Advances in Microbiology, 2025, 15(5), 253-267
https://www.scirp.org/journal/aim
ISSN Online: 2165-3410
ISSN Print: 2165-3402

Analysis of the Hygienic and Microbiological Quality of Ready-to-Eat Foods: The Case of "*fura da nono*" Sold at the *Dolé* Market in Zinder (Niger)

Aminatou Bachir Alkali[1], Mahamadou Seyni Yansambou[2], Mahamane Lawali Yahaya[3], Razinatou Souley Manzo[3], Issifou Liman[2], Al-Hadji Djibrine Moussa Mahamat[2], Harouna Ibrahim[3], Ibrahim Halilou Amadou[2], Mahamadou Doutchi[4], Lamine Mahaman Moustapha[2*]

[1]Institute of Technology, André Salifou University, CQA, Zinder, Niger
[2]Lab-EGB2S, Department of Biological Sciences, Faculty of Science and Technology, André Salifou University, Zinder, Niger
[3]Department of Environmental Health, National School of Public Health, Zinder, Niger
[4]Faculty of Health Sciences, André Salifou University, Zinder, Niger
Email: aminabachiralkali@gmail.com, bioyans@gmail.com, mahamadou.seyniyansambou@uas.edu.ne, laoualicapi@yahoo.fr, souleymanzorazinatou@gmail.com, kamaloudine2000@gmail.com, alhadjidjibrinemousssa@gmail.com, ibouhar2@gmail.com, halilou2002@yahoo.fr, m.doutchi@yahoo.fr, *lamine.moustapha@uas.edu.ne

How to cite this paper: Bachir Alkali, A., Seyni Yansambou, M., Yahaya, M.L., Souley Manzo, R., Liman, I., Moussa Mahamat, A.D., Ibrahim, H., Amadou, I.H., Doutchi, M. and Mahaman Moustapha, L. (2025) Analysis of the Hygienic and Microbiological Quality of Ready-to-Eat Foods: The Case of "*fura da nono*" Sold at the *Dolé* Market in Zinder (Niger). *Advances in Microbiology*, **15**, 253-267.
https://doi.org/10.4236/aim.2025.155018

Received: March 18, 2025
Accepted: May 11, 2025
Published: May 14, 2025

Abstract

Access to safe and edible food is a right for the international community. However, food safety is a major challenge for most African countries. In Niger, a West African country, poor hygiene is one of the major public health problems. This study examined the microbiology of traditional "*fura da nono*" production and the hygiene practice of female sellers at the *Dolé* market in Zinder. Samples were collected from eighteen (18) female sellers at the *Dolé* market in Zinder. Foodborne pathogens were identified based on their morphology, culture, Gram staining and a biochemical test. The results of this study showed the presence of pathogenic bacteria and fungi in the "*fura da nono*". Analyses of the number of viable colonies, and pH were also carried out. These results show that bacteria such as *Escherichia coli* are present in 100% of the samples; while *Staphylococcus spp* are present in 38.9%, *Klebsiella pneumoniae* 33.3%, *Staphylococcus aureus* 22.2%, *Citrobacter koseri* 5.6%, *Pseudomonas aeruginosa* 5.6%. Three (03) species of fungi were identified which are *Candida glabrata* present in 77.8% samples, while *Candida krusei* are in 33.3% and *Candida albicans* 22.2%. The average pH of these samples is 4.34. This indicates poor hygiene practices during the production and sale of this food. It was

found that 100% of the "*fura da nono*" sellers in the *Dolé* market of Zinder do not have a health record for handling food products, nor follow-up medical examination and 72% of the sellers have not had training on food hygiene. Therefore, to produce commercial "*fura da nono*" in quantity and quality, it is necessary to improve the acceptability, microbiological stability and hygiene of this "*fura da nono*" food product.

Keywords

"*fura da nono*", Pathogens, Street Foods, Food Hygiene, Zinder, Niger

1. Introduction

Good food hygiene and safety practices help prevent the risk of food-borne illnesses, which can have a serious impact on public health. Street foods are an essential source of nutrition and employment in developing countries, but the absence of adequate standards can lead to the spread of bacteria, viruses and toxins [1].

Street food plays an important role in the life of the urban population. The sale of street food in developing countries like Niger can lead to a number of health problems. Food that is unfit for consumption is a global health threat, putting everyone at risk. Infants, young children and pregnant women are particularly vulnerable [2].

"*Fura*" is a cereal dumpling made from millet flour mixed with spices. "*Nono*" is a dairy product obtained by fermenting animal milk (cow, small ruminant). It is a traditional food in many West African countries, including Niger, Nigeria, Ghana, Cameroon and Burkina-Faso [3].

