Scholars Academic Journal of Biosciences
Abbreviated Key Title: Sch Acad J Biosci
ISSN 2347-9515 (Print) | ISSN 2321-6883 (Online)
Journal homepage: https://saspublishers.com

OPEN ACCESS

Agriculture

Risk Factors Linked to the Beef Processing and Marketing Chain in Major Cities Representative of Côte d'Ivoire's Main Regions

Emmanuel Diane Dibi[1*], Etienne Fatogoma Silué[1], Hortense Anoumou Yao Epouse Achy[1], Clément Djédjro Akmel[2], Tano Kablan[3], Emmanuel Nogbou Assidjo[2]

[1]UFR Agriculture, Fisheries Resources and Agro Industry, Polytechnic University of San-Pedro, San-Pedro, Côte d'Ivoire
[2]UMRI Food, Chemical and Environmental Process Sciences, Institut National Polytechnique Félix Houphouët-Boigny (INPHB) Côte d'Ivoire
[3]Department of Food Science and Technology, Nangui Abrogoua University, Abidjan, Côte d'Ivoire

DOI: https://doi.org/10.36347/sajb.2025.v13i01.006 | **Received:** 24.11.2024 | **Accepted:** 29.12.2024 | **Published:** 08.01.2025

***Corresponding author:** Emmanuel Diane Dibi
UFR Agriculture, Fisheries Resources and Agro Industry, Polytechnic University of San-Pedro, San-Pedro, Côte d'Ivoire

Abstract **Original Research Article**

Inappropriate sales and processing practices in the market-to-fork beef chain were studied in major cities representative of the main regions of Côte d'Ivoire. The study was initiated to identify the risk factors associated with the processing and consumption of beef sold on Côte d'Ivoire markets. Surveys were carried out among 900 consumers, 195 butchers (fresh beef) and 195 sellers of braised beef, commonly known as *Choukouya*. The results showed that a total of 94.1% of respondents, including 45.1% of men and 54.9% of women, consumed beef, compared with 5.9% who did not. The average age of consumers was 31 ± 15 years (min > 15 years; max = 60 years). Potential risk factors for infection were the use of inadequate packaging, which was 89.6% for fresh beef and 49.3% *(Choukouya)*, and weekly consumption frequency, which was 51.3% for fresh beef and 22.5% *(Choukouya)*. The average ambient temperature was 32 ± 0.5°C. The average time taken by consumers from meat purchase to the household was two hours. 25.7% of *Choukouya* consumers and 12.9% of household-cooked beef consumers reported gastroenteritis symptoms (diarrhea, vomiting, fever) following consumption of these two culinary forms. The unhealthy environment was identified as a source of contamination at all the sites studied. Poor hygiene practices during the sale and processing of meat led to the possibility of infections such as gastroenteritis.

Keywords: Risk factors, Beef, processing, Marketing.

INTRODUCTION

Beef presents a nutritional interest given its bioavailability in mineral elements [1]. In Côte d'Ivoire, livestock farming has always been a developing economic activity, with an estimated contribution to GDP of 4.5% [2]. In particular, beef is consumed by all social strata while national production of this meat only covers 23.4% of national consumption [3, 4]. According to FAO (Food and Agriculture organization of United Nation) statistics, average meat consumption in 2009 was 13 kg per person per year in Côte d'Ivoire [5]. The marketing and processing chain in the Côte d'Ivoire beef industry, particularly in the major cities representative of the country's main regions, presents several risk factors. These risks can affect meat quality, public health, the profitability of stakeholders and the sustainability of the chain.

Criteria deemed significant for hygiene management are those that have a direct impact on product quality. They make it possible to identify the causes of non-conformities and facilitate the implementation of preventive and corrective actions [6].

Slaughterhouses and processing units often fail to comply with sanitary standards to guarantee meat quality, increasing the risk of contamination at the point of sale and processing. These risks of bacterial contamination could lead to food intoxication. The contamination of carcasses by pathogenic germs such as *Escherichia coli, Salmonella enterica, Bacillus cereus, Clostridium botulinum, C. perfringens, S. aureus, Listeria monocytogenes, Mycobacterium bovis* and *Mycobacterium tuberculosis* could result from the various operations carried out during their treatment in slaughterhouses and processing sites [7]. Also, a lack of adequate training for staff can lead to inappropriate

hygiene practices, and a lack of control by the authorities can encourage the marketing of non-compliant products. What's more, the absence of an effective cold chain during distribution leads to meat spoilage, not to mention unregulated distribution channels which can increase the risk of contamination at the point of sale, resulting in poor-quality meat. Microbial loads can reach values of 10^4 to 10^6 bacteria, as the microbial flora of the skin of animals and handlers depends on the environment, such as soil, dust, air, water and hygiene [8]. Many meat breeders and processors operating in large cities are small, informal structures. As such, they may have a low level of professionalization, which can lead to poor risk management. Corruption within local authorities, particularly in the slaughtering and distribution sectors, can lead to non-compliance with health standards and the marketing of contaminated meat. However, health and veterinary authorities may be understaffed to ensure regular inspections and strict enforcement of hygiene and food safety regulations. It should also be noted that the lack of adequate infrastructures to maintain a constant temperature throughout the distribution chain, from slaughter to sale, can compromise meat quality and create health risks. Much of the meat sold in large cities comes from the informal market, making it difficult to regulate prices and guarantee quality. This can also encourage the sale of poor-quality or illegal meat.

The general state of hygiene in the marketing process for fresh and braised "*Choukouya"* beef in Côte d'Ivoire's major cities is unsatisfactory, due to undesirable contamination of the product [9]. Most breeders and traders (butchers and vendors after cooking the product) are not aware of good hygiene practices [10]. And the precarious slaughtering conditions observed in the meat industry have a negative impact on the quality of beef sold on the various markets. In addition, the fact that it is marketed fresh, and after cooking in contact with the often-unhealthy environment, makes the product vulnerable to microorganisms that could be responsible for intoxication [11, 12]. What's more, meat's biochemical composition generally makes it an excellent substrate for the proliferation of microbial flora when handled or stored under poor hygienic conditions [13, 14].

