

Assessment of Hygiene Practices and Identification of Critical Control Points Relating to the Production of Skewered Meat Sold in N'Djamena-Chad

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Abstract

Meat is a food of choice because of its nutritional quality. Grills are regularly consumed in Africa and particularly in the Sahelian countries. These are very popular consumer products. However, they can be contaminated by various microorganisms and cause food poisoning if the meat is not handled in hygienic conditions. In order to contribute to improving the quality of these products, we have followed the steps in production of meat skewers by the method of “5M” of Ishikawa. The “HACCP decision tree” model was used to determine the Critical Control Points (CCP). Hazard Analysis Critical Control Point (HACCP) is a method and principles of management of food safety. The results of monitoring procedures for making meat skewers showed many shortcomings in hygiene. Six (06) critical points were determined. As for testing, we conducted microbiological analyzes on fifty (50) units of samples corresponding to ten (10) different types of products collected at different stages of production. Compared to AFNOR (French Association of Standardization), criteria for cooked and dehydrated soups and considering the analytical variability associated with the methods of analysis, our results indicate that the products contaminated with germs indicating failure to comply with hygiene. Samples analyzed presented at different stages of production compliance rate of 40% for total bacteria (30 °C), 30% for total coliforms and thermotolerant coliforms (44 °C). The rate of non-compliance is 40% compared with sulphite-reducing anaerobes. Molds identified in meat skewered and ingredients are *Aspergillus niger*, *Aspergillus flavus*, *Penicillium sp* and *Geotrichum sp*. Salmonella, *S. aureus* and yeasts are absent in the samples. Training on good hygiene practices is required at vendors in order to ensure the hygienic quality of grilled meats.

Keywords: meat, grilling, skewers, hygienic quality, HACCP, Chad

1. Introduction

The consumption of beef like other livestock or hunting animals in the world is very important (Chatellier et al., 2003). The meat is the main source of protein. Beef is also an important source of essential nutrients including high quality protein, iron, zinc and B vitamins. However, because of its nutritional value, meat is a favorable substrate for the development of proteolytic microorganisms (Guiraud & Galzy, 1980). Meat was traditionally considered responsible for a significant number of foodborne illnesses occurring in humans. Continuation of the problem has been amply demonstrated in recent years by monitoring studies on humans for agents in meat, such as *Escherichia coli* O157: H7, *Salmonella spp*, *Campylobacter spp*. and *Yersinia* (FAO/WHO, 2004). According to the WHO, more than four (4) billion episodes of diarrhea occur each year worldwide, mostly in developing

countries. Epidemiological data in hospital showed a prevalence of 19% of the global disease and bacterial and viral diarrhoea were estimated at 20-70% of cases (WHO, 2004). Diseases such as brucellosis caused by *Brucella*, tuberculosis caused by *Mycobacterium*, coal by *Bacillus anthracis* can be transmitted through undercooked meat. *Taenia saginata* may be provided by beef (Guiraud & Galzy, 1980). Meat may be contaminated by the dirty hands of manipulators, soils, polluted water, an unhealthy environment harboring flies and other insects (Barro et al., 2007). In most of Asia, Africa and Latin American cities, a growing number of people use for their daily food, street food, defined as Ready to Eat Foods (RTE), prepared and sold by street vendors or fixed on the street or in public places (FAO, 1988). Street foods provide about 80% of the urban population (Students, workers, unemployed, street children and traders etc.) to eat outside the home easily and low cost (Dawson, 1991). In Africa, as elsewhere, the food security in terms of health remains precarious. This situation is largely attributable to the street food including meat. This sector (street food) has many shortcomings including the anarchic occupations and unsafe places for the preparation and sale, but also and especially the problem of the sanitary quality of foods due to the non compliance or ignorance of the rules of hygiene in the preparation and sale of food (Yasmeen, 2001; Barro et al., 2002). Several studies have shown that the area of street food is growing in major and secondary cities, while the products offered are not always of good quality (Umoh & Odoba, 1999). In Chad, major part of the population dinner and lunch in street food shops. Meat is among the most popular street food. But Meat Hygiene is a challenging science with different types of risk (FAO, 2006). Also, food elaborated with satisfactory hygienic standards is one of the essential conditions for promoting and preserving health, and inadequate control is one of the factors responsible for the occurrence of foodborne disease outbreaks (Oliveira et al., 2003). Foodborne disease is caused mainly by the oral ingestion of viable microorganisms (infection) or of the toxins they produce (intoxication) in sufficient amounts to develop pathology (Souza et al., 2004). The objective of this study is to investigate on hygiene practices in order to determine the causes of contamination of meat skewers. The study also proposes to determine the CCP and bring corrective measures to improve the quality of meat skewers consumed in Chad. The results of this work could be a useful tool for information and awareness on good hygiene practices for healthy food production sold on public roads.

