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Impact of Hygiene Practices on the Microbiological Quality of Dishes Sold in Five Schools in the Educational Zone of Niamey II (Niger)

Alio Sanda Abdel-Kader[1], Hamidou Bonkano Amina[2], Almou Abdoulaye Alio[2], Sabo Seini Haoua[2]

[1]Department of Biology, Faculty of Science and Technology, Laboratory of Management and Valorization of Biodiversity in the Sahel, Abdou Moumouni University, Niamey, Niger; [2]Department of Chemistry, Faculty of Science and Technology, Laboratory of Nutrition and Valorization of Agro-resources, Abdou Moumouni University, Niamey, Niger.

ABSTRACT

Introduction: School canteens must comply with hygiene and food safety rules, especially when it comes to children. It is important to take into consideration what is on their plates and how they are made. Snacks offered in schools contribute to a balanced diet, allowing students to stay focused and improve their academic performance.

Aim/Objective: This study aims to improve the hygienic quality of ready meals sold in schools in Commune II of the city of Niamey.

Methodology: The data was collected from December 2023 to January 2024 and involved 60 vendors in five schools, including two private primary schools, one public primary school, and two secondary schools (one public and one private).

Result: The results showed that 96.7% of vendors are women and are mostly out of school (38.3%). Several food safety and hygiene issues were observed, including selling food near gutters (3.3%), exposure to sunlight and open air of food (61.7%), use of street clothes (93.3%), neglected hand hygiene (68.3%), and nail care (71.7%). For the FAMT, microbiological analysis showed that 40% of the samples were compliant, while 60% were non-compliant. The results showed that all samples were non-compliant for total and fecal coliforms. Concerning *Escherichia coli*, 60% of the samples were also non-compliant. On the other hand, for yeasts and moulds, 100% of the samples were found to be compliant and 20% of the samples were non-compliant for *Salmonella*.

Conclusion: A comprehensive and systematic assessment of the safety and quality of food and food prepared by school vendors would therefore be crucial, both to ensure the health of school children and to ensure the socio-economic importance of school food sales.

Key Words: Street food, hygiene, microbial contamination, school, Niamey (Niger), Food sales

INTRODUCTION

A school-aged child's diet is essential for growth, psychomotor development and learning abilities. It must be balanced, varied and distributed throughout the day and present no risk to his health. [1] School feeding refers to the set of conditions under which pupils have access to food, choose it and consume it inside the school. It has been the subject of increased interest in recent years and is positioned as a lever to be activated to achieve the objectives of quality education. [2] School feeding can lead to increased enrolment and attendance rates and contribute to learning. [3] Faced with the difficulty, or even the impossibility, of returning to the family environment for a meal during break times, students then fall back on canteens or other eating places within their school or in the surrounding area. [4] Studies have shown that food sold on the streets of our cities and in public places such as schools is a major public health problem due to the multiplicity and diversity of the microbial flora it carries. [4, 5, 6] However, the lack of safety and quality surrounding the preparation and sale of food in schools leads to great health risks, which have consequences for the psychological development of schoolchildren. [7] The preparation and packaging equipment, the cleanliness of the preparation and sales site, and the personal hygiene of the

Corresponding Author:
Alio Sanda Abdel-Kader, Department of Biology, Faculty of Science and Technology, Laboratory of Management and Valorization of Biodiversity in the Sahel, Abdou Moumouni University, Niamey, Niger; Email: aliosanda@yahoo.fr

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sellers are all risk factors for contamination that can have a negative influence on the microbiological and sanitary quality of these foods. [5,8] The consequence is frequent food poisoning, with effects that are sometimes difficult to manage. [3] Food poisoning is very common in African countries where street food allows more than 80% of urban populations to eat easily and cheaply. Food sold on the streets of our cities and in public places such as schools is therefore a major public health problem because of the multiplicity and diversity of the microbial flora it carries. [5,6] These types of food poisoning are accidents due to the ingestion of foodstuffs contaminated with pathogenic germs, common germs and/or their toxin. As the site of microbial multiplication, ready meals can be the cause of collective food poisoning in the event of non-compliance with hygiene conditions, which constitutes a real public health problem. [9] This study aims to improve the hygienic quality of ready meals sold in schools in Commune II of the city of Niamey.