It is well known that a dangerous agent present in food can induce adverse effects on human health, leading to hospitalization and complications. The aim of this study is therefore to identify risk factors in the marketing of beef, to reduce the incidence of food contamination at meat product distribution points in major cities, and to draw the attention of the authorities to the need to guarantee food safety.

MATERIAL AND METHODS

Study Site

The study was carried out in major cities representative of the main regions of Côte d'Ivoire (Figure 1). These were Korhogo (Poro region), Daloa (Haut Sassandra region), Bouaké (Gbêkê region), Yamoussoukro (Yamoussoukro District), Abengourou (Indénié Djuablin region) and Abidjan (Autonomous District). These towns were chosen because of their high population density and importance in terms of beef supply, as well as the willingness of beef chain stakeholders (butchers and sellers) to take part in the study.

Inquiry Form

The socio-demographic survey involved the development and use of a questionnaire on the socio-demographic characteristics of beef consumers, butchers and sellers of braised beef *"Choukouya"* in the various study sites (Abidjan, Bouaké, Yamoussoukro, Daloa, Abengourou, Korhogo).

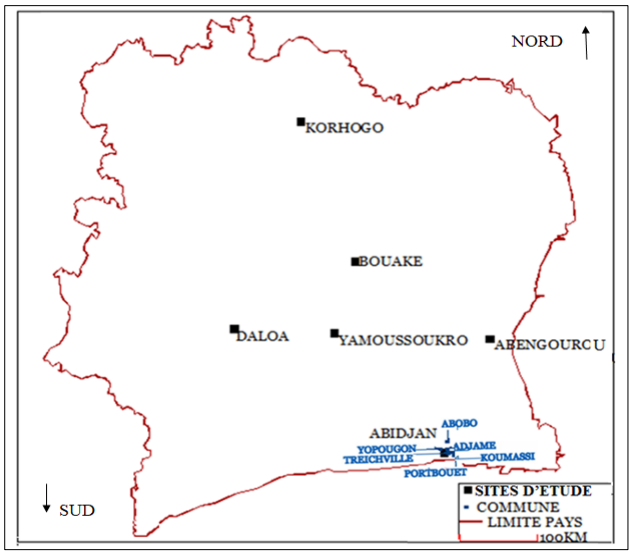

Figure 1: Map of Côte d'Ivoire showing the different towns surveyed by beef sellers and consumers

Consumer and Vendor Sample Sizes

The sample size of consumers to be surveyed was calculated on the basis of the percentage of beef consumers in Côte d'Ivoire derived from national consumption data, which is estimated at 23.4% [3]. This consumption was calculated according to the formula described for an independent, non-exhaustive sample [15].

$$n = t^2 . \frac{p.(1-p)}{e^2} \qquad (1)$$

With **n:** sample size, **e:** margin of error, **t:** margin coefficient deduced from confidence rate, **p:** proportion of beef consumers in Côte d'Ivoire. For **t** = 1.96: **p** = 0.234 and **e** = 0.05 the sample size is:

$$(1,96)^2 x\ 0,234\ x\ (1-\ 0,234)\ /\ (0,05)^2 = 276$$

In this study, the minimum sample size calculated for a representative sample is 276. This number was maximized to obtain a wider distribution of data. Thus, for the survey, nine hundred (900) consumers were interviewed.

Vendor sample sizes were estimated using the [16] equation, for a 95% confidence interval with a precision (d) of 5%. The calculation was based on an independent, non-exhaustive sample. The prevalence of germs in target products is unknown.

$$N = \varepsilon . \frac{pq}{d^2} \qquad (2)$$

N : Sample size
P : Proportion or prevalence
q = 1-p
ε =1.96 (reduced deviation) for α = 5%.
d : precision considered at 5%.

As the prevalence of vendors is unknown in Côte d'Ivoire, the values of p and q were set so that p = 50% and q = 50%. Thus, the minimum sample size calculated for a representative sample is 384 (three hundred and eighty-four). For the survey, 390 (three hundred and ninety) vendors were selected for the study.

Vendor Surveys

Choukouya butchers and vendors were surveyed on site using a single-pass questionnaire. In all, one hundred and ninety-five (195) butchers and one hundred and ninety-five (195) *Choukouya* vendors were surveyed, with twenty-five (25) per category per site (Korhogo, Bouaké, Daloa, Yamoussoukro, Abengourou) and thirty-five (35) per category per site for Abidjan-North and Abidjan-Sud. As it was not possible to gather twenty-five (25) or thirty-five (35) vendors in a single market or street in the different sites, the selection of twenty-five (25) or thirty-five (35) vendors was divided according to meat type respectively. The number of vendors and butchers was selected from the three (3) busiest markets and three (3) busiest streets. In the case of *Choukouya*, street vendors were included. In line with Codex Alimentarius recommendations on food hygiene, the questionnaire for meat vendors covered 2 areas: meat provenance and sales practices (several observations were made on vendors' behavior). At the same time, a survey of housewives was carried out to find out their habits when purchasing foodstuffs at the various markets in the study sites. A total of 390 housewives were interviewed.

Consumer Surveys

A survey of beef consumers was carried out at the seven sites selected for the study. The survey took place in the busiest markets and streets in the various towns. Its purpose was to gather information on the frequency and quantity of meat consumed, and the impact of beef consumption on consumer health. Thus, the questionnaire includes in the first section (i) basic socio-demographic information (age, sex, level of education and field of activity); in the second section (ii), the quantity of meat consumed and the frequency of beef consumption, and finally in the third section (iii), the adverse effects following meat consumption. At the end of the survey, 900 people were interviewed, 100 for each town and 200 for each part of Abidjan. The method consists of interviewing at least 100 people to predict the attitudes of the target population [17]. Beef and non-beef consumers over the age of 15 were surveyed.

Survey of Storage Temperatures in Households and Among Meat Sellers

Using a thermometer, temperature measurements were taken to determine the ambient temperatures at the time of sale and the storage temperatures in the refrigerators of various households. The survey was carried out during the day between 12pm and 2pm. The thermometer was inserted into the household refrigerator in the part reserved for meat preservation for 30 minutes. For vendors, measurements were taken in the open air in an environment close to the point of sale. Cooking temperatures were set at 100°C, as this temperature is the boiling point of water.