2. Methods

This is a descriptive study and investigation on hygiene practices in a small establishment of production of meat skewers. The establishment is located in the 5th district of the city of N'Djamena, capital of Chad. The choice of this establishment was made on this site due to regular customers looking cooked skewers. The establishment is the most popular in the city of N'Djamena. The Monitoring procedures by the principles of "5M" of Ishikawa allowed to record information about characteristic of staff and hygiene practices in the establishment. The model "decision tree" of the HACCP system (FAO, 2006; Quittet & Nelis, 1999) was used to determine the CCP. It's a point, step, or procedure at which a significant hazard occurs in food preparation and handling, and at which control can be applied to prevent, eliminate, or reduce the hazard to an acceptable level (FAO, 1993). To get an idea of the bacterial flora contaminating products, a total of fifty (50) units of samples were collected. Its five (05) units of samples corresponding to ten (10) different types of products (fresh meat, raw skewer, raw skewers soaked in water, raw skewers with ingredients, skewered cooked, powder of ingredients etc.) at the production steps of skewers. The samples of fresh meat (beef fillet in the first stage of production) units were collected using gloves, a knife and a sterile clamp and sampling held in different levels (the center and ends of the mass of meat). The same aseptic conditions were used for sample of skewers. Sample units of ingredient powders were obtained by the method of cone (quartering method). Samples are made in the required sampling conditions, then the samples packed in sterilized aluminum paper and then introduced into a cooler and transported to the laboratory. Microbiological analyzes were conducted at the Laboratory of Veterinary and Animal Research (LRVZ) Farcha and Laboratory of Microbiology and Quality Control of Foodstuffs of the High School of Biological and Food Techniques (ESTBA) at the University of Lome-Togo. Microbiological analyzes were performed according to the standard of the French Association of Standardization (AFNOR). Also supports methods for these standards are used (AFNOR, 2002). Searched germs are total mesophilic flora (Total bacteria) (30 °C) (NF.V08-051), Total coliforms 30 °C (NF.V08-050), Thermotolerant coliforms and *E. coli* (NF ISO 4831), Anaerobic Sulfite-reducing 44 °C (NF.V08-061), *S. aureus* 37°C (NF ISO 6888-1) and salmonella (AFNOR.V08-052). Also, molds and yeasts (ISO 21527) were the subject of research. Sample were performed then, after grinding with a moulinex Blender ® type 1500 rev/min, 10 g of each homogenate were suspended in 90 ml of tryptone-salt solution containing 0.03 g/l of tween 80 and then the regeneration is made for 45 min at room temperature. For the detection of salmonella, 25 g of sample of meat and ingredients are homogenized in 225 ml of Buffered Peptone Water (BPW). The count after count taking into account the dilution factor is expressed in Colony Forming Units (CFU)/g. After counting germs, mould colonies form have been isolated in pure culture by subculturing on agar OGA (Oxytetracycline Glucose Agar) and PDA (Potato Glucose Agar) for

2-6 days of incubation at 30 °C and 25 °C. After culture, moulds were identified in relation to their cultural characteristics, morphological observation by optical microscopy using the lactophenol cotton blue dye (Guiraud & Galzy, 1980). The interpretation of the results is made according to the analytical criteria of AFNOR taking into account the analytical variability associated with the methods of analysis. Data on staff characteristics were analyzed using Excel software. Statistical analysis was performed using the chi-square test (χ^2) for comparison of two variables. Differences were considered significant when $P \leq 0.05$.

3. Results

3.1 Monitoring the steps for the production of meat skewers

The boneless beef meat is used for making skewers. Using a knife, the meat is cleaned of film, set nets and then cut into pieces, small pieces of meat are placed in string. Skewer thus obtained is then sprinkled with a mixture of ingredients (ginger, pepper, salt and in large part groundnut cake). Then producers pressed the flat with hand on the tray or the table. It is watered from time to time in peanut oil. The weight of a skewer is about 20 grams. The cooking is done on a circular grill supported by brick: the light located approximately one meter from the grill. In other respects, the cooking is done on a grill with metal stand; fire is 10 or 15 cm from the grill. Skewers are then placed one by one on the grill. The fire is lit from another source of fire. During cooking, the skewers are sprayed with oil. Toasting time is estimated at 10-15 minutes and sometimes more depending on the number of skewers and fire intensity. At the end, we get cooked are tender, good, smell, yellowish to reddish color and taste. The finished products are then stored on the edge of the grill on a platter. At the request of the customer, they are served on a plate or wrapped in paper. Thus, monitoring of manufacturing steps of meat skewers has established. As shown in Tables 1 and 2, the study identified personal characteristics and hygiene of practices within the establishment. Diagram of production is shown in Figure 1. Figure 2 shows the improved diagram of meat skewers.

Table 1. Staff characteristics

STAFF	Proportionality (%) n=32
SEX	
Male (n=32)	100
AGE	
Middle age (year)	29,48 years old
Level of education	
Illiterate (n= 21)	65,62
Primary level (n= 08)	25
Secondary level (n=03)	09,37
University	None
Other training in good hygiene and good manufacturing practices	None
MEDICAL EXAMINATION	
Regular medical examination (n= 12)	37,5
Irregular medical examination (n= 20)	62,5

As shown in Table 1, the property is consists exclusively of males with an average age of 29.48 years. Most of the staff is illiterate and does not undergo medical examinations.

