**Evaluation of the microbiological quality of kebab sold in Commune III of Niamey, Niger**

**Abstract:**

Skewers represent an important source of nutrients because they are very rich in proteins, minerals and vitamins, relative to human needs. This richness makes them favorable for microbial proliferation. The general objective of this study is to evaluate the microbiological quality of skewers sold in the streets of Niamey. For this purpose, a survey was carried out from September 18 to October 20, 2023 in Niamey among sixty-three (63) sellers, one hundred (100) consumers and the head of the health police. Ten (10) samples of two (2) types of skewers taken from five (5) sellers were subjected to microbiological analyses. Six (6) contamination indicator germs were searched according to the appropriate standards for each germ (Total Aerobic Mesophilic Flora (FAMT), total and fecal coliforms, *E. coli,* *Salmonella* and yeast and mold). The survey results showed that sellers are exclusively male, 90.5% of whom are aged between 18 and 45 and 63.3% unschooled. The overwhelming majority of sellers wash their hands, the meat they use and their work materials (respectively 100%, 93.6% and 95.2% of our respondents). However, these skewers are not kept in good conditions after cooking; 87.3% of sellers sell them in the open air on barbecues or by putting the products in a large tray. All sellers say they use tap water for washing meat and equipment. Regarding microbiological analysis, samples of skewers with peanut meal had the highest microbial loads than samples of skewers without peanut meal. In fact, 100% of the samples are unsatisfactory for Total Aerobic Mesophilic Flora (FAMT); 90% unsatisfactory in Total Coliforms (TC) and E. coli; 80% unsatisfactory in Fecal Coliforms (FC); 20% and 70% non-compliant respectively for salmonella and yeasts and molds. These results exceed the maximum values allowed by the microbiological criteria, which cooked charcuterie products must meet to be officially recognized as clean from contamination. As a result, these skewers pose risks to the health of consumers. It is therefore important to implement several strategies aimed at improving the safety of these foods for better monitoring.

**Keywords: meat, kebab, microbiological, Niamey(Niger)**

**Introduction**

African cities have been experiencing a demographic surge and significant economic development for several years. This leads to the emergence of various catering activities, as residents are forced to find relatively affordable catering outside their family home (Chauliac *et al.,* 1998). It is developing more and more due to the need for out-of-home food linked to the distance between homes and workplaces as well as the gradual generalization of the continuous working day. In developing countries, foodborne infections remain a major public health problem since they can affect a very large population (Malvy and Djossou, 2009; WHO, 2010).

Among these foods sold on public roads are kebabs that are produced from meat, which is one of the most consumed and nutritious foods from the flesh of animals. It is a highly perishable food due to the abundance of a number of nutrients that promote the growth and multiplication of microorganisms (Iheagwara, 2016). Processing meat into kebab is a common artisanal activity practiced by butchers and some restaurants (Boudechicha, 2016).

The risk of food poisoning associated with food sold on public roads remains a threat in many parts of the world; microbiological contamination is one of the major problems. Foodborne pathogens are recognized as a serious health hazard, with the risk depending primarily on the type of food and the method of preparation and storage. Vendors' ignorance of the causes of foodborne illness is a risk factor that cannot be ignored. Lack of hygiene, inadequate access to drinking water and waste disposal, and unsanitary environments (such as proximity to sewage and landfill sites) further increase public health risks (FAO, 2007).

Hence the importance of conducting a study on the kebabs sold in the city of Niamey, more specifically in the neighborhoods of communal district Niamey III. The general objective of this study is to contribute to the improvement of the hygienic quality of the kebabs sold in Niamey.