Determination of Critical Infection Risk Points Based on Survey Results

The fault tree of events that can lead to gastroenteritis was constructed following a survey of events occurring from the purchase of beef to its consumption, including the practices and behavior of sellers. This schematic model summarizes all the combinations of these events [18]. These combinations of events could lead to the contraction of infection linked to beef consumption.

Microbiological Analysis

Fresh and braised beef samples were collected from 27 vendors at all sites. Three campaigns were conducted per site, and a total of 180 braised beef samples were collected. One hundred and eighty-nine (189) samples were collected from all sites. For each campaign, nine (09) samples of approximately 100 g of beef were taken from each vendor at each site. The ideal conditions to ensure sample preservation were rapid

transport in a cooler containing cold packs, to maintain the temperature at less than 5˚C. In the laboratory, 10 g of each sample was homogenized in 90 ml of sterile bacteriological peptone (Oxoid, Hampshire, England). Decimal dilutions (1:10) of all samples were made in buffered peptone water (BioRad). *Staphylococcus aureus* enumeration was performed [19]. Sulfite-reducing anaerobes were counted as a presumptive count of *C. perfringens*. Vegetative forms were counted [20]. The average load of samples analyzed was calculated [21].

Statistical Analysis

Statistical analyses were performed using the STATISTICA 7.1 program. Sociodemographic survey data were entered using IBM SPSS Statistics 20.0 data processing software (IBM Corpration, Spss Inc, Chicago, USA) and transferred to Excel. Non-parametric tests that do not take the mean into account were applied to test the variability of microbiological parameters between different localities. These were the Kruskal-Wallis test (a non-parametric alternative to the one-factor ANOVA 1) followed by the multiple comparison of ranks test. The significance level of the probability value for this test is $p < 0.05$.

RESULTS

Socio-Demographic Characteristics of Consumers and Risk Factors for Beef Contamination

The socio-demographic characteristics of beef consumers were determined following a consumption survey, the results of which are presented in Table I. A total of 94.1% of respondents, including 45.1% men and 54.9% women, consumed beef, compared with 5.9% who did not. The average age of consumers is 31 ± 15 years (min > 15 years; max = 60 years). They come from all social strata, with a predominance of university-educated workers (46%). Consumers with no schooling but working in odd jobs accounted for 17.1% of those surveyed. The highest proportions of users were found among young people aged 20 to 30 (47%) and adults aged 30 to 50 (41.6%). Young people under the age of 20 account for only 6.4% of consumers, while older people over 50 make up only 5% of beef consumers.

Table 1: Socio-demographic characteristics of people surveyed for consumption at all study sites

Consumer characteristics	Workforce	Percentage (%)
Beef consumption	***n =900***	
Yes	847	94,1
No	53	5,9
Gender	***n =847***	
Male	382	45,1
Female	465	54,9
Academic level	***n =847***	
Out of school	145	17,1
Primary	109	12,9
Secondary	203	24
University	390	46,0
Age	***n =847***	
< 20 ans	54	6,4
20 - 30 ans	398	47,0
30 - 50 ans	353	41,6
> 50 ans	42	5,0
Minimum age	15 ans	
Maximum age	60 ans	
Average age	31 ± 15 ans	

n : sample

Risk Factors for Contamination

Consumer Risk Factors for Beef Contamination

Behaviors likely to promote contamination of fresh or braised beef are shown in Table II. Following the survey, it was noted that while buying food at the market, the meat was found in the household basket with other foodstuffs. Thus, 37.6% of consumers stated that there was direct contact between the beef purchased and the vegetables and other foods in the basket during shopping. On the other hand, the majority (62.3%) answered in the negative. Also, when buying fresh beef (BF) at the different sites, the average ambient temperature was equal to 32 ± 0.5°C. The average time taken by consumers from the purchase of the meat to the household was two hours.

Table II: Different factors in the contamination of BF by housewives

Contamination factors	**Workforce**	**Prevalence (%)**
BF	***n= 390***	
Contact between beef and other foods		
Yes	147	37,6
No	243	62,3
Average time from purchase to household		
2 ± 0,2 heure		
Average ambient temperature during sale		
32± 0,5°C		

BF : fresh beef

Time-Temperature Profile of the Different Stages in the Traceability of Fresh Beef

These different stages, i.e. end of transport (M1), end of storage (M2) and end of cooking (M3), were conducted as a function of time and temperature. The time-temperature profiles used for these stages are: 2.4 ± 0.6 h; 29.9 ± 2.9°C for transport (M1), 11.9 ± 7.5 days; 5.5 ± 4.9°C for storage (M2) and 2.0 ± 0.5 h - 100 ± 0°C for cooking (M3) **(Table III)**.

Table III: Average times and temperatures for the various stages of the journey taken by fresh beef

Stages					
Transport (M1)		Storage (M2)		Cooking (M3)	
t (hour) T (°C)		t (day) T (°C)		t (hour) T (°C)	
2,4 ± 0,6	29,9 ± 2,9	11,9 ± 7,5	5,5 ± 4,9	2,0 ± 0,5	100 ± 0

t : time T = Temperature

Risk Factors for Contamination of Fresh Beef and *Choukouya* Observed at Vendor Level

The various factors likely to promote contamination of fresh or braised beef are listed in Table IV. The majority of butchers declared that they pack their meat in cement paper (89.5%) or teak sheets (10.5%). Furthermore, 74.3% of butchers do not have a refrigerator to maintain the cold chain for meat, while 25.7% use refrigerators to maintain the cold chain and reduce the risk of meat spoilage. Furthermore, when meat is cooked in the braised *"Choukouya"* form, it is packaged in various types of packaging, either cement paper (49.3%) or aluminum foil (18.2%). Those who eat *Choukouya* sold by the roadside are often served on the spot, in plastic plates (21.3%). The various sales outlets were found to be in poorly maintained environments, with the meat exposed to the open air (82.5%), while only 17.5% of outlets were protected by display windows. Most vendors wore smocks and had access to drinking water this represented 79.7% for fresh beef (BF), compared with only 23.3% for braised beef (BB).