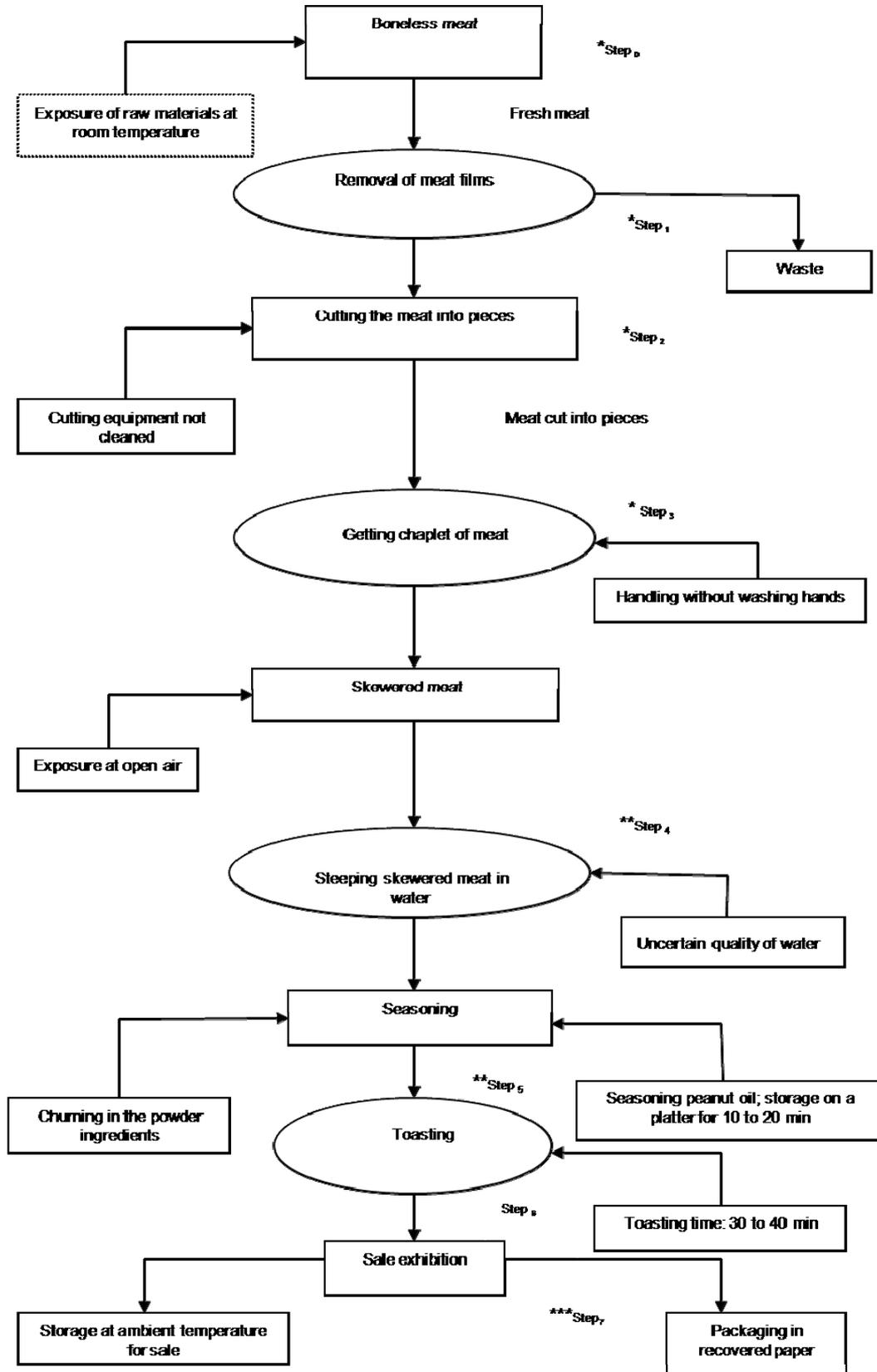


Figure 1. Process flow diagram of meat (beef) skewers

* = Intake germs; ** = Proliferation of germs *** = Recontamination of the finished product