The "*fura da nono*" blend is a two-in-one product of a cereal (millet), "*fura*" made from millet and "*nono*", a fermented dairy product. "*Fura*" is generally prepared by mixing the dry flour ingredients (millet and spices together), then adding a little water to bind the dry ingredients. It is then ground into medium-sized balls, and when the water begins to boil, the molded balls are plunged into the water and left to boil for around 20 minutes, then transferred to a mortar and pounded. They are then stirred into small balls by hand. The "*fura*" is served by placing it in a calabash or bowl, then adding the "*fura*" to the "*nono*", stirring and adding sugar according to the consumer's taste. This food combination is called "*fura da nono*".

The manual labor involved in local "*Fura*" production, particularly hand-molding, can be a source of contamination, which can lead to food poisoning or toxi-infection. These foods are generally prepared and sold in deplorably unhygienic conditions.

National food control systems play a fundamental role in protecting consumer health and ensuring fair practices in the food trade [4]. The public therefore has the right to expect that the food they consume is safe and fit for consumption. Like other countries around the world, Niger is committed to implementing the

"National Food Safety Plan for Niger" approach to achieving Sustainable Development Goal (SDG) 2 of ensuring food security. According to the World Health Organization (WHO), every year almost one person in ten worldwide (*i.e.* nearly 600 million people) falls ill, and 410,000 of them die as a result of eating food contaminated by bacteria, viruses, parasites or chemical substances [2].

In order to protect this population, it is necessary to inspect and analyze street foods, which meet a vital need for the population. It is therefore important to identify the consequences of poor hygiene management among street food sellers.

The aim of the present work is to analyze the hygienic and microbiological quality of ready-to-eat "*fura da nono*" (dumpled cereal and milk) sold at the *Dolé* market in Zinder (Niger).

2. Materials and Methods

2.1. Study Area

Zinder's large market, called "*Kassua'n Dolé*", whose name "*Dolé*" means "obligatory" in Hausa, offers a real multitude of interests that go beyond the mere need to buy goods. It contributes both to the modernization of the town through its architectural character and to the economic development of the region. Zinder's large "*Dolé*" market is located to the south of the health center "CSI Dispensaire" and to the north of the Sabon gari district. The Zinder *Dolé* market is a recently renovated infrastructure; it was modernized 6 years ago but the official opening took place on September 20, 2018. It is an infrastructure with a capacity of 8.6 hectares, 2152 stores, including 2136 medium-capacity stores with a surface area of 9 m^2 and 16 large-capacity stores with a surface area of 63 m^2, medium shed spaces, 539 floor spaces with 16 toilets, 8 mosques and 8 parking lots. The market boasts several "*fura da nono*" sellers, 18 of whom are permanent as shown in Figure 1.

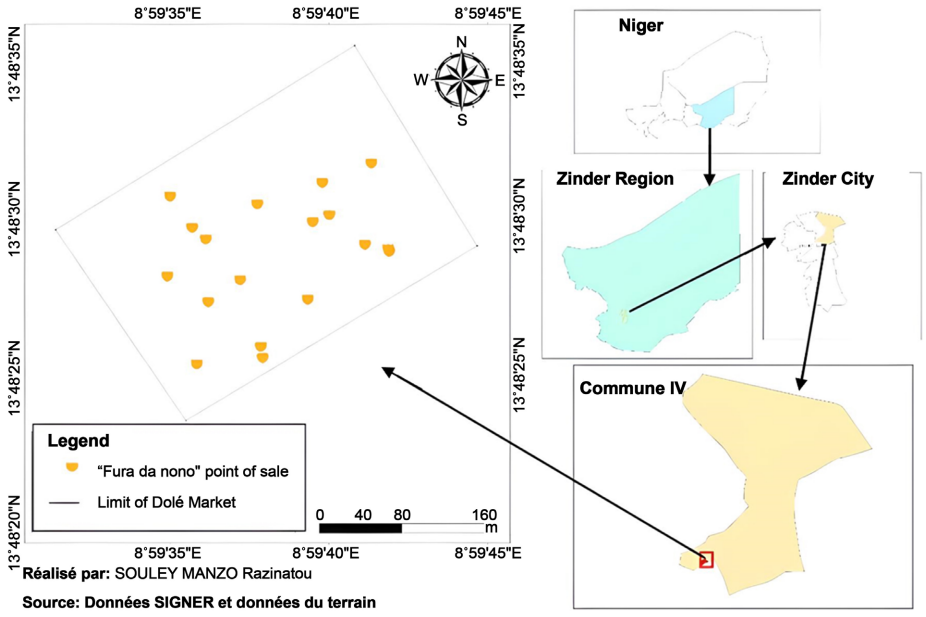

Figure 1. Location map of the Zinder *Dolé* market.