Table IV: Different factors in the contamination of BF and Choukouya by vendors

Contamination factors	**Staff**	**Prevalence (%)**
Fresh beef (BF)	***n= 390***	
Packaging mode		
Cement bag paper	349	89,5
Teak leaf	41	10,5
Cold chain at points of sale	**Yes**	**No**
	290 (74,3)	77 (25,7)
Origin of fresh beef		
Slaughterhouse	89(22,8)	
Place of killing	301(77,2)	
Average ambient temperature at time of purchase	32 ± 0,5°C	
***Choukouya* (BB)**	***n= 390***	
Type of utensils and packaging used		
Plastic	83	21,3
Aluminum	44	11,2
Cement bag paper	192	49,3
Aluminum foil	70	18,2
Point-of-sale system	***n= 390***	
Displayed in the open air	322	82,5
Protected in display case	68	17,5
Wearing a smock	**Yes**	**No**
BF Seller	311 (79,7)	79 (20,3)
BB Seller	91 (23,3)	299 (76,7)

BF : Fresh beef; BB= Braised beef

Beef Consumption Pattern and Frequency

Information Fresh beef purchased on the markets is prepared in the form of cooked beef in sauce in households, under undefined conditions of cooking time and temperature. The consumer survey shows that only 25.6% of those surveyed prefer to eat it cooked in sauce, while 74.4% prefer it braised *"Choukouya"*.

Consumption frequency varies by household. The consumption survey also showed that 17.9% of individuals surveyed ate fresh beef cooked in sauce every day (7 times a week), compared with 51.3% weekly (1 time a week) and 30.8% three to four times a week. Among *Choukouya* consumers, 12.8% ate it more than three times a week, while 41.5% ate it occasionally.

Table V: Beef consumption habits

Parameters	**Consumption mode and frequency**	**Number (%)**	
Mode de consommation *number (n=847)*	cooked Beef in sauce (BFc)	217 (25,6)	
	Braised beef (BB)	630 (74,4)	
		BFc BB	
Consumption frequency	Occasionally (1 time / month)	0 (0)	261 (41,5)
	Every two weeks	0 (0)	146 (23,2)
	Weekly	111 (51,3)	142 (22,5)
	More than seven times in four weeks	0 (0)	81 (12,8)
	Three to four times a week	67 (30,8)	0 (0)
	Every day	39 (17,9)	0 (0)

BFc : Cooked fresh beef; BB : Braised beef

Prevalence of Gastroenteritis Risk Indicator Germs in Beef

Contamination of Fresh Beef by *Staphylococcus Aureus* and *Clostridium Perfringens* at the Sites

Maximum loads of *S. aureus* were observed in fresh beef sold in Bouaké, Yamoussoukro, Daloa and Abengourou ($2{,}10^7$ CFU/g). On the other hand, minimum quantities were recorded for fresh beef sold in Abidjan-North and Korhogo ($3{,}10^5$ CFU/g). However, for C. perfringens, minimum loads were observed in Abidjan-North and Abidjan-Sud (0 CFU/g), while maximum loads were recorded in Bouaké and Abengourou ($2{,}10^7$ CFU/g). In terms of S. aureus, there was no difference between sites. For *C. perfringens*, there was a significant difference between sites. This difference was found between Abidjan-North and Daloa, but was not observed at the other sites.

Tableau VI: Minimum and maximum bacteria load values in BF

	Bacterial load (CFU/g)			
Sites	***Staphylococcus aureus***		***Clostridium perfringens***	
	Min - Max	**Mediane**	**Min - Max**	**Mediane**
Abidjan-Nord	3.10^5 -1.10^7	1.10^{7a}	$0 – 1.10^7$	4.10^{5a}
Abidjan-Sud	11.10^6– 17.10^6	15.10^{6a}	$0– 1.10^7$	9.10^{6ac}
Bouaké	1.10^7– 2.10^7	1.10^{7a}	1.10^4 – 2.10^7	1.10^{7ac}
Yamoussoukro	9.10^6– 2.10^7	1.10^{7a}	9.10^5 – 1.10^7	1.10^{7ac}
Daloa	1.10^7– 2.10^7	1.10^{7a}	9.10^5– 1.10^7	1.10^{7bc}
Abengourou	1.10^6– 2.10^7	1.10^{7a}	8.10^4– 2.10^7	1.10^{6ac}
Korhogo	3.10^5 -1.10^7	1.10^{7a}	5.10^3– 1.10^7	1.10^{7ac}

Values with the same letters are not significantly different at the 5% level ($p > 0.05$) and those with different letters indicate a significant difference at the 5% level ($p < 0.05$).

Contamination of *Choukouya* (BB) by *Staphylococcus Aureus* and *Clostridium Perfringens* at the Sites

Minimum contamination levels were observed in *Choukouya* sold in Abidjan-Sud, Yamoussoukro and Daloa (0 CFU/g). On the other hand, maximum loads were recorded in *Choukouya* sold in Abidjan-North, Abidjan-South, Bouaké and Yamoussoukro, with a value of 1,107 CFU/g for *S. aureus*. Similarly for *C. perfringens*, the minimum load values are more or less the same at 0 CFU/g, with maximum loads of $1{,}10^7$ CFU/g reported for *Choukouya* sold in Abidjan-Sud, Bouaké and Yamoussoukro. There was therefore no difference in *S. aureus* loads between sites. With regard to *C. perfringens*, the Kruskal-Wallis test ((H (6, N= 189); W = 8.924; p = 0.177)) showed that no significant difference was observed.

Table VII: Minimum and maximum bacterial load values in *Choukouya*

	Bacterial load in (CFU/g)			
Sites	***Staphylococcus aureus***		***Clostridium perfringens***	
	Min - Max	**Mediane**	**Min - Max**	**Mediane**
Abidjan-Nord	1.10^4– 1.10^7	1.10^{6a}	0– 6.10^5	4.10^{5a}
Abidjan-Sud	0 – 1.10^7	4.10^{4a}	0– 1.10^7	2.10^{4a}
Bouaké	2.10^5– 1.10^7	4.10^{5a}	0– 1.10^7	2.10^{5a}
Yamoussoukro	0 – 1.10^7	1.10^{5a}	0– 1.10^7	$4.10^{5\,a}$
Daloa	0 – 7.10^5	$3.10^{4\,a}$	0– 6.10^5	1.10^{4a}
Abengourou	1.10^4– 1.10^6	$5.10^{5\,a}$	0– 5.10^5	2.10^{5a}
Korhogo	5.10^3– 8.10^5	$4.10^{5\,a}$	0– 6.10^5	1.10^{5a}

Alphabetical letters (a) in the table indicate that there was no significant difference in germs between sites.

