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MICROBIOLOGICAL ANALYSIS OF FOOD SERVED IN MAKESHIFT RESTAURANTS IN THE CENTRAL MARKET OF KISANGANI, DEMOCRATIC REPUBLIC OF CONGO

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ABSTRACT

Introduction: Foodborne illnesses pose a major global public health threat, with adverse consequences for both individuals and healthcare systems. The objective of this study was to assess the bacterial load and sanitary quality of food served in makeshift restaurants in Kisangani. **Methods:** Twenty food samples were collected from 63 makeshift restaurants in the central market of Kisangani. The samples were analyzed to assess their bacterial load by enumeration of coliforms, staphylococci, and salmonella, and to evaluate the sanitary quality of the food. **Results:** The results showed that 80% of the samples were contaminated with coliforms, 40% with staphylococci, and 65% with salmonella. None of the samples were of satisfactory quality for the three types of germs. **Conclusion:** The study revealed that the bacterial load of coliforms, staphylococci, and salmonella is significantly higher than the authorized standards, indicating a flagrant lack of hygiene in the preparation and handling of food. All the meals analyzed presented a potential risk of foodborne infections, threatening the health of consumers as none met the

sanitary quality criteria for all the germs studied. Urgent and concerted multisectoral measures are needed to improve food hygiene practices in these establishments, ensure food safety and protect consumer health.

KEYWORDS: Bacterial load, food sanitary quality, makeshift restaurants, Kisangani.

1. INTRODUCTION

Foodborne diseases (FBDs) pose a major public health threat worldwide, with detrimental consequences for both individuals and healthcare systems. The World Health Organization (WHO) estimates that over 200 different diseases can be transmitted through food. Every year, billions of people fall ill from FBDs, and millions die. Children under the age of 5 are particularly vulnerable, accounting for nearly one-third of deaths [1].

These diseases caused by microbial pathogens, biotoxins, and chemical pollutants present in food pose serious health threats to thousands of consumers. They impose a heavy burden on the healthcare system and have significant consequences for economic productivity and development [2].

Potential sources of food contamination include soil, water, air, plants, animals, humans, equipment, and packaging materials [3]. This is due either to generally unsanitary conditions in which these foods are prepared, or to the improper storage of these foods [4], or to the equipment and utensils used. Street-side food stalls, which provide an affordable source of food for many people in urban areas, play an important role in the transmission of these diseases [5]-[6].

For many people with limited resources, street food is often the cheapest and most accessible way to obtain a quantitatively balanced daily meal [7]. As in most developing countries experiencing multifaceted crises and insecurity, this phenomenon of makeshift catering affects all layers of the population in large cities in Black Africa [8]. The Democratic Republic of Congo (DRC) is not spared from this scourge of food sold on public roads (AVP).

Indeed, in the DRC, street restaurants commonly called "Malewa" proliferate in almost all major cities and particularly in densely populated cities such as Kinshasa, Lubumbashi, and Kisangani [9]-[10]. Despite their socioeconomic importance and apparent popularity, the issue of hygiene in the AVP system is a major concern for consumers. The sanitary quality of the food served in these often compromised establishments leaves much to be desired, given the large quantity of food prepared daily, the low level of education and continuous training of managers and the workforce, thus exposing consumers to a high risk of food poisoning [11]-[13].

In Kisangani, these makeshift restaurants are omnipresent and scattered in the corners and nooks of the city, especially around large markets. They are often frequented by residents looking for less expensive and quantitatively acceptable meals [14]. However, adherence to hygiene rules in these establishments is often neglected, which increases the risk of food contamination. Meals are prepared and served in unsanitary conditions. The unsanitary environment coupled with the problem of water supply and the precariousness of hygiene measures are factors that favor bacterial contamination of the food served in these makeshift restaurants.

In view of the magnitude of the problem and its detrimental consequences for health, it was important to conduct a study in these restaurants in the city of Kisangani. The objective of this study is therefore to assess the bacterial load of food served in makeshift restaurants in the central market of Kisangani. By identifying the bacteria present and assessing the sanitary quality of the food, it aims to raise awareness of the risks incurred by consumers and to propose concrete solutions to improve the situation.