2.2. Data Collection Techniques

The population of our study consisted mainly of permanent sellers of *"fura da nono"* from the *Dolé* market in Zinder and the person in charge of the hygiene and sanitation department of the health district of the city of Zinder. The study lasted six (6) months, from November 2023 to May 2024.

An exhaustive sampling of stationary sellers of "*fura da nono*" from the Zinder *Dolé* market was carried out. "*Fura da nono*" was collected from eighteen 18 permanent vendors, and a single sample was taken from each of these outlets for a total of eighteen 18 samples.

All eighteen permanent "*fura da nono*" sellers located inside the Zinder *Dolé* market are included in this study, while those located in the vicinity of the Zinder *Dolé* market are not.

2.3. *"fura da nono"* Sampling

Samples are taken from 1 p.m. onwards, the time at which saleswomen arrive at the points of sale. Three to four samples were taken and analyzed per day. Once there, the *fura* balls are placed in a calabash or bowl, and some volume of *nono* and water is added before mixing.

This mixture is then aseptically removed using the same ladle that was used to introduce it into the sterile bottle. Once the sample has been labelled (sample number, time and date of collection), it is placed in the cooler (temperature between 4˚C and 10˚C) and sent as quickly as possible to the laboratory for analysis. The pH of the samples was measured using a Palintest pH meter. The pH meter electrode is immersed in the "*fura da nono*" sample residue after sampling. The materials and equipment used to minimize contamination include autoclave, bacteriological oven, optical microscope, sterile 50 ml bottles for sampling "*fura da nono*", cooler containing cold accumulators for transporting samples, Calibrated handles, spatula, beakers, Erlenmeyer flasks, graduated test tubes, sterile 90 mm-diameter Petri dishes, sterile graduated pipettes, sterile test tubes, sterile hemolysis tubes, gloves, object slides, marker, staining tray.

2.4. Sample Dilution Preparation

A 10^{-1} dilution of the stock solution was made for each sample by introducing 90 ml of sterile physiological water and 10 ml of *"fura da nono"* into sterile vials, before homogenizing with a vortex. Next, successive dilutions from 10^{-2} to 10^{-5} are made by taking 1 ml of the diluted solution and transferring it to tube number 1 containing 9 ml of sterile physiological water. A sample is then taken from this tube and transferred to the next, and so on until the 10^{-5} dilution is reached. All 18 samples underwent the same treatment, with dilutions of 10^{-2} and 10^{-3} chosen for inoculation.

2.5. Germ Research and Enumeration

2.5.1. Total Germ Count (Aerobic Mesophilic)

Principle

This is the enumeration of all microorganisms forming colonies in aerobic conditions on nutrient agar or PCA (Plate Count Agar) after 24 to 72 hours incubation at 35˚C to 37˚C.

This test is used to assess the sanitary quality of the food, as it gives an idea of whether the food is fresh or decomposed.

Procedure

- Prepare petri dishes, noting on each the date of inoculation, dilution and incubation temperature;
- Apply 1 ml of each dilution (10^{-2}, 10^{-3}) to the agar surface;
- Spread the sample evenly over the agar surface using a handle;
- Afterwards, the plates are turned upside down and incubated at 37˚C for 24 to 72 hours.

Reading the results

The total flora appears in the form of whitish colonies of different sizes and shapes.

2.5.2. Research and Enumeration of Total and Faecal Coliforms

Principle

Coliforms are counted on Methylene Blue Eosin (MBE) agar. After spreading the test sample over the entire surface of the medium, the plates are incubated for 24 hours at 37˚C for total coliforms and 44˚C for faecal coliforms.

Procedure

- Identify petri dishes containing solidified EMB medium by writing the date, sample number and time of inoculation;
- Deposit and spread 1ml of the respective dilution on the medium contained in each dish (10^{-2} and 10^{-3}); one series for faecal coliforms and another for total coliforms;
- Afterwards, the dishes are turned upside down and incubated at 37˚C for 24 h to 72 h for total coliforms and at 44˚C for faecal coliforms.

Reading the results

On medium incubated at 44˚C, fecal coliform colonies (*Escherichia coli*) appear as 2 to 3 mm colonies, flat, very dark purple with generally a metallic green sheen.

On plates incubated at 37˚C, total coliform colonies appear as large to medium-sized, convex, pinkish-gray, sometimes mucous colonies (*Klebsiella*), with a tendency to coalesce.

2.5.3. *Staphylococcus aureus* Detection and Enumeration

Principle

The sample is inoculated onto Baird Parker agar or Chapman mannite medium, then incubated at 37˚C for 24 hours.

Procedure

- Identify the dishes containing the solidified culture medium;
- Place 1 ml of successive dilutions on the surface of the culture medium and spread evenly over the entire surface;

- Incubate for 24 h at 37˚C.