1. **Materials and methods**
	1. **Study area**

The Niamey region is located in the southwestern part of Niger between latitudes 13°35' and 13°24 South and longitudes 2°15' East. Its altitude is between 160 m and 250 m and its administrative boundaries extend over 552.27 km2, of which about 297.46 km2 is urbanized. Regarding the climate, the region benefits from a Sahel-Sudanese climate characterized by a short rainy season (June to September) and a long dry season (October to May) (INS, 2015). The latest decentralization reforms, which still maintain a full communalization of the territory, establish the region as a municipality with a special status. It is one of the regions where the number of communes is the lowest: five (5) communal districts (Niamey 1, Niamey 2, Niamey 3, Niamey 4 and Niamey 5). The Niamey 3 communal district, which constitutes our study area, is composed of 16 neighborhoods (Bani Fandou II, Banizoubou, Boukoki IV, Cité Caisse, Cité Faycal, Couronne Nord, Kalley Centre Amirou, Kalley Est, Kalley Sud, Kalley Nord (Abidjan), Lacouroussou, Madina, Nouveau Marché, Poudrière, Sabon Gari, Terminus) and three villages (Kongo Gorou, Kongou Zamey and Kongou Mekirey) (INS, 2022). And in this area, we are targeting kebab sellers and consumers.

Map of the Niamey region and administrative boundaries:

# Figure 1. Study area mapping

#  Conduct of the investigation

The survey was conducted in Commune III of Niamey among kebab sellers from September 18 to October 20, 2023. To carry out this activity, questionnaires were sent to sellers and consumers to collect information; and a grid of systematic observations on the sales practices of kebabs. The questions asked of the sellers focused on the practices of the kebabs from production (preparation) to sale, the practices related to the sanitation and hygiene of the sellers. The questions asked to consumers focused on the reasons for their choices, the frequency of purchase, the appearance of discomfort and their duration of consumption.

* 1. **Bacteriological analysis**

***Preparation of stock solutions***: ISO 6887-V08-010-6 (**2013**) was used for the preparation of stock solutions. Thus, 10 g of each kebab sample was weighed and poured into a vial containing 90 ml of buffered peptone water (BPW) after grinding. The filtrate obtained is homogenized for 45 minutes under magnetic agitation. This stock suspension solution was used to achieve a series of decimal dilutions. For this purpose, 1 mL of the stock suspension was introduced into a test tube containing 9 mL of sterile buffered peptone water, using a sterile graduated pipette to obtain a 10-2 solution. Then, 1 mL of this test tube was introduced into another test tube containing 9 mL of the diluent, and so on until a 10-4 solution was obtained.

***Enumeration***: The FAMT enumeration was carried out according to the ISO V08-051(1992) / ISO 4833 standard on PCA (Plat Count Agar) agar. Incubation was done at 37° C for 24 hours in the oven, with the lids facing down. All colonies that have grown on the surface have been counted.

Total and faecal coliform counts were performed according to the standard (ISO V 08-015 (1991) / ISO 4832 and ISO V 08-017 (**1996**)) on Mac Conkey agar. The boxes were incubated at 37 °C (total coliforms) and 44°C (faeces) for 24 hours with the lids facing downwards. Bright red to pinkish colonies were counted.

*Escherichia coli* is a member of the *Enterobacteriaceae family*. It is considered a good indicator of fecal contamination. The search for *E. coli* was carried out on EMB (Eosine Methylene Blue) medium according to the ISO 3811 method. The incubation of the petri dishes was done at 37°C for 24 hours. Blue colonies with metallic reflections were counted.

The search for *Salmonella* was carried out in two stages: enrichment on liquid selective medium (Rappaport Vassiliadis), and isolation on SS solid selective medium (Salmonella-Shigella).

* Enrichment: 0.1 mL of the sample already pre-enriched in peptone water was introduced into a sterile test tube containing 10 mL of Rappaport Vassiliadis. The mixture was homogenized and incubated for 24 hours at 42°C.
* Isolation: Cultures in Rappaport Vassiliadis medium were inoculated on the surface of SS (Salmonella-Shigella) solid selective medium using a platinum loop. The boxes were turned over and incubated for 18 to 24 hours at 37°C.

