significant difference between the sampling day the number of *Salmonella* spp. isolated by period and sampling sites in this study does not rule on the effectiveness of further contamination to that recorded at the slaughterhouse despite the trend. However, the health risk is for consumers.
These observations show how many times the hygienic quality freshly slaughtered beef meat to urban slaughterhouses Bukavu, South Kivu and sold in markets and butcheries from Bukavu prone to bacterial contamination in disturbing thresholds for the health of consumers, from the slaughterhouse to the place of sale.

Daily absence of certain bacteria such as *Pseudomonas* and *Staphylococcus* our abattoir samples does not necessarily imply the absence of the surface of carcasses tested, but would especially at a sampling problem as their distribution can be so punctual that we were able to miss them by taking some tattered and not others; some authors believe that it is not desirable to use them as hygienic quality indicator slaughterhouse meat **(Stolle, 1988)**.
The impact of this research to the population of Bukavu is that it permeates to the community of the dangers to the development of bacteria on beef and state veterinary service to know the hygienic quality of meat produced in slaughterhouses and sold to urban markets.
Finally, this study which was limited to a category of animal food products should continue to lead to the evaluation of the full microbiological quality of other meat and meat products consumed by the population of Bukavu city, South Kivu province in eastern Congo. We have reviewed the estimation of potential health risks spanned by the consumption of beef contaminated the population of Bukavu, but the specifics of these hazards for humans were identified by **Fosse *et al.* (2006)** cattle slaughterhouse of the Great West region of France who discovers twenty-five biological hazards that can be transmitted to humans by the consumption of beef.

Table 8 Salmonella expense of Charge (UFC/10g) of carcasses slaughterhouse where sampling took place

Day and websites taken	Names slaughterhouse where sampling took place				Statistics Chi²-test)		
	Elakat	Ciriri	Brasserie	Bagira	*DF*	X^2	*P*
1. Flank	Total Aerobic Mesophilic per abat./day						
Monday	140	170	200	124	3	21,369	<0.0001
Thursday	132	100	184	139	3	25908	<0.0001
2. Shoulder							
Monday	150	180	162	145	3	4.5636	0207
Thursday	144	182	159	158	3	4.6205	0202
3. Necklace							
Monday	240	160	250	132	3	52394	<0.0001
Thursday	340	152	256	146	3	115.2	<0.0001

CONCLUSION

This study discovers the hygienic quality of fresh beef meat slaughtered in urban slaughterhouses along the sales chain that can be beneficial for limit contamination of meat and reduce health hazards transmitted to humans by the consumption of beef. This study will help the researcher to uncover the critical areas of risk analysis dimension among consumers that many researchers were not able to explore. Thus a new theory about the dangers transmitted to humans by the consumption of other contaminated meat, may be arrived at.
Worry about contributing to hygienic quality perception (microbiology) food of animal origin, in order to identify potential hazards transmitted to humans by beef consumption, by assessing the bacteriological quality of fresh beef meat from slaughterhouse to the point of sale and the amount variation of microbiological germs of beef carcasses meat after transport to sales positions (meat injurious to health); enumeration of total aerobic mesophilic flora load from the same carcasses; and by identification and isolation of beef pathogenic bacteria.
Microbiological study assessing the hygienic quality of fresh beef meat has revealed a very high degree of contamination in most samples of beef carcass meat analyzed from slaughterhouse to distribution location. The very high bacterial load of these products is observed at the slaughterhouse and the public market during carcasses transport, it is lesser at butchery shop. This charge varies as well according to slaughterhouse, site and date of collection, including public Bukavu/Elakat slaughterhouse, most visited by distributors and that of pre-urban Ciriri is the most famous. The necklace and shoulder are most contaminated sampling sites at the end of the week (Thursday) by pathogenic bacteria such as *Staphylococcus aureus*, *Salmonella* ssp., *E. coli*, *Coliforms* and other *Enterobacteria* represents a great food poisoning infection danger for consumer, hence the need to implement an effective program against the contamination of beef meat and observe hygiene from the breeding farm, abattoirs, slaughtering procedures, the method of handling meat, transportation to sale to consumers.
As for the microbial charge just after slaughter, certain conditions such as the cleanliness of the animals, respecting the water diet, hygienic condition of the slaughter premises, cleanliness knives used in the bleeding and evisceration, have an effect on the nature and number of microorganisms present in the carcasses. Hence, the decrease in fresh meat microbial load of fresh beef meat along the chain of sale would be possible by improving the hygienic conditions of the slaughterhouse, the place of sale and method of handling meat by actors (butchers and sellers) including the replacement of display and cutting taking place in the open air by the use of cold storage and packaging in bags in the refrigerator pieces of meat ready for sale. It would be important that the public be able to invest in the maintenance of good quality instead of sales to try to reduce the rate and microbial diversity on meats intended for human consumption. The control of transport conditions through the application of good hygiene practices and the temperature of respect would allow owners to avoid contamination and microbial growth in local sales outlets.

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