Event Tree Identifying Critical Contamination Risk Points

Microbiological analyses confirmed the presence of the pathogenic germs *S. aureus* and *C. perfringens* in fresh beef and *Choukouya*. According to the consumers who took part in the survey, the inadequate practices of vendors observed during preparation and sale could lead to contamination of the meat, thus posing a public health problem. In addition to this remark, a group of consumers decried the poor personal hygiene observed among butchers and *"Choukouya"* sellers. All these vendors do not observe the rules of hygiene that could attract customers on a massive scale. These events could allow bacteria to grow to unacceptable levels. If the meat does not meet microbiological quality standards, it is unfit for consumption and particularly risky for sensitive consumers, especially children, pregnant women, the elderly and the immuno-depressed. "The consumer can also be the source of contamination, because after purchase, beef can undergo poor treatment before and after cooking", said one survey participant. Furthermore, if beef is undercooked, it can lead to gastro-enteritis linked to pathogenic germs. However, prolonged cooking at adequate temperatures above boiling points could reduce the risk of gastroenteritis (Figure 2).

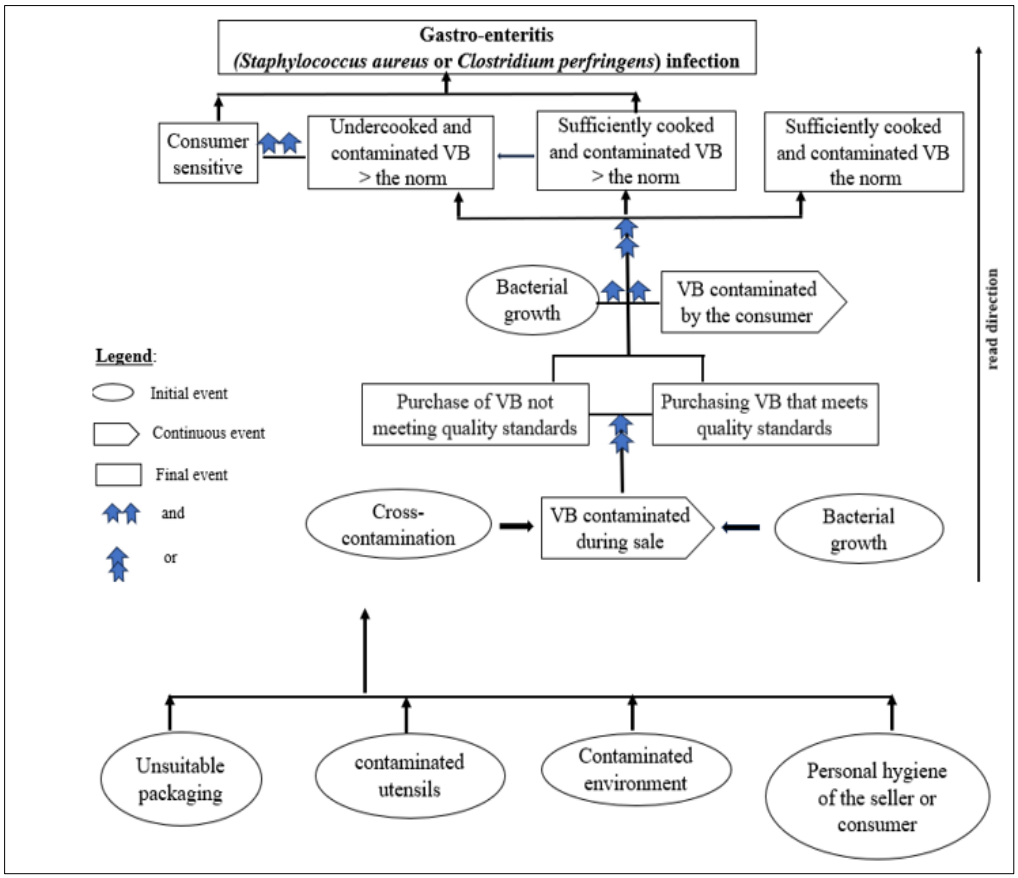

Figure 2: Fault tree for gastroenteritis linked to the consumption of beef (cooked in sauce and braised "Choukouya") contaminated with pathogenic germs

VB: Beef; **Norme: 10 ^{4} UFC/g. Sensitive consumers:** children, pregnant women, the elderly, the immunocompromised.

Gastroenteritis Symptoms Observed in Beef Consumers

Table VIII shows the percentage of consumers with gastroenteritis symptoms that could be linked to the consumption of beef cooked in sauce and braised beef *(Choukouya)*. Potential previous symptoms associated with food poisoning related to the consumption of these two types of beef were reported by 12.9% and 25.7% of BFc and BB consumers respectively. The three main symptoms reported were diarrhea, vomiting and fever. In both cases of consumption, diarrhea was the most frequently mentioned symptom, with respective prevalences of 76.5% for BF cooked in households and 46.4% for BB or *Choukouya*.