Reading results

Staphylococcus appear as bulging golden-yellow colonies surrounded by a yellow halo resulting from mannitol reduction.

Non-pathogenic Staphylococci generally form small red colonies which do not alter the color of the medium. The presence of *Staphylococcus aureus* is confirmed by the catalase test.

1) Catalase test

This is the test generally used to differentiate catalase-positive from catalase-negative staphylococci.

Procedure

- Place a drop of 10-volume hydrogen peroxide on a clean slide;
- Using a Pasteur pipette or calibrated plastic loop, add the bacterial inoculum and observe immediately.

Reading results

- Catalase positive if bubbles appear (release of oxygen gas);
- Catalase negative if there are no bubbles.

2) Coagulase test

Coagulase or staphylocoagulase is an enzyme capable of coagulating blood plasma. The demonstration of free coagulase activity in a *Staphylococcus* strain is one of the criteria for identifying *Staphylococcus aureus*.

Procedure

Introduce into a sterile hemolysis tube:

- 0.5 ml suspension of a characteristic *Staphylococcus aureus* colony;
- 0.5 ml rabbit plasma suspension;
- Homogenize and incubate at 35˚C - 37˚C for 2 h to 4 h.

Reading

If the plasma coagulates in less than 24 hours, the germ possesses coagulase.

Research and enumeration of fungi:

For fungi (candida), we inoculated Chromatic TM Candida medium with yeast colonies from Sabouraud medium by direct streaking. Incubation took place aerobically at 30˚C - 37˚C for 24 - 48 hours. After incubation, colony color and morphology are observed and results are interpreted as indicated in the identification Table 1 below.

Table 1. Fungi identification table.

Microorganism	Typical colony color
Candida albicans	Light green
Candida dubliniensis	Yellow-green
Candida glabrata	Blanche beige
Candida krusei	Purple violet
Candida parapsilosis	Pale pink-white
Candida tropicalis	Blue

2.5.4. Gram Staining

It helps to identify bacteria by classifying them into two groups: Gram-positive bacteria stain violet and Gram-negative bacteria stain pink.

- The colony to be studied is spread on a clean, degreased slide;
- The slide is left to air-dry, then fixed by passing it two or three times over the flame of a Bunsen burner;
- The slide is placed on a staining tray and stained with gentian violet for one minute;
- Then rinse with tap water and cover with lugol, leaving for approximately 30 seconds;
- Rinse with tap water and decolorize with methanol (90˚C alcohol) until decolorized for 30 seconds, then rinse with tap water;
- The slide is then covered with the safranin solution (fuchsin) and left to act for one minute, then rinsed with tap water and left to dry before examining under the microscope with an ×100 objective.

3. Results

3.1. Results of Microbiological Analysis of "*fura da nono*" de Marche Dole Zinder

Colony counts for total germs (GT) range from 300×10^3 UCF/g to $15{,}680 \times 10^3$ UCF/g, highlighting a significant variation in bacterial load among samples. Poor hygiene levels are associated with the highest GT counts (Samples 12 and 14). Total coliform (TC) counts ranged from 5×10^3 UCF/g to $25{,}600 \times 10^2$ UCF/g, showing substantial differences in the presence of coliforms. High TC counts are associated with poor hygiene levels (Samples 12 and 14). Samples with Questionable hygiene levels show elevated microbial counts in several categories, including total germs, total coliforms and yeasts. The presence of fecal coliforms and staphylococci in some of these samples is also of concern, and indicates significant contamination (Table 2).

Table 2. Results of microbiological germ analysis (CFU/g) of "*fura da nono*" samples.

N˚ of samples	GT/g	CT/g	CF/g	Yeast/g	*Staphylococci*/g	Hygiene level
1	2700×10^2	410×10^2	170×10^2	240×10^2	103×10^2	Good
2	300×10^3	170×10^3	13×10^3	14×10^3	17×10^3	Very good
3	1070×10^2	720×10^2	80×10^2	190×10^2	66×10^2	Good
4	660×10^2	308×10^2	21.7×10^2	38×10^2	50×10^2	Good
5	800×10^2	440×10^2	110×10^2	68×10^2	33×10^2	Good
6	300×10^3	5×10^3	0	186×10^3	0	Very good
7	1300×10^2	38×10^2	0	450×10^2	2×10^2	Very good
8	2180×10^2	55×10^2	0	1040×10^2	0	Very good
9	3140×10^2	110×10^2	0	840×10^2	15×10^2	Very good