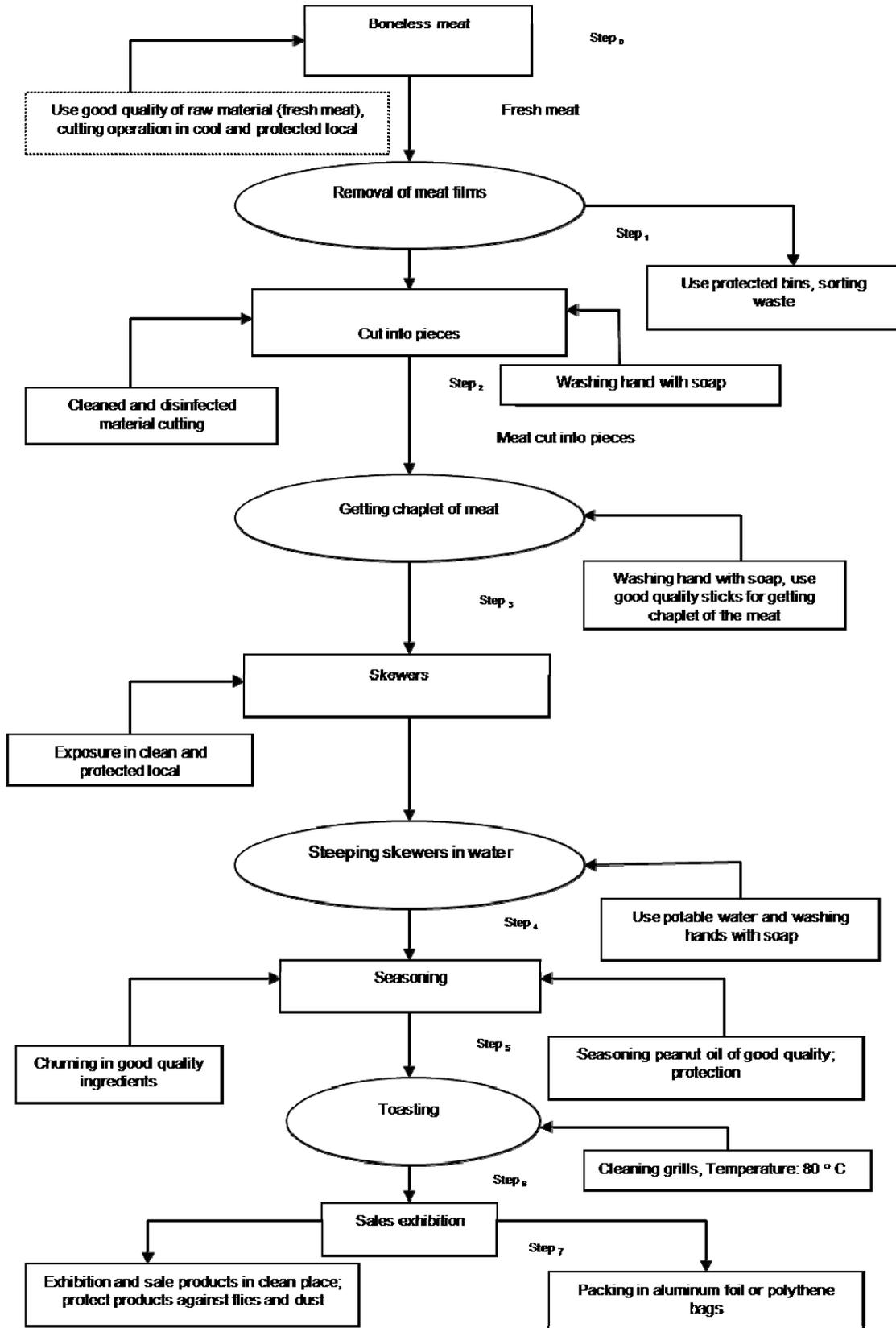


Figure 2. Improved flow diagram of meat (beef) skewers

Table 2. Evaluation of hygienic practices

CONTROL POINTS	Appreciation
HYGIENE OF STAFF	
Wearing blouse/Apron	+
Hair protection	-
Cleanliness of clothes	+
Hand washing	+
Regular medical monitoring	-
Knowledge of good hygiene practices, HACCP plan	-
SALES ENVIRONMENT	
General conception (separation of dirty / clean areas, walking forward, presence of flies and insects)	-
Environment and surroundings (accessibility, cleanliness, garbage storage)	+
State of the surfaces (integrity and cleanliness of floors, walls, doors)	+
Air systems (air quality and ventilation, risk of introducing dust, flies, other insects or spiders)	-
Water points (number, effective operation, clear separation of various non-potable water circuits)	-
Waste water (slopes, presence of areas of stagnation)	+
Cloakroom and toilets	-
UTENSILS AND OTHER MATERIALS	
State sales tables	++
State of the furnace	+
State of knives and spoons	+
Control systems (thermometers, ...)	-
Transport food (trucks and containers)	-
Waste containers (containers, garbage bags)	+
OPERATION METHODS	
Hygienic handling of food	+
Waste and by-products (storage conditions, separation of raw materials and finished products, ...)	-
Compliance with the procedure of cleaning and disinfection (before, during and after the workday)	+
Compliance with the procedure of cleaning and disinfection (before, during and after the workday)	+
RAW MATERIALS	
Quality and traceability of raw materials and ingredients (appearance, compliance, packaging, certificates of origin, storage, ...)	+
Containers and packaging (storage conditions, contact with other materials or products, ...)	-
Finished products (conformity, packaging, labeling, health brands, storage conditions, ...)	+
Management of by-products and waste (circuits, final destination, local treatment)	-
Water dishes	+

- = improper ; + = little consistent; ++ = consistent.

Table 2 shows the evaluation of hygiene practices taking into account the method of Ishikawa.

3.2 Microbiological Analysis

Microbiological analysis shows the presence of aerobic mesophilic bacteria (30 °C) with extreme values between

0.09 x 10⁵ and 304.4 x 10⁵ CFU/g for an average of 80.18 x 10⁵ CFU/g. The average germ is 175.02 x 10³ CFU/g for extreme values 0 to 0.25 x 10³ CFU/g corresponding to total coliform. For thermotolerant coliforms (44 °C), the values range from 0 to 250000 CFU/g with an average of 102713 CFU/g. Counting Sulfito-reducing anaerobes gives values between 0 and 960 CFU/g with an average value of 180 CFU/g. The number of germs varies from 0 to 5.5 x 10² CFU/g with an average of 0.74 x 10² CFU/g for moulds. *S. aureus*, *Salmonella sp* and yeasts are absent in products. Test results and compliance rates are indicated in Tables 3 and Table 4.