2. MATERIALS AND METHODS

2.1. Study Setting

This study was conducted at the central market in the city of Kisangani, the capital of the TSHOPO province in northeastern DRC. This open-air market is a crossroads where traders and customers from diverse backgrounds meet. There are about 50 makeshift restaurants officially authorized by the market administration, in addition to an indeterminate number of clandestine establishments [15]. With an estimated population of 1,356,640 inhabitants in 2021 [16], Kisangani is the fifth most populous city in the country.

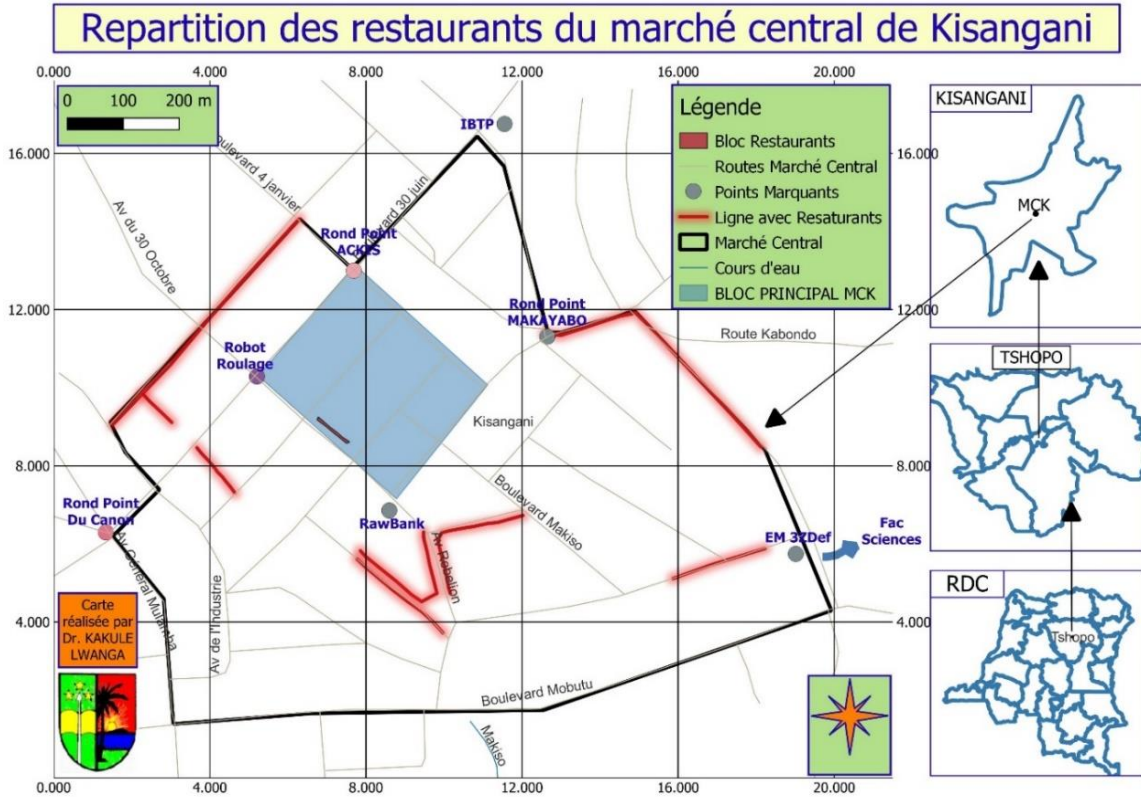


Figure 1: Distribution of makeshift restaurants in the central market of Kisangani, included in this study.

2.2. Study Materials

The study materials consisted of food dishes served in makeshift restaurants in the central market of Kisangani, which were estimated to number 63 [15].

2.3. Study Type and Period

A cross-sectional descriptive study with an analytical purpose was conducted at the central market of Kisangani from February 15 to 28, 2024.