Continued

10	3700×10^2	348×10^2	0	330×10^2	100×10^2	Good
11	3360×10^3	17×10^3	0	210×10^3	2×10^3	Good
12	$35{,}000 \times 10^2$	$25{,}600 \times 10^2$	372×10^2	6200×10^2	120×10^2	Poor
13	4400×10^3	200×10^3	0	600×10^3	0	Very good
14	$15{,}680 \times 10^3$	2300×10^3	140×10^3	920×10^3	0	Poor
15	4160×10^3	500×10^3	3120×10^3	110×10^3	0	Questionable
16	3880×10^3	580×10^3	130×10^3	118×10^3	0	Questionable
17	1580×10^3	290×10^3	0	1360×10^3	960×10^3	Questionable
18	6000×10^3	1520×10^3	210×10^3	3800×10^3	0	Questionable

Escherichia coli is the most common bacterium, detected in all samples (100%). *Staphylococcus spp*, *Klebsiella pneumoniae* and *Staphylococcus aureus* are also significantly present, with 38.9%, 33.3% and 22.2% respectively. *Pseudomonas aeruginosa* and *Citrobacter koseri* are the least frequent, each present in 5.6% of samples (Table 3).

Table 3. Different bacteria identified in "*fura da nono*" samples.

Bacteria	Frequences	%
Escherichia coli	18	100
Staphylococcus spp	7	38.9
Klebsiella pneumoniae	6	33.3
Staphylococcus aureus	4	22.2
Pseudomonas aeruginosa	1	5.6
Citrobacter koseri	1	5.6

Candida glabrata is the most common fungus, detected in 77.8% of samples. *Candida krusei* and *Candida albicans* are also significantly present, with 33.3% and 22.2% respectively (Table 4).

Table 4. Different fungi identified in "*fura da nono*" samples.

Fungi	Frequences	%
Candida glabrata	14	77.8
Candida krusei	6	33.3
Candida albicans	4	22.2

Figure 2 shows the culture on petri dishes, of different fungi identified from "*fura da nono*" samples.

The pH measurements of "*fura da nono*" samples show that they are almost acid. The distribution was shown in Figure 3.

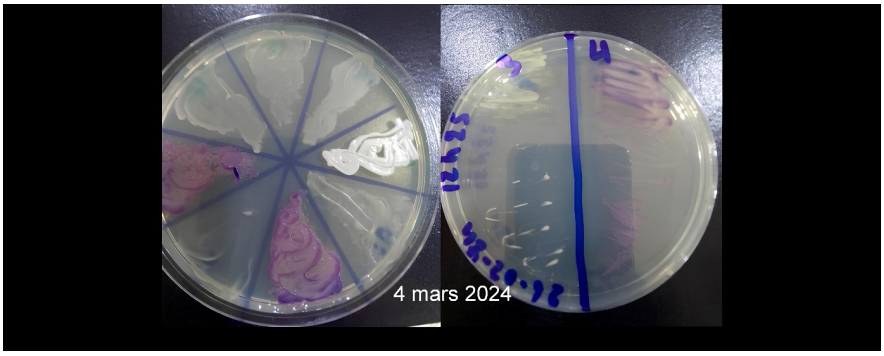

Figure 2. Different fungi identified in "*fura da nono*" samples.

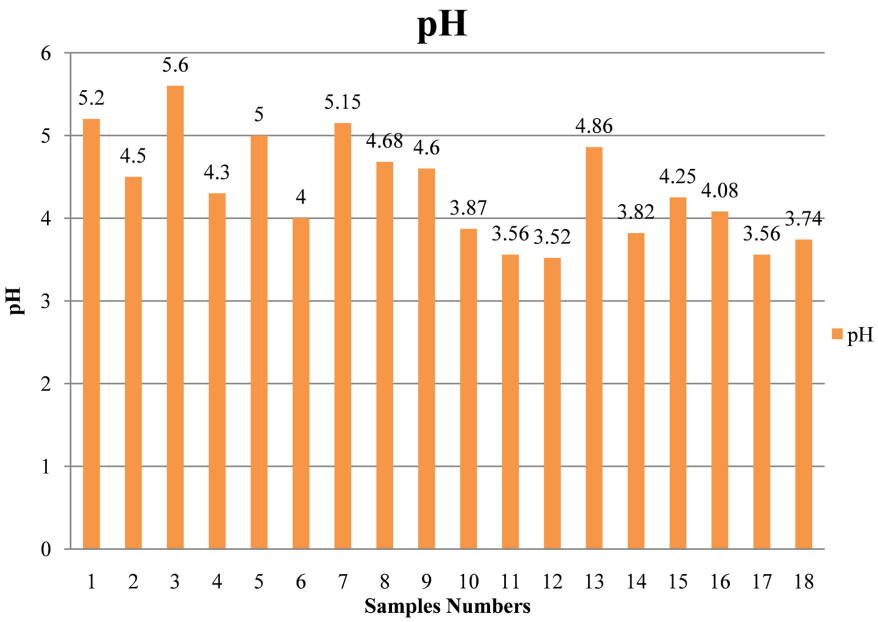

Figure 3. pH distribution of "*fura da nono*" samples.