Table 3. Assessment of samples at different steps of production of meat skewers

types sample / step	Total germs (30 °C)	NUMBER OF GERMS CFU/g			
		Total coliform	Coliform thermotolerant (44 °C)	Sulfito- reducing anaerobes	Moulds
Fresh meat	104.4 x 10 ⁵	250 x 10 ³	250000	220	0
Raw skewer	304.4 x 10 ⁵	250 x 10 ³	250000	960	0
Raw skewers soaked in water	42.7 x 10 ⁵	250 x 10 ³	250000	0	0
Skewers of seasoned meat	150.2 x 10 ⁵	250 x 10 ³	250000	320	0
Skewered cooked	0.09 x 10 ⁵	0.006 x 10 ³	0	0	0
Cooked skewers cooled	88 x 10 ⁵	0	0	300	0
Powder of ingredients	4 x 10 ⁵	250 x 10 ³	130	0	1.94x10 ²
Cooked skewers served	0.09 x 10 ⁵	0.25 x 10 ³	6	0	0
Cooked skewers without ingredients	9 x 10 ⁵	250 x 10 ³	25000	0	0
Skewered cooked stored	99 x 10 ⁵	250 x 10 ³	2000	0	5.5 x 10 ²
AFNOR criteria :	3 x 10 ⁵ CFU/g	10 ³ CFU/g	10CFU/g	30 CFU/g	NC

Notes: Samples do not contain salmonella, *S. aureus* and yeasts.

Table 4. Conformity of samples

Germs	Average n* = 50 CFU/g	Extrem value CFU/g	m* CFU/g	3m* CFU/g	10m* CFU/g	Conformity Number of samples In accordance	Not in accordance	%
Total germs (30 °C)	80.18 x 10 ⁵	0.09 x 10 ⁵ 304.4 x 10 ⁵	3 x 10 ⁵	9 x 10 ⁵	NA	4	6	40
Total coliform	175.02 x 10 ³	0 250x10 ³	10 ³	NA	10 ⁴	3	7	30
Coliform thermotolerant (44 °C)	102713	0 250x10 ³	10	NS	100	3	7	30
Sulfito- reducing anaerobes	180	0 960	30	90	NA	6	4	60
<i>S. aureus</i>	0	0	102	3 x 10 ²	NA	10	0	100
<i>Salmonella sp</i>	0	0	Abs/25	NA	NA	10	0	100
Mold	0.74 x 10 ²	0 - 5.5 x 10 ²	NC	NC	NC	NC	NC	NC

n* = Total number of units of samples; m* = Standards AFNOR (French Association of Standardization) Acceptability limit related to the method of counting: 3 m* = Solid medium; 10 m* = Liquid medium; NA = Not applicable; NC: Not considered.

3.3 Determination of Critical Control Points (CCP)

Using the “decision tree” of the HACCP system, we have identified six (6) critical points on steps. Hazards and causes of hazards have been identified. Risk analysis, critical point and corrective measures are shown in Table 5.

Table 5. Critical control points and corrective measures

N°	Steps	Methods	Dangers	Due to the dangers	CCP	Remedial action
1	E* ₀	Receipt of meat, boning	Development of microbial contamination germs, infections, poisoning	Sick animal; Defect inspection, out of the cold chain, long duration of transport	Yes	Inspection of the animal and removal of diseased animals; use refrigerated vehicles and supply containers with traceability; compliance with GHP ; quickly transport the meat; refuse suspect meat
2	E ₁	Removal of meat film (waste)	Microbial contamination	Non-compliance with basic hygiene; use of non-disinfected cutters; tables and other equipment not cleaned	No	Wash hands with soap; using clean clothes for the filter
3	E ₂	Cutting the meat into pieces	Proliferation of microbes	Poor control of the temperature	No	Cut the meat in a clean and fresh environment
4	E* ₃	Getting chaplet pieces of meat	Proliferation of microbes	Non-compliance with basic hygiene; Poor control of the torque-time temperature;	Yes	Wash hands with soap; Quickly place the pieces of meat in the pins
5	E* ₄	Steeping skewers in water	Microbiological and physicochemical water contamination	Poor quality of water; non-renewal of the water used for washing utensils	Yes	Use potable water;
6	E* ₅	Seasoning	Microbiological and physicochemical contamination	Inappropriate ingredients and oil; Poor conservation	Yes	Use a good quality ingredients and oil; good conservation
7	E* ₆	Toasting	Microbial and chemical contamination	No mastery of the time-temperature	Yes	Grilling at a temperature of 80 ° C; use quality wood for toast
8	E* ₇	Storage and packaging	Microbiological and physicochemical contamination	Improper packaging	Yes	Choose a good sealed packaging