***Reading and Interpretation***

According to the French standard V 08-011, each box retained must contain a maximum of 300 colonies and at least 15 colonies. The number of microorganisms per gram of the sample was calculated from the boxes retained at the level of two successive dilutions by applying the formula below:

N = $\frac{\sum\_{}^{}C}{v(n1+n2\*0,1)d}$

Σc = Total number of colonies counted in the boxes with a number of colonies between 15 and 300.

n1 = number of boxes counted from the first dilution;

n2 = number of boxes counted from the second dilution;

v = volume inoculated, generally 0.1ml;

D = dilution factor from which the 1st counts were made.

* 1. **Statistical analysis**
1. **Results**

***Socio-demographic characteristics of kebab sellers***

The socio-demographic characteristics of kebab sellers are presented in Table I. The results show that the vendors are exclusively male (100%), 90.5% of whom are between 18 and 45 years old. kebab sellers have little education (about 63.3% are not in school), only 17.6% have reached a secondary level of schooling.

**Table I.** Socio-demographic characteristics of kebab sellers

|  |  |  |
| --- | --- | --- |
| **Characteristics** |  **Number** | **Percentage** |
| Sex  | Male | 63 | 100% |
| Female | 0 | 0% |
| Age | Under 18 years old | 0 | 0% |
| 18 to 45 years old | 57 | 90,5% |
| Over 45 years | 6 | 9,5% |
| Level of education | Not in school | 40 | 63,3% |
| Primary | 12 | 19,1% |
| Secondary | 11 | 17,6% |

***Kebab sales practices***

Table II shows the conditions and practices for the sale of kebabs. The latter are generally exposed to the open air at the time of sale, about 87.3% of sellers sell in the open air on barbecues or by putting the products in a large tray, 4.8% of sellers use display cases to protect the kebabs and 7.9% use thermoses. All vendors say they use tap water to wash meat and vending utensils. The main source of meat purchase is the refrigerated slaughterhouse in Niamey. About 88.9% of vendors use beef compared to 11.1% who use camel meat. All (100%) of the sellers say that they wash their hands with soap before preparation and 95.2% say that they clean utensils (barbecues, knives, etc.) with soap before use. Meats are organic materials that can attract microorganisms through debris that disperses during slaughter, transport and preparation. This is why cleaning meat with clean water is necessary to reduce the germs responsible for contamination. According to the survey results, 93.6% of sellers wash meat before cooking, compared to 6.4% who do not wash. As far as the addition of condiments is concerned, 100% of respondents say they use condiments (ginger, green pepper, garlic, parsley, pepper, onion, tomato, edible oil, salt) for seasoning.

**Table II.** Conditions and practices of the kebab industry

|  |  |  |
| --- | --- | --- |
| **Characteristics** | **Number** | **Percentage (%)** |
| Packaging method  | Open air | 55 | 87,3 |
| Thermos | 5 | 7,9 |
| Showcase  | 3 | 4,8 |
| Water source | Tap water | 63 | 100 |
| Borehole water | 0 | 0 |
| Origin of the meat | Slaughterhouse | 63 | 100 |
| Home | 0 | 0 |
| Nature of the meat | Beef | 56 | 88,9 |
| Camel meat | 7 | 11,1 |
| Hand washing  | Yes | 63 | 100 |
| No | 0 | 0 |
| Washing the meat | Yes | 59 | 93,6 |
| No  | 4 | 6,4 |
| Washing of equipment | Yes | 60 | 95,2 |
| No | 3 | 4,8 |
| Adding an ingredient | Yes | 63 | 100 |
| No  | 0 | 0 |

Approximately, 87.3% of vendors use medium intensity fire when cooking while 12.7% use low intensity fire. It appears from this **Table III** that 68.3% of our respondents put the kebabs directly on the fire just after pecking, 20.6% have a maceration time of 1-60 minutes and 11.1% have a maceration time of more than 60 minutes. As for the cooking time, 66.7% have a cooking time varying from 1 to 30 minutes, 27% have a time of 31-60 minutes and 6.3% have a time of 60 minutes.