3.2. Results of Questionnaire Sent to *"fura da nono"* Sellers at the Zinder *Dolé* Market

1) Time of preparation and storage of *fura* for sale

According to the results of our survey, all eighteen (18) saleswomen, *i.e.* 100%, prepare the *fura* destined for sale on the same day and keep the remainder (unsold) at room temperature until the following day.

2) Saleswomen's knowledge of the risk of consuming unhealthy food and training in food hygiene

According to our results, 78% of "*fura da nono*" saleswomen are aware of the risks associated with consuming unhealthy foods, while 22% are not. The majority of saleswomen (72%) have not had any training in food hygiene, while 28% have received at least one course in food hygiene. The saleswomen were asked how often they washed their hands, in order to assess the regularity of this hygienic gesture during the sale of "*fura da nono*". The survey revealed that 67% of saleswomen did not wash their hands regularly, only 17% washed regularly and 16%

washed their hands before starting the sale. The results show that none of the permanent "*fura da nono*" saleswomen have a health book and does not carry out a medical examination. The aim here is to observe the hygiene of the sales environment, which is a factor that can contaminate the food.

The results in Table 5 show that all samples were sold on the ground, and that the majority of sales environments were affected by the presence of garbage, flies and dust, which could compromise the quality and safety of the products sold.

Table 5. Quality of the "*fura da nono*" sales environment at the Zinder *Dolé* market.

Sales environment	Frequencies		Percentage	*P-value*
Sale of *fura* on the ground	Yes	18	100 %	
	No	0	0%	
Garbage presence	Yes	10	55.6%	<0.0001
	No	8	44.4%	
Presence of flies	Yes	14	77.8%	0.000
	No	4	22.2%	
Presence of dust	Yes	13	72.2%	0.000
	No	5	27.8%	

3) Unhygienic behavior

These are unhygienic behaviors by the sellers that could contaminate the dish during service.

Observations show varied hygiene practices among sellers. Positive points include the fact that most sellers do not clean their hands with clothes or cough near food. However, worrying practices such as talking on food, not covering food, not washing utensils after each use and handling money while selling are common, which could compromise food safety (Table 6).

Table 6. Gestures observed during the sale of "*fura da nono*" at Zinder *Dolé* Market.

Gestures observed during the sale	Frequencies		Percentage	*P-value*
Cleans hands with clothes	Yes	5	27.8	0.000
	No	13	72.2	
Talking on food	Yes	15	83.3	0.001
	No	3	16.7	
Coughing around food	Yes	2	11.1	0.007
	No	16	88.9	
Food is covered	Yes	3	16.7	0.001
	No	15	83.3	
Wash utensils after each use	Yes	4	22.2	0.000
	No	14	77.8	
Taking money by hand while selling food	Yes	18	100	
	Non	0	0	

4. Discussion

In our study, germ counts for "*fura da nono*" showed 300×10^3 CFU/g to $15{,}680 \times 10^3$ CFU/g for total germs, from 5×10^3 CFU/g to $25{,}600 \times 10^2$ CFU/g for Total Coliforms (TC) and from 14×10^3 CFU/g to 6200×10^2 CFU/g for yeasts. As for fecal coliforms, the numbers vary from 0 to 3120×10^3 CFU/g and for Staphylococci, from 0 to 960×10^3 CFU/g. In a study carried out in Nassarawa (Nigeria) by Ajobiewe *et al.* (2022), bacterial counts ranged from 4.0×10^4 to 7.0×10^4 CFU/ml [5]. These results are lower than those obtained in our study. On the other hand, a study carried out in Kebbi, Nigeria by Abbas *et al.*, (2020) showed higher results than ours, with viable bacterial colonies in "*fura da nono*" ranging from 8.3×10^5 to 1.25×10^8 CFU/ml [6]. This high bacterial load could be due to contamination of the utensils used during processing and to the hygiene of the sellers. It could also be attributed to micro-organisms present in the raw materials, in the environment and in the processing water. But even the milk used in preparation is not free from microorganisms. Like other dairy products, "*fura da nono*" is frequently contaminated by microbial agents. The microbiological analysis carried out in this study revealed the presence of six (6) bacterial species (*Staphylococcus aureus*, *staphylococcus spp*, *Escherichia coli*, *klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Citrobacter koseri*). These results are not very similar to those of Ajobiewe *et al.*, (2022); Nneoma Confidence, (2019) who identified bacteria such as *Staphylococcus*, *Escherichia*, *Lactobacillus*, *Streptococcus*, *Leuconostoc*, *Pseudomonas* and *Bacillus* [5] [7].