* = CCP = Critical Control Point

4. Discussion

4.1 Hygiene Practices in the Manufacturing Process of Skewered Meat

It appears from our study of the deficiencies in hygiene practices at the point of sale and production of skewered meat. The establishment is located on the road. Generally, producers and sellers occupy haphazardly places (anarchic way) to prepare and sell their products. Cutting and toasting of meat do so outdoors. We found that the removal of dirty water is usually in the nearest gutter, in landfills and roadside. Waste management is also a concern. There is no liquid discharge system, which leads to an accumulation of dirty water and garbage that may attract flies and other insects. Studies (Barro et al., 2006; Muinde & Kuria, 2005) indicate that an unsafe

place for the preparation and sale of street food, marked by the presence of various solid waste liquid provides a favorable environment for flies and other insects. Other studies (de Jesus et al., 2004; Szalanski et al., 2004) showed that insects play an important role in the transmission of pathogenic microorganisms that cause infections. The flies are especially dangerous because of their feeding mode. They provide the mechanical transmission of germs from one place to another landing on contaminated surfaces (waste or feces) and on the food briefly opened. Large populations of two species of flies have been identified on the websites selling street food: it is the housefly and green fly respectively *Musca domestica* and *Lucilia caesar* (Barro et al., 2006). The observations revealed that these two insects flit and are often found in foods. In addition, the analysis showed that these flies carry many different bacteria and thus are vectors. *Musca domestica*, each time landing on the surface of the food, leaving a large number of pathogenic bacteria (de Jesus et al., 2004) and is recognized as a vector responsible for several diseases in all continents (Allan & Zurek, 2004). The importance of the fly population on sites of preparation and sale of food indicates the presence or proximity of an unhealthy environment so favorable to the living conditions of these insects (Barro et al., 2006). Microbiological analyzes on feces, legs and snout of two species of fly *M. domestica* and *L. caesar* have highlighted their role as a reservoir of microorganisms. In their diet or their movement on a surface or on food and through their excreta, these flies can deposit several microorganisms (de Jesus et al., 2004. Nichols, 2005). In addition, FAO (2007) reports that pests (mice, roaches, termites, etc.) are a major danger to the safety and suitability of food. Other studies (Yasmeen, 2001) showed that in Africa, food security in terms of health remains precarious. This is largely due to the street food. This area has many shortcomings, including the anarchic occupations and unsafe places of preparation and sale of food.

Compared to raw materials, the meat used in the manufacture of meat skewers comes from the central market of the city of N'Djamena or directly from slaughterhouses. For transportation, the establishment has not an adequate vehicle to transport meat. Refrigerated vehicles are used only to transport meat from the slaughterhouse to market. From the market to establishment, often transporting meat is done by commercial vehicles or rickshaws (holder all). The cold chain is interrupted at this point, which could affect the quality of meat for processing. It has been reported by several authors use of raw materials and low quality ingredients, food additives unauthorized, poor manufacturing practices, preservation, packaging and sales, often in unhealthy environments (Barro et al., 2002). However, FAO (2007) indicates that whatever the mode of supply of raw materials and ingredients, it is important to choose wisely raw materials and ingredients from known trader or to the market with guaranteed safety. According to FAO/WHO (2004), primary production is an important source of risk associated with meat. In many developing countries, the lack of proper slaughter structure and the existence of unsatisfactory conservation techniques can result in enormous losses of meat and its derivatives (FAO, 2006), which could affect the quality of the raw material. Another concern is that of the origin and the level of contamination of these products because of illegal slaughter cases with an unknown over the health of the animals were reported by Barro et al. (2002). Also, the quality of the finished product depends on the quality of the raw material. There is a need for the seller to procure fresh meat of good quality. About the water used in the establishment, we noticed a severe lack of drinking water in the meat processing sites. Producers often use water from different fountains in the city, but the treatment of these waters and especially their distribution is made in very poor hygienic conditions. Use of poor quality water could be the source of contamination and can cause poisoning in consumers. Similar observations were made by other authors (Borchardt et al., 2003; Leclerc et al., 2002; Mamontova et al., 2000). Another study in Calcutta showed that 47% of water used in street food was contaminated with fecal bacteria (Chakravarty and Canet, 1996). Criteria for quality of drinking water, bacteriological parameters deserve the utmost vigilance because they reflect an immediate risk to the health of the consumer (Kimassoum et al., 2011).

For the equipment, cutting operations are carried out on non-cleaned tables, other equipment and utensils (knives, cleavers, plates etc.) are poorly cleaned and disinfected. Several authors (Pérez- Rodríguez et al., 2007; Vorst et al., 2006) have noted that slicing machines and cutting utensils are recognized as important vehicles of contamination of cooked meat products both at factory and sale points. Meat can become contaminated during storage by contact with toxic substances or absorption of toxic metals.

The study also revealed shortcomings in the working methods and staff attitude. Most of the staff (65.62%) is not educated. The difference between literate and illiterate is not significant ($\chi^2 = 3.5$, $ddl = 1$, $p \geq 0.10$). However, rarely the staff wears blouses and aprons; uses dirty and worn clothes and often do not wash their hands before starting work. But disease prevention is through good practices, including hand washing with soap. The importance of providing theoretical and practical training at all levels of the food chain, including food handlers and consumers has been highlighted by several authors (Abdelrahim et al., 2012; FAO, 2007; Barro et al., 2007).