Table VIII: Gastroenteritis symptoms following ingestion of contaminated beef

Parameters	**Consumer *n= 630***	**Prevalence (%)**	**Consumer *n= 217***	**Prevalence (%)**
	BFc		**BB**	
Not sick	468	74,3	189	87,1
Sick	162	25,7	28	12,9
Reported symptoms	***n= 162***		***n= 28***	
Diarrhea	124	76,5	13	46,4
Fever	21	12,9	3	10,8
Vomiting	10	6,3	6	21,5
Fever + Vomiting	5	3,1	5	17,8
Diarrhea + Vomiting + Fever	2	1,2	1	3,5

BFc: Cooked fresh beef; BB : Braised beef

DISCUSSION

The results of the survey on beef consumption in the two forms studied (fresh beef and *Choukouya*) clearly show that this foodstuff is consumed by 94.1% of the populations surveyed at the various study sites. The highest proportions of consumers were observed among young people aged 20 to 30, with a frequency of 47%, and among adults aged 30 to 40, with a frequency of 41.6%. This rate is higher than that determined where 70% of consumers are from all social categories for an age between 4 and 80 years with 49% of young people whose age is between 20 and 35 years [10]. These results show that beef is part of the country's eating habits. In cattle and sheep farming, sensory quality is the primary guide to feed choice for these animals [22]. Calf diet has a significant impact on meat quality [3]. Thus, an increase in certain levels of fatty acids of interest, vitamin B2 and health indicators is observed. It should also be noted that the government has made livestock farming a key national interest [24]. This dynamic, whose main objective was food self-sufficiency in animal protein, has produced positive results in several regions of Côte d'Ivoire. The presence of several cattle farms in these regions offers the population the opportunity to consume beef, especially given its relatively low cost of between 1,500 and 2,500 FCFA/kg, which is considered affordable in the major production zones of northern, central and central-eastern Côte d'Ivoire. Various factors contributing to the risk of beef contamination and therefore to consumer exposure were identified in this study. Beef's contact with other foods in the household basket, packaging (unhygienic packaging and utensils), storage conditions (at room temperature) and after-sales storage, notably the absence of a cold chain, point-of-sale facilities and the wearing of gowns as opposed to personal hygiene, all contribute to contamination. Exposure of fresh beef to other foods in the market basket reported by 37.6% of housewives is a key factor in cross-contamination. However, certain ingredients used to season the various dishes could also be sources of contamination. Indeed, authors reported in one study an increased number of Salmonella contaminations linked to dried spices [25]. Also, microbiological analysis carried out at critical control points during the preparation of chicken meals in a hospital, showed bacterial contamination of onions, eggs and spices in addition to the raw material used [26]. Cement paper is used by 89.5% of butchers and 49.3% of *Choukouya* vendors, to package beef for purchase. However, this type of wrapping encourages the possibility of contamination by germs, including certain pathogens, before and after cooking. This practice was observed in studies, where cement paper was used for 59.5% of the packaging [10]. It should be noted that cement paper and teak leaves are preferred for beef packaging, as they have a low cost and are easily accessible to all beef sellers. The average ambient temperature was 32 ± 0.5°C, and the average time taken by consumers from the purchase of the meat to the household was two hours. Thus, fresh beef is sold all day long at room temperature, and the temperature is likely to rise from the warm hours onwards. This results in the growth of microorganisms already present in the meat, according to their respective optimal growth temperatures, since human pathogenic microorganisms grow easily at 37°C.

Product quality controls include a period of product ageing at a refrigeration temperature of 4°C, with a possible temperature break at 8°C if the products are destined directly for consumers, as indicated in Technical Instruction DGAL/SDSSA/2019-861 [27].

These temperatures, between 25 and 33°C, favour a doubling in the number of germs every 20 minutes [28]. In their study of the bacterial quality of red

meat and offal (beef), the authors had already pointed out that the highest bacterial populations are observed during the warm season, when ambient temperatures are high, at around 36°C. However, basically, meat can deteriorate during transport, especially during hot periods, as the absence of a refrigerated transport system for meat between cattle slaughtering areas and urban consumption centers would represent a major risk [29]. Furthermore, exposure of fresh and braised beef to the open air and poorly maintained sales areas, as observed in 82.5% of vendors, is a major factor in contamination. Bacteria are ubiquitous in the environment and can be easily isolated from dust. What's more, the processing of the two types of beef and the way they are sold on the different sites encourage the presence and development of bacterial germs, which could be the cause of product spoilage [30]. The use of display cases could considerably reduce the level of contamination. Alongside the use of showcases, the wearing of smocks by the majority of butchers (79.7%) is an attitude to be promoted among *Choukouya* sellers, who do not use them frequently. However, it could help to limit human contamination of meat due to inadequate personal hygiene. The results of the microbiological analysis showed that there was no variability in germ concentrations for the majority of sampling sites. No significant differences were observed for the *Choukouya* samples. However, in the fresh beef samples from the different sites, the loads of C. perfringens varied from one site to another. This variability is significant between Abidjan-North and Daloa. Furthermore, exposure of fresh and braised beef to the open air and poorly maintained sales areas, as observed in 82.5% of vendors, is a major factor in contamination. Bacteria are ubiquitous in the environment and can be easily isolated from dust [30]. What's more, the processing of the two types of beef and the way they are sold on the different sites encourage the presence and development of bacterial germs, which could be the cause of product spoilage. The use of display cases could considerably reduce the level of contamination. Alongside the use of showcases, the wearing of smocks by the majority of butchers (79.7%) is an attitude to be promoted among *Choukouya* sellers, who do not use them frequently. However, it could help to limit human contamination of meat due to inadequate personal hygiene. The results of the microbiological analysis showed that there was no variability in germ concentrations for most sampling sites. No significant differences were observed for the *Choukouya* samples. However, in the fresh beef samples from the different sites, the loads of *C. perfringens* varied from one site to another. This variability is significant between Abidjan-North and Daloa. This observation corroborates the work of authors, who counted several unprotected lettuce sales outlets in various communes of Abidjan, located near sources of contamination such as garbage cans and public toilets [31]. These unsanitary environments have an impact on the sanitary quality of produce sold nearby [32]. The maximum loads observed in fresh beef sold in Bouaké, Yamoussoukro, Daloa and Abengourou show that most study sites are located in tropical zones where average temperatures ranging from 25 to 32°C, are conducive to bacterial proliferation [33]. According to the work of some authors, staphylococci have been quantified in meat from certain South African abattoirs, with levels of $1.7.10^6$ CFU/g exceeding national recommendations of 10^2 CFU/g. Furthermore, the presence and proliferation of these microorganisms could be due to poor carcass handling practices and other factors such as dust and temperature variations during sale [34]. Thus, the health risk is high for the pathogens studied, such as *S. aureus* and *C. perfringens*, as the values obtained exceed the threshold of 10^5 CFU/g in ready-to-eat food [35].