**Table III:** Distribution according to maceration, cooking time and fire intensity.

|  |  |  |
| --- | --- | --- |
| **Characteristics** | **Number**  | **Percentage** |
| Maceration time | Directly  | 43 | 68,3% |
| 1-60 minutes | 13 | 20,6% |
| More than 60 minutes  | 7 | 11,1% |
| Cooking time | 1-30 minutes | 42 | 66,7% |
| 31-60 minutes | 17 | 27% |
| More than 60 minutes | 4 | 6,3% |
| Fire intensity | Medium  | 53 | 87,3% |
| Weak  | 10 | 12,7% |

***Levels of microbiological contamination of kebabs***

Figure 2 shows the contamination levels of the FAMT kebabs samples by the contamination indicators according to the neighborhoods visited. Analysis of this figure shows that the average loads range from 2.22±2.20.106 CFU/g (Q4) to 1.62±0.008.107 CFU/g (Q1). The concentration levels of the samples in Ward 1; 2 ; 3 and 5 are above the standards. Only samples from Quarter 4 (Q4) present an acceptable microbiological quality. The one-way analysis of variance (ANOVA) shows significant differences between neighborhoods (*p-value* = 0.009). Next, Duncan's comparison test divided the neighborhoods according to their contamination levels into three (3) groups. Group (a) consists of Q2 and Q4, Q1 is in group (c) and Q3 and Q5 are in both group (a) and (b).

**Figure 2**. Contamination levels of kebabs samples in FAMT. Values that do not have the same letter are significantly different *(P ˂ 0.05).* ***Q1****: Kaley South,* ***Q2****: Bani fondou II,* ***Q3****: Lakouroussou,* ***Q4****: North Shore,* ***Q5****: New market*

Figure 3 shows the levels of contamination of skewers in total and fecal coliforms. Quarters 3 and 5 (Q3 and Q5) are more contaminated with total coliforms, around 1.00±0.35.105 CFU/g and 1.45±10.92.104 CFU/g respectively. It should be noted that there is a significant difference between neighbourhoods (*p-value* **=** 0.008). Thus, samples from quarter 3 (Q3) are more contaminated with fecal coliforms, with an average load of 5.32±2.70.104 CFU/g. For all the samples analysed and regardless of the district considered, the average loads recorded are higher than the standards defined by AFNOR. A statistically significant difference was recorded between neighbourhoods of (*p-value* **=** 0.0032). The Duncan test reveals the formation of a group (a) for total coliforms and two groups (a and b) for feces. Group (a) of fecal coliforms contains Q1; Q2; Q4 and Q5 and group (b) Q3.

**Figure 3**. Contamination levels of kebabs samples in coliforms. Values that do not have the same letter are significantly different *(P ˂ 0.05).* ***Q1****: Kaley South,* ***Q2****: Bani fondou II,* ***Q3****: Lakouroussou,* ***Q4****: North Shore,* ***Q5****: New market.*

Figure 4 shows the levels of E. coli contamination. The result of the E*. coli* count shows a variation in loads ranging from 1.02±0.16.103 CFU/g to 6.81±9.62.104 CFU/g. Samples from Quarters 1 and 5 (Q1 and Q5) are unsatisfactory microbiological qualities, unlike Quarters Q2, Q3 and Q4 which are of acceptable quality. The charges do not vary significantly according to quarters (*p-value* = 0.536).

**Figure 4**. E*. coli* contamination levels of kebabs samples. Values that do not have the same letter are significantly different *(P ˂ 0.05).* ***Q1****: Kaley South,* ***Q2****: Bani fondou II,* ***Q3****: Lakouroussou,* ***Q4****: North Shore,* ***Q5****: New market*

Figure 5 shows the levels of contamination of yeast and mould samples in the kebabs according to the quarters. The result of the yeast and mould count shows a minimum value of 2.27±3.21.101 CFU/g obtained at the level of Q2 and the maximum value of 1.36±1.28.102 CFU/g at the level of Q1. It should be noted that there were no yeasts and moulds in the samples from Ward 4 (Q4). The one-way analysis of variances shows that yeasts and molds do not vary significantly in the five (5) quarters studied (*p-value* 0.245). Duncan's placement test shows the shape of a single homogeneous group (a).