The hands of food handlers are an important means of cross-contamination (Allwood et al., 2004). Poor personal hygiene of food vendors frequently contributes to outbreaks of foodborne diseases caused by microorganisms such as *Staphylococcus aureus* and Gram-negative bacilli such as *Salmonella sp* (Hundy & Cameron 2002). We noticed that sellers handle at the same time money and the cooked skewers. The handling of finished products and money by the same time probably can potentially causes cross-contamination. These improper practices have been identified as major contamination factor in this study and those of several other authors (Tidjani et al., 2013; Abelrahim et al., 2012; King et al., 2000). Inappropriate hand washing practices in handlers at a hospital school in India was observed too by Malhotra et al. (2006). In addition, Mosupye et al. (2000), Bhaskar et al. (2004) found that in street food, especially among sellers of grilled meat, knives are used for cutting raw and cooked meat without cleaning between these two uses, a practice that promotes germ contamination carried by raw foods (cross contamination). Furthermore, this study shows a significant difference ($\chi^2 = 4.5$, $ddl = 1$, $p \geq 0.02$) between the staff regularly conducts medical visits (37.5%) and those who do not (62.5%). In developing countries, more than 60% of food-related diseases are caused by microbiological agents, underscoring that food preparers are the main vehicles of this transmission (Panza & Sponholz, 2008). In their study, A.K.C. Campos et al. (2009) observed the absence of periodical health examination in 51.9%. According to Codex Alimentarius (2003), the persons, who are known or suspected of having any disease might be transmitted by food, are forbidden to handle food items. Also, Idowu and Rowland (2007) in their study, found the presence of fecal-oral transmission parasites in the handlers studied and they emphasize the importance of periodical health examinations to diminish the risk of food contamination.

4.2 Microbiological Analysis

Of all the products analyzed, 40% are consistent with respect to aerobic mesophilic bacteria (30 °C), 30% compared to total coliforms and 30% compared to thermotolerant coliforms (44 °C). Regarding the Sulfito-reducing anaerobes, 60% of the samples are consistent. Molds are present with an average of 0.74×10^2 CFU/g; it is *Aspergillus niger* in the sample skewer cooked retained by the seller and *Aspergillus flavus*, *Penicillium sp* and *Geotrichum sp* in the sample of ingredients.

It is clear from our analysis that the fresh meat is highly contaminated by germs indicating breaches of hygiene, the contaminations was due to the rupture of the cold chain during the transportation of the product to the place of production but also to cutting operations that are usually outdoors. According to Bourgeois & Leveau (1991), cutting operations meat may carry microorganisms from the environment (germs soil, air) or staff. Other studies (Barro et al., 2002) on the microbiological quality of staple foods have shown that products such as meat may be contaminated because of their exposures for hours at room temperature.

The number of germs increases considerably in the sample of raw skewer. This is due to the fact that the meat pieces are pressed into the pins by hand and the skewer is then deposited on a table littered with flies. This step is critical because the basic hygiene rules are far from being met due to the low level of education vendors and lack of training on Good Hygiene Practices (GHP) account and Good Manufacturing Practices (GMP). Several studies have shown that health precautions for handling street foods vary and have been identified as a major factor of contamination (Barro et al., 2002; King et al., 2000). However, the number of germs decreases after steeping in water: washing with water could be the cause of this decline. But the product can be contaminated again due to the quality of the washing water.

In the sample of spicy raw skewer, the number of germs increases, this contamination comes from the exposure of the product to air but also from spices and ingredients. Powders ingredients are composed mainly of groundnut cake. Peanut is a favorite place of *Aspergillus flavus* that in areas where this legume is grown ecological and climatic conditions are met ideal for the development of this slime. Studies have shown that the vast majority of these flavoring ingredients may be contaminated by microorganisms (Garrido et al., 1992) producing toxins harmful to consumer health. Among the toxigenic microorganisms, mycoflora occupies a significant place, they are all of the genus *Aspergillus*; three of them are involved: *A. flavus*, *A. parasiticus* and *A. nomius*, but it is unknown in the contamination of plant foods (Wilson & Payne, 1994). Studies performed on powders dried meat seasoning ingredients showed various species of fungi namely *A. flavus*, *A. Niger*, *Geotrichum sp.* and *Rhizopus sp.* Studies of dosage of aflatoxins in the ingredients used for seasoning dried meats showed in some samples the presence of aflatoxins (Tidjani et al., 2008). Baracco et al. (1982) observed that spices are a favorable substrate swarm of various microorganisms because they are not always collected in very good conditions: they are frequently contaminated by land, most often dried by hand, subject to weather conditions and their fermentation is not always desirable. Several species identified are spore forming bacteria resistant to heat (bacilli, *Clostridium perfringens* etc.), and often moulds responsible for defect in appearance. Pepper shows generally the most contaminated.