2.4. Sampling

To collect food samples from makeshift restaurants in the central market of Kisangani, we used systematic sampling with a sampling interval of 3, as the number of restaurants was estimated to be 63. Thus, we collected a total of 20 samples, including 6 meals of rice with a mixture of beans and pondou, 2 meals of

rice with beans, 4 meals of fufu with fish, 4 meals of rice with pondu, and 4 meals of fufu with meat. The selection of the meal to be sampled depended on availability at the time of sampling.

2.5. Study Parameters

The parameters studied during this work were:

- The bacterial load (BL) of the food samples (Number of colonies per gram) for the studied germs.
- The sanitary quality of food based on the studied germs.

2.6. Bacteriological Analyses

Bacteriological analyzes allowed the isolation and enumeration of enterobacteria, staphylococci, and salmonella. The following media were used: Eosin Methylene Blue (EMB) agar (Selective medium used for the isolation and enumeration of Enterobacteriaceae in food products by the classic plate count method after incubation at 44°C for 24 hours) for fecal Coliforms; Staphylococcus Agar (culture medium for the isolation of Staphylococci). After enrichment on Kauffman broth, Xylose Lysine Desoxycholate Agar (XLD - Agar) was used for the isolation of salmonella (Fig. 2)

The following diagram summarizes the sample analysis plan:

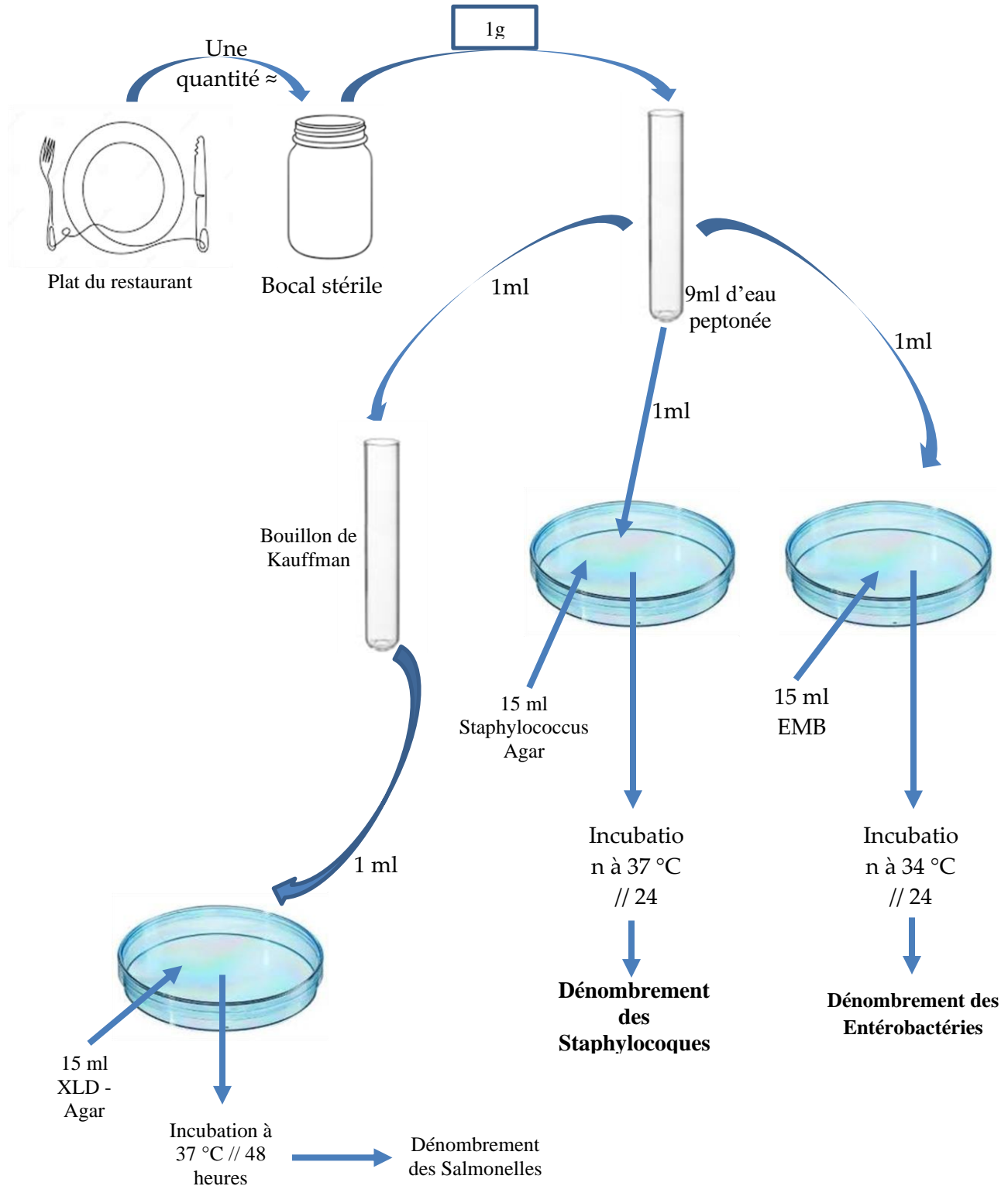


Figure 2: Food analysis plan for food served in makeshift restaurants in the central market of Kisangani.

2.7. Method of Results Interpretation

The samples were analyzed according to French standards for cooked dishes. These standards are defined in a decree of December 21, 1979, published in the Official Journal of January 10, 1980 [17].

Here are the authorized limits (microbiological criteria) for cooked dishes:

- Fecal Coliforms: maximum 10 colonies per gram of food
- Pathogenic Staphylococci: maximum 100 colonies per gram of food
- Salmonella: absence in 25 grams of food

In the case of counting in a solid medium, the interpretation of the results is done according to a 3-class plan: Satisfactory, Acceptable and Unsatisfactory. If m is considered as the microbiological criterion:

- The product is SATISFACTORY if the number of colonies is less than or equal to $3m$.
- The product is ACCEPTABLE if the number of colonies is greater than $3m$ and less than or equal to $10m$.
- The product is UNSATISFACTORY if the number of colonies is greater than $10m$.

In our experiment, since the counting was carried out in a solid medium, the interpretation of the results was done as follows:

Germ	Satisfactory	Acceptable	Unsatisfactory
Fecal Coliforms	CB < 30	CB: 30-100	CB > 100
Staphylococci	CB < 300	CB: 300-1000	CB > 1000
Salmonella	Absence	Absence	Presence

2.8. Data Analysis

The results of the counts were recorded on a results sheet, then encoded and analyzed using Excel 2016 software. The study parameters were presented using tables and graphs summarizing their frequencies and proportions.

3. RESULTS

Table 1: Bacterial load of food samples

NO.	DISH	FECAL COLIFORMS	STAPHYLOCOCCI	SALMONELLA
1	RICE BEANS PONDU	200	0	240
2	RICE BEANS	285	0	0
3	FOUFOU FISH	INC	0	0
4	RICE PONDU	2000	0	0
5	FOUFOU MEAT	INC	0	0
6	RICE BEANS PONDU	120	540	INC
7	RICE BEANS PONDU	140	0	60
8	RICE PONDU	310	0	0
9	FOUFOU FRESH FISH	2120	120	INC
10	FOUFOU MEAT	670	0	INC
11	RICE PONDU	70	0	0
12	FOUFOU FRESH FISH	260	0	120
13	FOUFOU DRIED FISH PONDU	220	0	0
14	RICE BEANS PONDU	0	70	INC
15	RICE BEANS PONDU	0	2960	330
16	FOUFOU MEAT	130	INC	INC
17	RICE PONDU	0	20	INC
18	FOUFOU MEAT	30	500	1810
19	RICE BEANS PONDU	10	0	INC
20	RICE BEANS	0	40	2670

Fecal coliforms, indicators of fecal contamination, were found in most of the samples (16 out of 20 samples). Staphylococci were present in 8 samples, and salmonella were present in 13 samples.