Microorganisms such as staphylococcus aureus and Escherichia coli were found by Abbas *et al.*, (2020) and also by Eluchie, *et al.*, (2019) in the "*fura da nono*" [6] [8].

These bacterial organisms identified in their study corroborate the results found in this study. Furthermore, some of the bacteria identified in this present study such as *Staphylococcus aureus*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* have also been reported by Edem, *et al.*, (2022) [9]. Then *E. coli* is present in all "*fura da nono*" samples in our study, this result is consistent with that of Eluchie, *et al.*, (2019) [8]. The presence of *E. coli* in "*fura da nono*" may be an indication of faecal contamination. It also indicates that hygiene standards are not respected during the *"fura da nono*" preparation and sale processes. Our results show the presence of pathogenic micro-organisms that can be a potential source of food-borne infections and related illnesses for consumers. The presence of *S. aureus* is probably due to poor handling by saleswomen using contaminated bare hands. It is an indicator germ of human contamination. Its main habitat is the nasal mucosa, mouth, throat and skin of healthy individuals. This bacterium is easily disseminated in the environment and can thus contaminate foodstuffs. At certain concentrations, this bacterium is considered dangerous and responsible for many cases of food poisoning.

Pseudomonas aeruginosa is widely distributed in soil and water, and can therefore contaminate food products. This can lead to infection if ingested. *Klebsiella*

pneumoniae can cause hospital-acquired infections. *Escherichia coli* causes haemorrhagic diarrhoea and poisoning. While *Streptococcus spp* are also implicated in urinary tract infections, nausea, vomiting and diarrhea in humans. The three species of fungi isolated from the "*fura da nono*" samples in our study were *Candida glabrata*, *Candida krusei* and *Candida albicans*. These results are not in line with those of Abbas *et al.*, (2020) in kebbi (Nigeria) who detected *Aspergillus niger*, *Aspergillus flavus* and *Saccharomyces cerevisiae* [6]. The same species were found by Edem *et al.*, (2022), with the exception of *Penicillium spp* and *Mucor spp* which were not also found in this study [9]. A study carried out in the Nigerian capital by Nneoma Confidence, (2019) identified two species of fungi, *Rhizopus stolonifera* and *Aspergillus niger* [7]. These results are not as identical to those of our study. Also, these fungi found in "*fura da nono*" can cause invasive candidiasis or mucosal infections according to a World Health Organization study, (2022), the presence of these species may be due to changes in the pH or microbial environment of the skin and mucosa [10]. This may be due to poor hygiene practices on the part of "*fura da nono*" sellers. While the reinforcement of hygiene in activities could be a general infection control measure to prevent the health of consumers. The presence of bacteria and fungi in "*fura da nono*" can be due to many factors. Female sellers are the main source at various stages from preparation to sale, and this could explain the failure of "*fura da nono*" sellers to comply with hygiene rules.

In fact, the average pH in our study was 4.34, with a range of 3.52 to 5.6. All "*fura da nono*" samples have an acid pH. The results of our study are almost similar to those of Abbas *et al.*, (2020) in their study carried out in Kebbi Nigeria, where the pH ranges from 3.1 to 6.8 [7]. Ajobiewe *et al.*, (2022) in a study carried out in Nasarawa Nigeria also showed that all the "*fura*" samples they studied were in the acid phase [6]. A study carried out by Omola *et al.*, (2019) identified the pH of these samples as 3.5 to 5.36, these results are in line with our findings [11]. This acidity may be explained by the addition of spices to the preparation, but also by the process of carbohydrate fermentation by microorganisms, favored by the environmental temperature of manufacture and storage.

The sale of "*fura da nono*" at the *Dolé* market is an economic activity reserved for women. The sources of contamination of these foods can be grouped into the materials used in direct contact with "*fura da nono*", which may constitute potential sources of contamination. The environment in which the food is handled (sales environment): all saleswomen sell "*fura da nono*" on the ground. This can be a source of contamination. The methods used to prepare, store and preserve these foods can be considered a source of contamination. For example, 100% of "*fura da nono*" sellers don't preserve their products, keeping their leftovers (unsold) at room temperature until the next day to resell. This method of preservation by *fura* sellers is a source of microbial proliferation. This poor preservation could be explained by the sellers' ignorance of the importance of good preservation, but also by a lack of resources.