After cooking, there is a decrease in the number of total germs (0.09×10^5 CFU/g), but the germs are not eliminated because the grill is remote from the fire, resulting in a lack of cooking. The number of germs increases again in the sample cooled cooked skewers and this is due to the fact that the skewers are exposed to the open air for sale at the moment and could have at this time secondary contamination. This step is also critical. The sample of raw skewers with ingredients showed high values of the order of 250×10^3 CFU/g higher than the threshold of acceptability in relation to total coliforms and thermotolerant coliforms (44 °C). Skewer cooked, retained and reheated presented values 99×10^5 CFU/g for total bacteria, 250×10^3 CFU/g for total coliforms and 2000 CFU/g for thermotolerant coliforms (44 °C), these values are above the threshold acceptability. Only the sample skewer cooked complies against all searched germs. Other studies (Bryan et al., 1992) reported that cooking and food exposure at room temperature are two important critical points at street food. Then cooked skewers are arranged on trays for sale. In most cases, they are not covered and are exposed to the open air and then sold without further heating. However, in a few outlets, the products are displayed in glass cases. Unfortunately many foods sold on the street are not covered (Barro et al., 2002). The skewers are served on plates washed in dirty water or sometimes on paper (for example packaging of cement recovered, newspapers etc.). About packaging, his role is to protect the contents against all attacks and contamination can affect the quality of the food, it should be sealed, suitable and cover all the food. Food packaging today is a major issue for both food businesses and companies producing plastic packaging (Mellouet et al., 2009). Food packaging are considered to be one of the causes of food contamination, they contain many low molecular weight additives in their formulation and consequently present a risk of interaction with food that they contain by releasing in this part of their additives or processing aids. The study of food contamination by packaging has been highlighted by others researchers (Petersen & Beindhal, 2000).

4.3 Identification of Critical Control Points

The foods that we eat are mostly of biological origin (plant or animal). Changes to this food, whether enzymatic or microbiological origin, make them quickly inedible or unfit for consumption (Clinquart, 2005). To control the quality of our food from farm to fork, approaches such as HACCP is essential. HACCP is internationally recognized as the best method to ensure the safety of a product (Montarjemi & Kaferstein, 1999). The control of hazards threatening the hygienic nature of food safety requires the adoption of this system (Rozier, 1996). We were able to identify on the production of meat skewers six (6) critical points concerning the steps of reception of the raw material, getting chaplet pieces of meat, steeping skewers in water, seasoning with ingredients and oil, toasting and packing. Also studies (Tidjani et al., 2013; John et al., 2001) have identified the critical points in the food preparation (complementary food and cheese). However, other studies (Pérez-Rodríguez et al., 2010) confirmed that Small and medium-sized establishments are associated with worse hygiene practices compared to Large Sized establishments. John et al. (2001) observed that the purchasing Ready-To-Use Foods and ingredients from market vendors poses a considerable health risk. The reasons for this are apparent from observational data on hygiene practices in the market. Foods and ingredients are often displayed openly on tables and on the ground in very poor sanitary environments.

According to Drabo et al. (2009), street food is both a source of revenue as an indicator of the reorganization of the domestic structure and dietary practices. It is therefore important to produce quality to protect the health of consumers, but also increase the efficiency of business. In view of these shortcomings and in accordance with procedures HACCP (Hazard Analysis and Critical Control Point), this study has developed an improved process flow diagram of meat skewers of meat (Figure 2) and propose corrective measures (Table 5) to improve the quality of meat skewers very popular with consumers. Also, at the end of this study, we had recommended to the producers, sellers and consumers to source raw materials of good quality; to control temperatures for cooking, cooling, storage and distribution; to have potable water at all times during working hours; to have an efficient effluent disposal and waste system; to clean and disinfect knives, steels, cleavers, saws and other instruments; to ensure a permanent training methods of hygienic handling of food: wash your hands often and thoroughly with a product suitable for cleaning the hands and use hot water ; to promote personal hygiene by medical visits and health education activities; to monitor the cooking; and to avoid cross-contamination.

5. Conclusion

This study has allowed us to appreciate the quality of meat skewers from the receipt of fresh meat until the end through the steps of cutting the meat into pieces, their seasoning and toasting etc. Tracking processing techniques enlightened us on the general hygiene conditions for making skewers. In retail butchers, producers and sellers, personal hygiene and clothing are not obvious (clothing and dirty, smock, non-existent or inadequate hand washing, dilapidated equipment often not remediated etc.). At different stages of production of skewers, there is a lack of personal hygiene and dress, the activity is outdoors and the finished products are exposed to the open

air, so that the cooked skewers cooled can be contaminated again with germs. Often the persons who serve skewers to customers are also those who collect money, it can be a support vehicle germ. Compared to the microbiology analysis, the products are much more contaminated by indicator germs breach of the rules of hygiene as by moulds. However, the samples analyzed did not contain salmonella, *S. aureus* and yeasts.

For the first time, this study has allowed us to exchange on the concept of HACCP with the producers of the skewers. Based on this system, the dangers and causes of hazards have been identified, six (06) critical points were determined and corrective actions have been implemented. Also, an approach for meat hygiene based on risk analysis requires that steps be taken at the point of the food chain where they can most contribute to reducing food-borne risks to consumers. This should happen through the prevention and control of cases of contamination of the raw material and in the processing steps of the meat skewers. Moreover, it is necessary to apply the principles of Hazard Analysis and Critical Control Point (HACCP) in all stages of production to mastering the critical points and protect the health of consumers. To avoid infections and food poisoning, precautions for hygiene practices including sanitation of raw materials, personnel and the environment should be taken to improve the quality of meat skewers and protect the health of consumers. Also training on Good Hygiene Practices (GHP) is required at vendors to ensure the hygienic quality of grilled meats. It's also important to develop Guides to Good Hygiene Practices (GGHP) for forming producers, sellers and consumers.

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