MATERIALS AND METHODS

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.

Method

This is a cross-sectional descriptive study carried out in Commune II of Niamey. The study sites (Mission Girl, Mission Boy, Lako College, Diori School and Lycée Kassai) were chosen based on their proximity to public voices and markets and the type of food sold. The investigation was carried out in two phases: a survey phase devoted to the collection of data relating to food hygiene and a final phase devoted to laboratory work which consists of the microbiological analysis of the dishes taken from the saleswomen of the said establishments. A cooler to keep the samples taken in a cool place for transport to the laboratory.

Survey and survey variables

This study involved several variables grouped into three groups: sociodemographic characteristics of participants, food quality, and food safety. Questions on these topics were formulated for sellers. The following sociodemographic characteristics were selected for our study: age, level of education. In addition, we asked salespeople about the practical training and type of training they received to conduct their sales activities. Questions about the safety and hygiene of sales practices were formulated according to the Ishikawa method, which define the five essential aspects of safety: method, material, matter, environment and labour.

Sample collection and transport

The samples were collected randomly from 8-10 hours from the different vendors. The samples were taken under aseptic conditions. The foods concerned were Appetizers, Sandwiches, Cakes, Milk-based Kakandadi, Sausages. A total of 10 samples were taken for 5 types of food. Each type of feed was collected two (2) times. The samples were introduced into sterile bags and sent as soon as possible to the microbiological laboratory of the Faculty of Science and Technology of the Abdou Moumouni University of Niamey in a cooler containing ice.

Bacteriological analysis

Preparing the stock solution and decimal dilutions

The preparation of the stock solution of the different dishes was carried out according to the NF EN ISO 6887-1:1999 standard, by grinding a sample. Then, 10 grams of the shredded material was taken and put into 90 mL of buffered peptone water. 1 mL of aqueous extract from each sample was taken and used directly for decimal dilutions. Then 1 ml of each decimal dilution in a petri dish.

Counting of contamination indicators

The Total Mesophilic Aerobic Flora (FAMT) has been enumerated according to ISO V08-051(1992) / ISO 4833. The enumeration of this flora was carried out on PCA (Plat Count Agar) agar. Incubation was carried out at 37°C for 24 hours.

Coliforms were tested on VRBL medium by incubation at 37°C for 24 hours for totals and 44°C for faeces according to ISO 4832 (February, 2006). Coliforms have purplish colonies of 0.5 mm or more in diameter after 24 hours of incubation.

E. coli enumeration was performed on EMB agar (Bio-rad, France) according to ISO 18140. After incubation at 37°C for 24 hours, the characteristic colonies of *E. coli* (green with metallic reflection) were counted.

Yeasts and moulds have been counted according to the NF V08 059: (2002) standard on Sabouraud chloramphenicol agar. The seeded dishes were incubated at 37°C for 72 hours. The colonies (lenticular, round, deep in the agar, generally white for yeasts and filamentous colonies, downy on the surface for moulds) were observed and counted.

The search for *Salmonella* was carried out in two stages: enrichment, and isolation.

- For enrichment, 0.1 mL of the sample pre-enriched in peptone water was added to a sterile tube containing 10 mL of Rappaport Vassilad is medium, followed by homogenization and 24-hour incubation at 37°C.

- For isolation, cultures of Rappaport Vassiliadis were inoculated on SS (Salmonella-Shigella) solid selective medium and then incubated for 18 to 24 hours at 37°C.

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:

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

N = number of colonies per ml or g of feed;

∑C: sum of colonies counted on all the boxes retained from two successive dilutions and of which at least one contains 15 colonies.

V: inoculated volume generally of 1ml;

n_1 : number of boxes retained for the 1st dilution;

n_2 : number of boxes retained for the 2nd dilution;

D: dilution ratio corresponding to the first dilution chosen.

Statistical analysis

The design of the questionnaires and the preparation of the document were done on Microsoft Word. Microsoft Excel software was used for the calculations and to generate the diagrams. The statistical software SPSS 23 was used for the data processing. The tests performed are: chi-square test for qualitative variables; the 1-factor ANOVA for the quantitative variables and the test and Duncan for the comparison between the samples.