Among the symptoms reported by consumers, diarrhoea was the most common, particularly when eating *Choukouya* (76.5%) and 46.4% when eating beef prepared in the home. Symptoms linked to the consumption of meat cooked in sauce in the household could be explained by a postponement of contamination, since most of the time the meal is consumed after a period of exposure in an environment favorable to contamination. Those linked to the consumption of *Choukouya* could be due to poor sales conditions and practices favoring more contamination [36]. Indeed, street food is much more destined for the informal sector [37, 38]. The result for the occurrence of diarrhoea among beef consumers is higher than that of the studies, who showed that, in terms of the ailments recorded, diarrhoea predominated with a frequency of 16%, compared with 10% for vomiting and 2% for fevers [10]. Also, cooked kebabs were more likely to cause diarrhea in 55.25% of cases. Diarrhoea is known to be the main symptom of toxic-infectious syndromes caused by several pathogens such as *E. coli, S. aureus, Salmonella spp*. and *Clostridium spp* [39]. Thus, *Choukouya* sold on public streets in Abidjan could cause infections in consumers. The link between beef in general and food poisoning has already been reported by several authors [40, 36].

It is important to note that household-cooked beef and *Choukouya* may not be the only foods implicated in these infections. However, they could very well contribute to them, given the poor conditions and sales practices applied to the meat, leading to contamination by pathogenic bacteria that could be toxinogenic. Thus, consuming beef under the conditions described in our study could have adverse effects on consumer health in Côte d'Ivoire, which could explain the discomfort evoked by the people surveyed.

CONCLUSION

The risks associated with the beef marketing and processing chain in Côte d'Ivoire are numerous. The study reveals that 94.1% of those surveyed consume beef. Several contamination factors, mainly linked to hygiene provisions, contribute to the deterioration in the hygienic quality of fresh and braised *"Choukouya"* beef

during marketing. Butchers and sellers of *"Choukouya*" use unhygienic practices at the point of sale. Poor practices such as selling fresh beef at room temperature, exposing *"Choukouya"* to the open air and using inadequate packaging further expose these foods to possible contamination by pathogens. Gastroenteritis linked to the consumption of beef, in the two forms studied under the conditions described in the study, is not negligible. Strengthening marketing and processing infrastructures, improving food safety standards and implementing a robust control and traceability system are crucial to mitigating these risks of contamination and gastroenteritis.

REFERENCES

1. Duchène, C., Gerard, P., & & Prigent, S. (2010). Meat today: Main nutritional characteristics. *Nutrition and dietetics notebook, 45*, 44-55.
2. MIRAH-DPP (Ministry of Animal and Fisheries Resources). (2013). 9th Conference of African Ministers in charge of Animal Resources: Livestock development policy in Côte d'Ivoire, provisional report. Planning and Programs Department. Ministry of Animal and Fisheries Resources, Abidjan, Cote d'Ivoire, 13p.
3. CNRA. (2007). Livestock production: assessment by the National Agricultural Research Centre. [On ligne]: http://www.cnra.ci/descprog.phpid=14&prog=Productions%20. (Accessed April 17, 2014).
4. Konan, R.V. (2013). Livestock financing system in Côte d'Ivoire: the case of the poultry and beef value chains in the Toumodi area. Cheikh Anta Diop University, Dakar. Interstate School of Veterinary Science and Medicine, *Presented and publicly defended*, 133.
5. Assidjo, E, Sadat, A., Akmel C., Akaki, D., Elleingand, E., & Yao, B. (2013). Risk analysis: Innovative tools for improving food safety. *African Journal of Animal Health and Production*, *11*(S), 3-13.
6. Clémence, B. T., & Christèle, P. (2024). Meat for short distribution channels: meat quality and profitability. Grand Angle Viande Conference By, Institut de l'Elevage Philippe Mauchamp, CDA Vosges, Paris, France. https://fr.slideshare.net/idele_institut_de_l_elevage
7. Salifou, C. F. A., Salifou, S., Tougan, P. U., Ahounou, G. S., & Youssao, A. K. I. (2010*). Evaluation of the hygiene of the slaughtering process at the Cotonou-Porto-Novo abattoirs using surface bacteriological examination*. 3th Journées des Sciences du Muscle et de la Technologie de la Viande, October 19 and 20, 2010 at Clermont Ferrand, France, 175-176.
8. Cuq, J. L. (2007). Food Microbiology: Microbiological control of foods, Department of Food Industry Science and Technology 4th year. University Montpellier II. *Sciences et techniques du Languedoc*, 103-104.
9. DIBI, E. A. D. B. (2020). Quantitative assessment of the risk of infection associated with the consumption of beef contaminated with *Staphylococcus aureus* or *Clostridium perfringens* in Côte d'Ivoire. Unique doctoral thesis, Université Nangui Abrogoua, Specialization: Food Science and Technology, Option: Biochemistry and Food Technology, N° 558. Defended 02/17/2020, Abidjan, Côte D'Ivoire, 198.
10. Kouassi, K. A., Dadié, A. T., N'guessan, K. F., Yao, K. C., Djè, K. M., & Loukou, Y. G. (2012). "Conditions hygiéniques des vendeurs et affections liées à la consommation de la viande bovine cuite vendue aux abords des rues de la ville d'Abidjan (Côte D'Ivoire)", *Microbiologie Hygiène Alimentaire*, *24*, 15-20.
11. Mensah, P., Owusu-Darko, K., Yeboah-Manu, D., Ablordey, A., Nkrumah, F. K., & Kamiya, H. (2002). The role of street food vendors in transmission of enteric pathogens. Ghana *Medical Journal*, *33*, 19-29.
12. Nel, S., Lues, J. F. R., Buys, E. M., & Venter, P. (2004). Bacterial populations associated with meat from the deboning room of ahigh throughput red meat abattoir. *Meat Science*, *66*, 667–674.
13. El, H., El, O. S., El, G. R., Kenana, H., & Quessy, S. (2005). Evaluation of surface contamination of bovine and ovine carcasses from the Constantine municipal slaughterhouse in Algeria. *Canadian veterinary Journal*, *46*(7), 638-640.
14. Fosse, J., Cappelier, J. M., Laroche, M., Fradin, N., Giraud, K., & Magras, C. (2006). Beef: a consumer biohazard analysis applied to the slaughterhouse. *Ruminant Research Meeting, 13*, 411-414.
15. Israël, D. G. (1992). *Determining Sample Size*. University if Florida, Facture sheet PEOP-65.
16. OMS. (1991). Manual of epidemiology for district health management. Ed. *World Health Organization*, 186.
17. Watts, B. M., Ylimaki, G. L., Jeffery, L. E., & Elias, L. G. (1991). *Basic methods for food sensory evaluation*, 159.
18. Vose, D., Acar, J., Anthony, F., Franklin, A., Gupta, R., Nicholls, T., Tamura, Y., Thompson, S., Threlfall, E. J., Van Vuuren, M., White, D. G, Wegener, H. C., & Costarrica, M. L. (2001). Antimicrobial Resistance: Risk Analysis Methodology for the PotentialImpact on Public Health of Antimicrobial Resistant Bacteria of Animal Origin. *Revue science et technique de l'Office international des Epizoties*, *20*(3), 811- 827.
19. ISO 6888-1 (V 08-014-1). (1999). Food microbiology. Horizontal method for the enumeration of coagulase-positive staphylococci (Staphylococcus aureus and other species). Part 1: Technique using Baird-Parker agar medium and Guidance for Microbiological Examinations. 3rd Edition, 66.