**Figure 5.** Contamination levels of yeast and mould of kebabs samples. Values that do not have the same letter are significantly different *(P ˂ 0.05).* ***Q1****: Kaley South,* ***Q2****: Bani fondou II,* ***Q3****: Lakouroussou,* ***Q4****: North Shore,* ***Q5****: New market*

Table IV compares the contamination levels of kebabs samples with and without groundnut meal. It appears from this table that kebabs samples with groundnut meal are more contaminated regardless of the contamination indicator considered. FAMT is the most common germ found in both kebab variants, with loads varying from 1.13±0.24.107 to 9.22±1.15.106 CFU/g of kebabs. Salmonella is present only on kebabs samples with peanut meal about 33% of the samples.

**Table IV.** Contamination levels by kebabs type

|  |  |  |
| --- | --- | --- |
| Germs | Average load ± standard deviation | Standard(\*)  |
| Kebabs with Peanut meal | Kebabs without Peanut meal |
| FAMT | 1.13±0.24.107 | 9.22±1.15.106 | 3.105 |
| Total coliforms | 5.81±1.60.104 | 4.20±2.73.103 | 103 |
| Fecal coliforms | 2.77±0.94.104 | 3.41±4.17.103 | 10 |
| *Escherichia coli* | 2.37±1.42.104 | 1.02±1.12.103 | 103 |
| *Salmonella* | 33,33% | 0% | 00 |
| Yeasts and molds | 1.25±0.32.103 | 6.82±8.03.102 | - |

1. **Discussion**

Food is eaten to ensure the maintenance and proper functioning of the body. However, they can behave as vectors of diseases or as a culture medium for microorganisms, if hygiene rules in food preparation, storage and packaging are not taken into account (Jean-Louis, 2007). The result of this study showed that the salespeople surveyed are men (100%). This constant does not confirm the result of Harivola (2019) in Madagascar which brought 57.74% of men. This can be explained by our cultural practices (because the sale of grilled meat is not a job for women). As far as age is concerned, 90.5% of vendors are between 18 and 45 years old, 63.3% are out of school. These results are at odds with those of (Harivola, 2019; Razafy, 2019).

In addition, it has been found that kebabs are mostly prepared and sold in unsatisfactory hygienic conditions. The sale is done on public roads, placed on tables, often on trays on the ground and for the most part in the open air exposed to insects such as flies which are vectors of contaminating food. These observations corroborate the constants of various authors (Harivola, 2019; Naibe, 2019; Aboubacar, 2023). Approximately, 100% of vendors say they wash their hands, 93.6% wash meat and 95.2% wash their work utensils. Regarding hand washing and equipment, the results found are satisfactory. These results do not confirm those reported by (Naibe, 2019; Harivola, 2019; Aboubacar, 2023) who found unsatisfactory results.

However, observations made at the point-of-sale show that the work clothes worn by the sellers are mostly dirty. It should also be noted that the majority of sellers are not very concerned about hygiene in preparation, the equipment is poorly washed and is either placed on the dirty tables after washing, or wiped with a multi-use cloth. The same observation was made in Madagascar by Harivola (2019).

At the microbiological level, the results of the analyses revealed very high loads of FAMT, i.e. in the order of 1.13± 0.24.107 CFU/g and 9.22±1.15.106 CFU/g respectively for kebabs with peanut meal and without groundnut meal (simple). These results are close to those found by several authors (Mariam, 2006; Hamad, 2009; Mbawala et *al*., 2010; Harivola, 2019; Almou, 2021). Total mesophilic aerobic flora is a group of microbes that can grow at room temperature and is a good indicator of hygiene. The high loads of FAMT in this study can be explained by external contamination (air, soil, manipulators, cutting tools that are washed only once a day) (Larpent, 1992). These results also showed a high level of coliforms (total and faeces). The average loads of total coliforms are in the order of 5.81±1.60.104 CFU/g and 4.20±2.73.103 CFU/g and in fecal coliforms of the order of 2.77±0.94.104 CFU/g and 3.41±4.17.103 CFU/g for the skewer with peanut meal and without groundnut meal respectively. This result is similar to the one found by Mbawala *et al.,* (2010) on twenty-four samples of spicy and non-spicy kilichi, taken from eight different producers in seven quarters of Ngaoundéré city (Northern Cameroon). Indeed, the values obtained by these authors are of the order of 1.00 105 CFU/g for spicy kilichis and 1.98 105 CFU/g for non-spicy kilichis. On the other hand, this result is lower than those of Almou (2021) in Niger. Indeed, although the average loads of these germs are lower than those of these authors, they remain above microbiological standards. This could be explained on the one hand by the overload of the atmosphere of the slaughterhouse with microorganisms and on the other hand by the sick or healthy carrier staff who handle the meat.