RESULTS

The socio-demographic characteristics of food vendors are described in this section (**Table 1**). The majority of sellers were women (96.3%), with an age mostly between 45 and 59 (43.3%) and 30 and 44 (31.7%). In terms of educational attainment, 38.3% of vendors have no formal qualification, 36.7% have primary education, 23.3% have secondary education, and only 1.7% have higher education. Generally speaking, the majority of salespeople (95%) have not followed any training related to their profession. Only 5% of salespeople have received initial training in this area. Of these trained salespeople, some say they have received vocational training in the field of food processing (5%), while the rest report having trained themselves (95%).

Table 1: Socio-demographic characteristics of food vendors in schools in commune II Niamey

	Variables	Frequency (n)	Percentage (%)
Sex	Feminine	98	96.7
	Masculine	2	3.3
Age range (years)	16-29 years old	11	18.3
	30-44 years old	19	31.7
	45-59 years old	26	43.3
	60-74 years old	4	6.7
Level of education	Not in school	23	38.3
	Primary	22	36.7
	Secondary	14	23.3
	Upper	1	1.7
Training received	Yes	3	5
	No	57	95

The characteristics of the sales premises and environment are presented in **Table 2**. The sellers' places of activity are spaces that have been allocated to them by the school, or spaces that are generally used by the school itself in the form of canteens. As far as the means of sale are concerned, the majority of vendors place their food on a table while others on the floor. Only half of the facilities are in a suitable environment (51.7%), while a fairly large number of vendors dispense food next to waste (45%), or gutters (3.3%). Indeed, 56.7% of food is protected against insects, flies and dust while 43.3% of food is exposed to the sun. At the time of our field visit, the majority of the food (61.7%) was placed in the open air, 35% in a tin shed and very little sheltered under an umbrella (3.3%) that some women hang above their point of sale, to create a little shade and protect the food.

Table 2: Characteristics of the sales environment

	Variables	Frequency (n)	Percentage (%)
Environmental state of the environment	Clean	31	51.7
	Dirty	27	45
Protected foods	Next to gutters	2	3.3
	Yes	34	56.7
	No	26	43.3
Places of activity	Sheet metal shed	21	35
	In the open air	37	61.7
	Under an umbrella	2	3.3
What the food is protected with	Glass body	1	2.94
	Stainless steel	2	5.88
	Thermos	5	14.71
	Cloth	1	2.94
	Plastic bucket	17	49.99
	Refrigerator not on	2	5.88
	Plastic bucket and thermos	6	17.64

The majority of sellers (93.3%) conduct their business wearing their own business clothes that they consider clean, although 6.7% of them are considered "dirty" (**Table 3**). At the time of sale, 18.3% of salespeople wear an apron as a professional outfit. A majority of salespeople did not have clean hands (68.3%) or neat nails (71.7%) at the time of the survey. Hand hygiene remains a major issue among sellers, as more than half of them do not wash regularly (75%) while about fifteen say they wash their hands at the beginning or at the time of their activities (25%). All sellers (100%) do not use personal protective equipment (gloves, bibs, etc.), they directly handle the food they offer for sale. Generally, (95%) of the vendors have their hair covered, while 5% of the vendors do not have medical follow-up because they argue that fresh water vendors do not need medical follow-up to practice their profession. All sellers (100%) are free of sores.

Table 3: Hygiene practices by salespeople at the point of sale

Variables	Caracterics	Frequency (n)	Percentage (%)
	Clean	56	93.3
	Dirty	4	6.7
Work Attire	Apron	11	18.3
	None	49	81.7
Ownership of the hands	Yes	19	31.7
	No	49	68.3
Neat nails	Yes	17	28.3
	No	43	71.7
Hand washing	Yes	15	25
	No	45	75
Individual use	Yes	26	43.3
	No	34	56.7
Collective use	Yes	2	3.4
	No	59	96.6
Use of soap	Yes	15	25
	No	45	75

Medical follow-up, presence of wounds, protective equipment are presented in **Table 4**. Although the utensils offered to school children generally seem clean, they are not washed until the end of the day. However, only 43.3% of sellers say they wash their equipment individually after each use, while 56.7% only do it at home after playtime. In addition, 3.4% of sellers offer a collective device for cleaning equipment. Finally, a quarter of sellers (25%) use soap to wash their equipment and hands.