20. AFNOR (French Standards Association) Standard NF V 08-061 (2009). Anaerobic microbiology of sulfite-reducing germs in food, 105.
21. ISO, 7218. (2007). Microbiology of food and Animal Feeding Stuffs-General Requirements 22-Favreau-Peigné, A., Baumont, R., Ginane, C. (2012). *Food sensory characteristics*: their unconsidered roles in the feeding behaviour of domestic ruminants. Animal, doi:10.1017-S1751731112002145.
22. Farruggia, A., Ellies-Oury, M. P., Listrat, A., Bardou-Valette, S., Meteau, K., Roche, B., Couvreur, S., Graulet, B., Riga, P., Papillon, S., Chadeyron, D., Picard, B., Gruffat, D., Boutifard, V., Pousin, M., Signoret, F., Durand, D. (2023). *Maraîchine cattle breeding and beef quality*. Meat and Meat Products, VPC-2022-3843
23. UEMOA. (2000). Study on agricultural financing in UEMOA member countries. http://www.hubrural.org/IMG/pdf/uemoa, study, financing general report. pdf 167p (page consulted on December 21, 2013).
24. Vij, V., Ailes, E., Wolyniak, C., Angulo, F. J., & Klontz, K. C. (2006). Recalls of Spices due to bacterial contamination monitored by the U. S. Food and Drug Administration. The predominance of Salmonellae. *Journal of Food Protection*, *69*, 233-237.
25. Yousif, E. I., Ashoush, I. S., Donia, A. A., & Hala, G. K. A. (2013). Critical control points for preparing chicken meals in a hospital kitchen. *Annals of Agricultural Science*, *58*(2), 203-211.
26. Clémence, B. T., Marie, B., Carole, F., Pierre, L., & Sabine, J. (2024). Microbiological criteria for fresh meats: a meaning to be rediscovered, Viandes & Produits Carnés: VPC-2024-40-14 Publication date: June 7, 2024 www.viandesetproduitscarnes.fr
27. Bonfoh, B., Wasem, A., Traore, A. N., Fané, A., Spillmann, H., Simbé, C. F., Alfaroukh, I. O., Nicolet, J., Farah, Z., & Zinsstag, J. (2003). Microbiological quality of cows' milk taken at different intervals from the udder to the selling point in Bamako (Mali). *Food Control*, *14*, 495-500.
28. Cohen, N., Ennaji, H., Hassar, M., & Karib, H. (2006). The Bacterial quality of red meat andoffal in Casablanca (Morocco). *Molecular Nutrition Food Research*, *50*, 557-562.
29. Akhtar, S., Paredes, S. D., & Sarker, M. R. (2008). Inhibitory effects of polyphosphates on *C. perfringens* growth, sporulationand spore outgrowth. *Food Microbiology*, *25*, 802-808.
30. Koffi-Nevry, R., & Gohou, G. (2012). *Food hygiene and sustainable development: the impact of the invisible (microscopic) world on poverty reduction*. This version: 20.
31. Koffi-Nevry, R., & Sika, A. E. (2010). Influence of the place of sale of vegetables on the health risk associated with the consumption of tomato (Lycopersicon esculentum) and lettuce (Lactuca sativa). *DEA dissertation submitted for publication*, 55.
32. Akollor, E. (1997). Contribution to the study of the microbiological quality of chawarmas sold in Dakar fast-food outlets. *The Revue de Medecine, Dakar*, *22*(94).
33. Schmid-hempel, P., & Frank. S. A. (2007). Pathogenesis, virulence, and infective dose. *PLoS Pathogens*, *3*(10), 147.
34. Bendech, M. A. G. (2013). Street food in Bamako, Mali: issues and intervention approaches". *Mali Public Health*, *3*, 116-118.
35. Latham, M. C. (2001). Nutrition in developing countries http://www.fao.org/ DoCreP/004/W0073F/w0073f00.htm#toc. Accessed December 15, 2014
36. Coulibaly, K. R. (2015). Assessment of the risk of Salmonellosis linked to the consumption of curdled milk (artisanal fermented milk) produced in Yamoussoukro. Single doctoral thesis, Félix Houphouët Boigny University, Specialty: Biochemistry and Food Sciences, No. 984. Defended on 21/11/2015, Abidjan, Côte d', 195.
37. Oliver, S. P., Boor, K. J., Murphy, S. C., & Murinda, S. E. (2009). Food safety hazards associated with consumption of raw milk. *Foodborne Pathology Disease*, *6*(7), 793–806.
38. Cohen, N., Ennaji, H., Bouchrif. & Karib, H. (2003). The quality of meats produced in greater Casablanca, 10.
39. WHO. (2010). Basic measures to improve the safety of street food. INFOSAN Information Note No. 3/2010. Street Food Safety, Geneva, Switzerland, 6.
40. Jonkuviène, D., Salomskienė, J., Zvirdauskienė, R., & Narkevicius, R. (2012). Determining Differences in Characteristics of Bacillus cereus Isolated from Various Foods. *Veterinarijair zootechnika*, *60*, 22-29.