Table 2: Germs isolated in food samples

N = 20	COLIFORMS		STAPHYLOCOCCI		SALMONELLA	
	Frequency	Proportion	Frequency	Proportion	Frequency	Proportion
PRESENT	16	80.00	8	40.00	13	65.00
ABSENT	4	20.00	12	60.00	7	35.00

Coliforms were isolated in 80% of the samples, staphylococci in 40%, and salmonella in 65% of the samples analyzed.

Table 3: Interpretation of results by type of germ

NO.	SAMPLE	FECAL COLIFORMS	STAPHYLOCOCCI	SALMONELLA
1	RICE BEANS PONDU	Unsatisfactory	Satisfactory	Unsatisfactory
2	RICE BEANS	Unsatisfactory	Satisfactory	Satisfactory
3	FOUFOU FISH	Unsatisfactory	Satisfactory	Satisfactory
4	RICE PONDU	Unsatisfactory	Satisfactory	Satisfactory
5	FOUFOU MEAT	Unsatisfactory	Satisfactory	Satisfactory
6	RICE BEANS PONDU	Unsatisfactory	Acceptable	Unsatisfactory
7	RICE BEANS PONDU	Unsatisfactory	Satisfactory	Unsatisfactory
8	RICE PONDU	Unsatisfactory	Satisfactory	Satisfactory
9	FOUFOU FRESH FISH	Unsatisfactory	Satisfactory	Unsatisfactory
10	FOUFOU MEAT	Unsatisfactory	Satisfactory	Unsatisfactory
11	RICE PONDU	Acceptable	Satisfactory	Satisfactory
12	FOUFOU FRESH FISH	Unsatisfactory	Satisfactory	Unsatisfactory
13	FOUFOU DRIED FISH PONDU	Unsatisfactory	Satisfactory	Satisfactory
14	RICE BEANS PONDU	Satisfactory	Satisfactory	Unsatisfactory
15	RICE BEANS PONDU	Satisfactory	Unsatisfactory	Unsatisfactory
16	FOUFOU MEAT	Unsatisfactory	Unsatisfactory	Unsatisfactory
17	RICE PONDU	Satisfactory	Satisfactory	Unsatisfactory
18	FOUFOU MEAT	Acceptable	Acceptable	Unsatisfactory
19	RICE BEANS PONDU	Satisfactory	Satisfactory	Unsatisfactory
20	RICE BEANS	Satisfactory	Satisfactory	Unsatisfactory

It is noted that 13 samples (65%) have "Unsatisfactory" results for fecal coliforms. 2 samples (10%) have "Unsatisfactory" results for staphylococci. 13 samples (65%) have "Unsatisfactory" results for salmonella. None of the 20 samples fully comply with the microbiological standards for the three types of germs analyzed.

Figure 3 shows the quality of food according to the germs studied.