Table 4: Medical follow-up, presence of wounds, protective equipment

Variables	Characteristics	Frequency (n)	Percentage (%)
Protective equipment	Yes	0	0
	No	60	100
Hair covered	Yes	57	95
	No	3	5
Medical follow-up	Yes	57	95
	No	3	5
Presence of wounds	Yes	0	0
	No	60	100

Level of bacteriological contamination

Table 5 shows the variation in the levels of total mesophilic aerobic flora (TMAF) and *E. coli* contamination of the different dishes sold. Loads range from $4.11\pm0.795.10^4$ to $1.25.10^6\pm1.13.10^6$ CFU/g. Food A1 is the most contaminated (about $1.53\pm0.252.10^6$ CFU/g), while food A4 is the least loaded ($4.11.10^{4a}\pm0.795.10^4$ CFU/g). The one-way analysis of variance shows significant differences (p-value = 0.040). The results also show that *Escherichia coli* is more common in the A3 feed with an average load of $2.22\pm2.22.10^4$ CFU/g. On the other hand, foods A2 and A4 do not show any trace of *Escherichia coli*. The one-way analysis of variance shows that there is no significant difference between the samples of the different foods (p-value>0.5).

Table 5: Level of contamination of FAMT and *E. coli* in ready meals

Food	Mean± Standard deviation (CFU/g)	
	FAMT	Coli
A1	$1.53\pm0.252.10^{6c}$	$3.50\pm2.50.10^{2a}$
A2	$1.20.10^6\pm0.661.106^{bc}$	0
A3	$1.25.10^6\pm1.13.106^{bc}$	$2.22\pm2.22.10^{4b}$
A4	$4.11.10^4\pm0.795.10^{4a}$	0
A5	$4.62.10^5\pm0.257.105^{ab}$	$3.30\pm3.30.10^{3a}$
Norm	5.10^{5abc}	10^{1a}
p-value	0.040	0.067

Values with the same letter in the same column are not statistically significant (p-value>0.05). A1: Appetizers; A2: Sandwich; A3: Cake; A4: Milk-based Kakandadi; A5: Sausage

Table 6 shows the levels of total and fecal coliform contamination of the various foods. Food A2 is the most contaminated with an average load of $2.75\pm0.383.10^5$ CFU/g. However, the least loaded of these foods is A4 food with an average load of about $2.01\pm1.33.10^3$ CFU/g. The one-way analysis of variance shows significant differences (p-value = 0.001).

Even for fecal coliforms, A4 is the least contaminated food ($2.27\pm2.27.10^{1}$ CFU/g) and the most contaminated A2 food (about $1.43\pm0.277.10^{5}$ CFU/g). The one-way analysis of variance shows that there is no significant difference (p-value = 0.086).

Table 6: Level of total and faecal coliform contamination of ready meals

Food	Mean± Standard deviation (CFU/g)		
	CT	CF	LM (UCF/g)
A1	$5.93\pm0.149.10^{4a}$	$9.83\pm7.84.10^{4ab}$	$5.82\pm0.455.10^{2b}$
A2	$2.75\pm0.383.10^{5b}$	$1.43\pm0.277.10^{5b}$	0
A3	$1.04\pm1.04.10^{5a}$	$1.40\pm1.40.10^{5b}$	$5.82\pm3.45.10^{2b}$
A4	$2.01\pm1.33.10^{3a}$	$2.77\pm2.77.10^{1a}$	$1.23\pm0.227.10^{2a}$
A5	$9.57\pm9.54.10^{4a}$	$5.71\pm5.70.10^{4ab}$	$7.45\pm1.55.10^{2b}$
Norm	10^{3a}	10^{1a}	5.10^{5a}
p-value	0,001	0,086	0,000

Values with the same letter in the same column are not statistically significant (p-value>0.05). *A1: Appetizers; A2: Sandwich; A3: Cake; A4: Milk-based Kakandadi; A5: Sausage.*

The results of the microbiological analysis of the food samples in this study show that:

For the FAMT, 40% of the samples are compliant and 60% are non-compliant.

For total coliforms, 100% are non-compliant.

For fecal coliforms, 100% are non-compliant.

For *Escherichia coli*, 60% of the samples are non-compliant.

For yeasts and molds, 100% of the samples are compliant.