The presence *of Escherichia coli* in ground beef is considered as an indicator of gut bacteria. It can be used as an indicator to reflect the microbiological quality of food in terms of product shelf life or safety of foodborne pathogens. Indicators are often used to assess food safety and improve food quality (Abdeldaiem *et al*., 2017). Our analyses showed that 40% of the samples from the different quarters show charges above the standards. The values obtained for kebab with peanut meal and kebab without peanut meal are respectively in the order of 2.37±1.42.104 CFU/g and 1.02±1.12.103 CFU/g. This result is similar to that of Harivola *et al.* (2019) on 30 kebab samples taken from 30 different vendors in six quarters of Antananarivo city (Madagascar). In contrast, the results found in this study are lower than those found by Almou (2021).

According to Guiraud (2003), moulds and yeasts contaminate meat and degrade it from a qualitative point of view. The presence of fungal flora is mainly due to climatic conditions and meat storage conditions. Almost all the kebab samples analyzed were contaminated by the latter. The results also show that kebabs with groundnut meal are not significantly more contaminated with fungal flora than kebabs without groundnut meal (P ˃ 0.05). This result is similar to that found by Mbawala *et al.,* (2010).

For all the sprouts tested, the microbiological loads of the samples kebabs with peanut meal are higher than those of the samples without peanut meal. This high contamination of kebabs with peanut meal can be caused, among other things, by the ingredients (peanut meal powder, spices, etc.) used in their preparation, which are most often crushed in mills previously cleaned with water of questionable hygienic quality (borehole water or tap water kept in the can for a few days) and where food of various origins of unknown microbiological qualities has been previously ground (Mbawala, 2010). This is consistent with what was reported by Ramatou et *al.,* (2019), who for all the germs studied, found a higher microbial load for coated kilichi than uncoated kilichi. In addition, Almou (2021) reported that coated kilichi (kilichi PA and kilichi PAJ) is heavier than simple kilichi. And on the other hand, the low presence of these microorganisms in kebab without peanut meal could be explained by the fact that this type of kebab is marinated by a high concentration of green chili pepper. This is in agreement with the observation of Mbawala *et al.* (2010) which reported a higher microbiological load for non-chili kilichi than the chili ones.

However, almost all the bacterial loads obtained in this study are higher than the maximum values allowed by the microbiological criteria that must be met by cooked deli meat products to be officially recognized as safe for consumption. This can be explained by the lack of hygiene observed throughout the sale. The overload of the atmosphere with microorganisms could also impact the microbiological quality of food sold in this area. Then, Sabo *et al.* (2018), link the high level of kilichi microorganism obtained in their study, to the inadequate hygiene measures taken during production, by doing a critical point analysis (5M).

**Conclusion**

This study showed that the sellers of kebabs in Niamey are exclusively male and mostly out of school. The hygienic conditions for the sale of kebabs in commune III remain below the recommended standards. For microbiological characteristics, all samples analyzed have microbial loads that exceed the normal load required for cooked deli meat products to be recognized as fit for human consumption. As a result, these kebabs represent health risks for consumers. It has been shown that the behavior of vendors has an influence on the quality of food. Hence the importance of training and raising awareness among sellers on good hygiene practices when preparing and selling kebabs. It would also be important to look for heat-resistant pathogens (such as *Clostridium perfringens*) in these products.

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