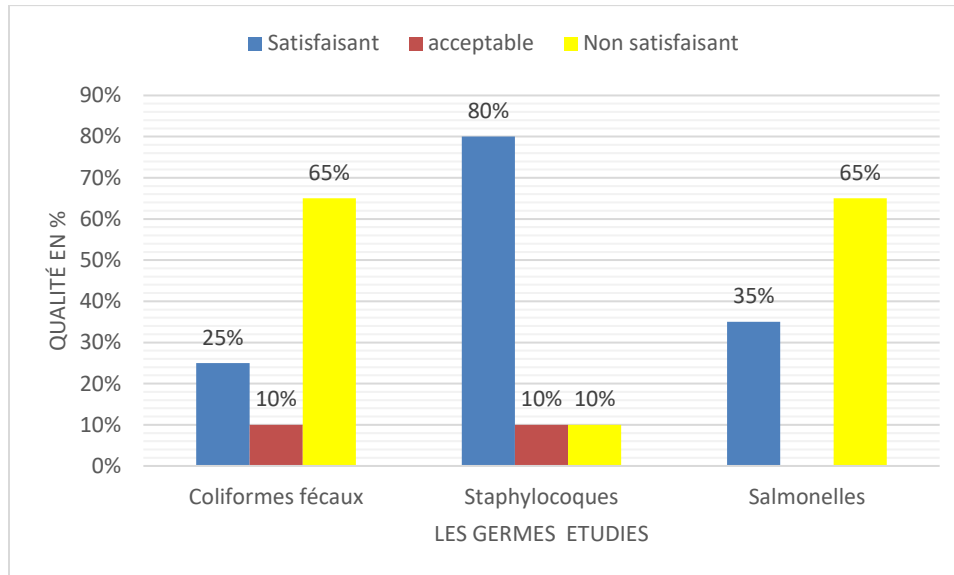


Figure 3: Food quality according to the germs studied

This graph presents simultaneously the sanitary quality of the food samples for the three germs studied. We observe a significant proportion of unsatisfactory samples for fecal coliforms (65%); a significant proportion of satisfactory samples for staphylococci (80%); and a significant proportion of unsatisfactory samples for salmonella (65%).

4. DISCUSSION

Analysis of the food reveals that 80% of the samples analyzed are contaminated with fecal coliforms, of which 65% are classified as unsatisfactory, indicating a poor level of hygiene in the handling and preparation of food. This high fecal contamination exposes consumers to a significant risk of diarrheal diseases (Tables I and II). Urgent measures to strengthen hygiene and rigorous microbiological control are needed to ensure the safety of food served in these makeshift restaurants. Studies conducted in Kinshasa [18] and Goma [19] showed 72% and 65% fecal coliform contamination, respectively, compared to 80% for our study. In Kenya and Cameroon, studies have found slightly higher levels of contamination; 90% and 88% [20]. These overall very high figures reveal a widespread food hygiene problem in makeshift restaurants in the DRC and Africa.

While the presence of staphylococci in 40% of the samples is concerning as they can cause skin infections, food poisoning, and other serious infections (Table II), only 10% were classified as unsatisfactory (Fig.

3). Studies conducted in Nigeria [21] and Ghana [22] have shown higher levels of staphylococcal contamination (52% and 47%, respectively, compared to 40% in our study). These differences may be due to different methodological approaches, or to variable hygiene, water supply or sanitation conditions from one country to another.

Salmonella contamination in 65% of the samples, all classified as unsatisfactory, puts consumers at significant risk of salmonellosis, a serious diarrheal disease that can lead to severe complications (Tables II, III and Fig. 3).

In Kinshasa [18], a study revealed a much lower level of salmonella contamination (20%). The same is true for studies conducted in Kenya [20] and Côte d'Ivoire [23], where levels are low compared to our study (30% and 27%, respectively, compared to 65% in our study). This significant difference raises major concerns about food safety in makeshift restaurants in the central market of Kisangani. Urgent measures must be taken to identify and correct the sources of contamination in order to eliminate this risk. Various factors on which actions are possible can be studied, including food hygiene practices, water sources, waste management, the supply chain, and environmental factors.

Depending on the type of germ, 65% of the samples are unsatisfactory for fecal coliforms, 10% for staphylococci and 65% for salmonella (Fig3). At the same time, 10% of the samples are acceptable for fecal coliforms, and 10% acceptable for staphylococci (Fig.3). None of the 20 samples fully comply with the microbiological standards for the three types of germs analyzed (Table III). All samples analyzed pose a potential risk to consumer health. In other words, the food served in makeshift restaurants in the central market of Kisangani is unfit for consumption. These results indicate a lack of hygiene and a significant risk of foodborne illness for consumers.

5. CONCLUSION

The microbiological analysis of meals served in makeshift restaurants in the central market of Kisangani highlights a worrying situation of bacterial contamination. The microbial load for fecal coliforms, staphylococci and salmonella is well above the permissible standards, indicating a flagrant lack of hygiene in the preparation and handling of food. All meals analyzed present a potential risk of food poisoning, threatening the health of consumers as none of the meals meet the sanitary quality criteria for all the germs studied.

Urgent and concerted multi-sectoral measures are needed to improve food hygiene practices, ensure food safety and protect consumer health.

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