For salmonella, 20% of the samples are compliant. In addition, the presence of salmonella in two samples is very worrying.

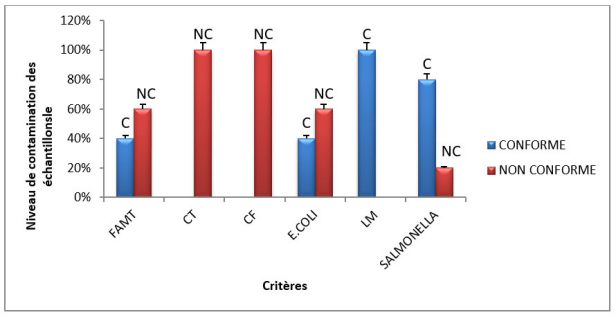

Figure 1: Contamination of dish samples by different types of germs.

DISCUSSION

Given the proven impact of school feeding in improving student performance, it has become a major emerging issue for the promotion of quality education. [2] We eat food to maintain and guarantee the proper functioning of the body. However, if hygiene rules are not followed during the preparation, storage and packaging of food, it can be used as vectors for diseases or as a culture medium for microorganisms. [12] At the time of the survey, the majority of salespeople were women, 96.7%. This result is higher than those of. [5-7,13-15] This result is not surprising for an African country like Niger where sociologically the preparation of dishes is traditionally reserved for women. The increase in the number of women in this sector could be explained by the cultural context in Niger, where women are considered to be the ones responsible for catering in the family given their status as housewives. [6,16] As shown in Table II, 38.3% of vendors are out of school and 36.7% have a primary education. Lower results were reported by Yaou et al. [6] in Niger. According to these authors, 80% of vendors are out of school. This lack of education results in a lack of knowledge of the basic rules of hygiene and sanitation at the level of sellers. [5, 8] This study also showed that many vendors serve food by hand and this can lead to bacterial contamination inherent in hand sanitation and hygiene. Most of the time, the hands carry faecal contamination germs (*E. coli*, other heat-resistant bacteria) which are often responsible for diarrheal diseases and gastroenteritis. [5] Only three (3) vendors have received training on the sale of food. A similar constant was made by Yaou et al. [6] in Niger and by Naibe [7] in Chad. The sales environment is very unhealthy. Wastewater and garbage are dumped on the streets near the points of sale, thus attracting disease vectors. The lack of public sanitation is detrimental to good food preparation and distribution practices. As for the characteristics of the sale of food in schools, we can say that the food offered to schoolchildren is prepared and sold in deplorable sanitary and hygienic conditions. In many schools, food is served on tables, often uncleaned, or either on pieces of cloth or on carts. It is generally placed in the open air and in the sun or under a tin shed, thus attracting disease vectors. All of these different elements suggest a high level of unsanitary food sales environment, but also poor sanitary conditions in food preparation processes. The lack of adequate garbage collection services leads to the accumulation of waste at the point of sale. The presence of these wastes promotes the proliferation of pests and leads to an increased risk of food contamination. [14]

With regard to the clothing and personal hygiene of food vendors in schools, it was found that poor wearing of gowns or aprons, non-compliance with hygiene rules such as regular hand washing, uncut and poorly cared for nails, failure to cover hair and non-use of personal protective equipment by almost all vendors. Thus, 95% of salespeople do medical

follow-up. These results corroborate those of Yaou et al. [6] On the other hand, Naibe [7], who worked on the assessment of food quality in schools, reported a low rate of medical follow-up (2.2%). Sellers carry out their activities, most of the time, with their own business clothes that they consider clean (93.3%). The utensils used to serve the schoolchildren are generally clean, and they are washed at the end of the day. Only 43.3% of sellers wash their equipment individually after each use.

In addition, the conditions of handling and storage of these foods are sources of contamination. The results of bacteriological analysis show a high level of contamination of FAMT in food A1 (Appetizers). This load is of the order of $1.53\pm0.252.10^6$ CFU/g. This result is higher than that of Kamara [17] (56.07 10^4 germs/gram) who worked on the microbiological quality of appetizers prepared in the restaurant of the Regional Centre for University Works of Saint-Louis (CROUS). On the other hand, Yaou et al. [6] reported superior results (approximately $4.6.10^8$ CFU/g). The elevated level of FAMT may be explained by exposure to the product in the open air. It is also important to note that sick individuals or healthy carriers participate in the preparation of the food sold even if they are not directly involved in the sale. For example, high levels of microorganisms could be due to inadequate hygiene measures taken during production. [18,19]

The results of this study also show a high level of total coliforms in the sandwich (food A2) ($2.75\pm0.383,10^5$ CFU/g). This result is higher than those found by Baba-Moussa et al. [5] who worked on the study of the possibilities of contamination of street food in Benin: the case of the city of Cotonou. The same is true with the fecal coliforms at the sandwich level (A2) with an average load of $1.43\pm0.277.10^5$ CFU/g. The presence of coliforms in large numbers may be the result of defective personal hygiene. In addition, it can be noted that faecal coliforms present in the external environment can contaminate food independently of fecal soiling. [17]

Concerning *Escherichia coli*, the analyses indicate a high contamination at the level of cakes (A3) with $2.22\pm2.22.10^4$ CFU/g. A high level of yeast and mould contamination is recorded in A3 (sausage) food (approximately $7.45\pm1.55.10^2$ CFU/g). This result is much lower than those of El Allaoui et al. [20] who worked on the hygienic quality of sausages traditionally made in the city of Meknes in Morocco, both of whom found in their studies $3.4x10^4$ CFU/g. The presence of yeast and mould can be explained by the use of pre-contaminated meat or by the contamination of the finished product via vectors such as flies. In addition, the food raw material can be contaminated from the outset or during processing, as well as the exposure of nutritional products to dust. [19,21]

As far as salmonella is concerned, the presence of this bacterial genus was noted in 20% of the samples studied (sausage (A5)). Thus, Alio Sanda et al. [8] reported a *Salmonella* contamination rate of 50% to 80% in samples of cowpea fritter and cowpea soup respectively, sold at the Abdou Moumouni University of Niamey.

In addition, it should be noted that, according to the recommendations of the AFNOR [22] standard, 100% of the dishes are of non-compliant microbiological quality for total and faecal coliforms and 60% for FAMT and *E. coli.* This contamination can have multiple sources: during the preparation of foodstuffs which can lead to cross-contamination, the infected man remains an excretory of *Salmonella* long after recovery; during the contamination of the environment and also the lack of hygiene at the final stage of food preparation; and in the case of mishandling by people working in this sector. The high level of microorganisms recorded in this survey may be related to inadequate hygiene measures taken during production. In addition, street food is often prepared in a traditional and manual way with household equipment. Materials used in direct contact with these foods can contaminate them. Contamination can also come from the environment in which the food is handled. It is possible that the methods of preparing, storing and preserving these foods are the main source of contamination. Indeed, it is crucial to control the relationship between temperature and time when preparing food. It is necessary to respect certain conditions for the preservation of food. Thus, Igene et al. [23] stated that critical control point analysis significantly improves the microbiological quality, sensory attributes and storage stability of food. These data call on us to encourage compliance with hygiene measures but also and above all the promotion of handwashing with soap to limit the contamination of food in collective catering.

CONCLUSION

The present study was conducted among food vendors in the playgrounds of the study schools of Commune II of Niamey. The results showed that women are in the majority in the food sales sector. However, many of its vendors have no level of education, and most of the vendors have not received any professional training. The hygiene and safety conditions for the sale of food are not respected. Microbiological analyses carried out on the different types of food have shown that the food is contaminated. Despite their decrease and absence after the cooking stage, these germs were reactivated during the sale, with strains of *Salmonella* discovered in the sausages. Most samples have a higher than standard bioburden. This shows that these foods are not in line with children's consumption.

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No competing of interest is related to this present manuscript.

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Authors' Contribution:

ASA and AAA conceptualized the study. HBA carried out the sampling, sample collection and bacteriological analysis at the laboratory. ASA and AAA supervised laboratory analysis. SHS corrected and validated the analysis protocol and participated in drafting the manuscript. All authors read and approved the final version of the manuscript.

Ethical clearance:

The Dishes Sold In Five Schools In The Educational Zone Of Niamey II were collected during the survey. All street food sellers freely accepted, collaborated and gave their consent for collection of the street food samples. The international standards were used for sample analysis.

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