"*fura da nono*" is mixed with water to improve mixing. The equipment used, such as buckets, cans, calabashes, bowls and ladles, which are not well maintained, are therefore the most important sources of microbial contamination. What's more, the majority of "*fura da nono*" sellers don't wash their hands before starting their shift, despite the fact that controlling food safety necessarily involves hand-washing, which should become a reflex. This shows how little "*fura da nono*" sellers know about food hygiene. Secondly, not all sellers cover the "*fura and nono*" balls during the entire sales period. 100% of sellers hold the money in their hands while selling fura, and 83.3% talk on the food, which can be a source of contamination. This demonstrates the lack of respect for hygiene rules at the Zinder *Dolé* market. Observation of the sales environment also reveals the presence of flies in 77.8% of sites, and dust in 72.2% of sales outlets. This is a major source of microbial contamination of foodstuffs. This poor practice is due to the position of the sales site, but also to the negligence of saleswomen despite their knowledge of the involvement of flies and dust in food contamination. It should be noted that 100% of "*fura da nono*" sellers operating on the *Dolé* market do not have food sales permits issued by the relevant authorities. This shows that medical examinations are not carried out. This proves that saleswomen are not informed about what they need to do to carry out their activity legally, in particular to obtain a sales authorization booklet. Whereas the appointment is given on a quarterly basis. What's more, if the staff handling the "*fura da nono*" are not in good health, or have skin or hand infections, bacteria can be added to the "*fura da nono*", hence the importance of the periodic medical check-up, which can detect illnesses in saleswomen. In Niger, article 4 of Decree 2008-224/PRN/MSP of July 17, 2008 stipulates that "personnel involved in the production or trade of foodstuffs must undergo medical examinations every three (3) months at the health police laboratory or any other approved laboratory. The medical examinations concerned are as follows: KOPA stool examination; urinary bile examination; physical examination.

Despite the rigor of this study's methodology, it has certain limitations that it is important to highlight. Firstly, sampling was limited to stationary "*fura da nono*" vendors located inside Zinder's *Dolé* market, thus excluding vendors located on the outskirts. This may reduce the representativeness of the results, as the hygiene practices of mobile vendors or those outside the main market may differ. Secondly, collecting a single sample per outlet may not reflect possible variations in preparation or hygiene conditions over time.

5. Conclusion

This shows that the *"fura da nono*" sold by permanent sellers are contaminated with micro-organisms. Some of the species identified in this study are known to be pathogenic and may therefore present a danger to public health. This is due to the fact that *"fura da nono*" sellers at the *Dolé* market have poor hygiene practices and little knowledge of good hygiene practices. It is therefore necessary to raise

their awareness of handling, preparation, sales methods and hygiene to avoid illnesses linked to the organisms encountered in this study. It can be concluded that prepared *"fura da nono"* contains pathogenic bacteria. Their presence indicates unhygienic handling during production. For this reason, the microbiological quality of "*fura da nono*" at the *Dolé* market should be improved by respecting and applying Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP).

Ethical Approval

This study does not require approval from an ethics committee, as it does not involve human participants or animal experiments.

Data Availability Statement

The data used to support the results of this study are available upon request from the corresponding author.

Conflicts of Interest

The authors declare that they have no conflict of interest.

References

[1] Bantie, G.M., Woya, A.A., Ayalew, C.A., Mitiku, K.W., Wubetu, G.A., Aynalem, Z.B., *et al.* (2023) Food Safety and Hygiene Practices and the Determinants among Street Vendors during the Chain of Food Production in Northwest Ethiopia. *Heliyon*, **9**, e22965. https://doi.org/10.1016/j.heliyon.2023.e22965

[2] FAO/WHO and ODD (2020) Guide a la journée internationale de la sécurité sanitaire des aliments. 8 p.

[3] Owusu-Kwarteng, J., Akabanda, F., Nielsen, D.S., Tano-Debrah, K., Glover, R.L.K. and Jespersen, L. (2012) Identification of Lactic Acid Bacteria Isolated during Traditional Fura Processing in Ghana. *Food Microbiology*, **32**, 72-78. https://doi.org/10.1016/j.fm.2012.04.010

[4] FAO and WHO (2020) Food Control Systems Assessment Tool: Introduction and Glossary. Food Safety and Quality Series World Health Organization N˚7 1.

[5] Ajobiewe, H.F., Ihekuna, P.U., Ajobiewe, J.O., Aniakor, G.C., Yashim, A.N., Alau, K.K., Udefuna, P.A., Umeji, L.C., Salami, A.O. and Dangana, A. (2022) The Level of Contamination of Fura Sold in Karu Local Government Area of Nasarawa State of Nigeria. *Scholars Journal of Applied Medical Sciences*, **10**, 1123-1132. https://doi.org/10.36347/sjams.2022.v10i07.014

[6] Abbas, B.Y., Zaharaddin, M.K., Bashar, H.G., Bashar, M.D., Basiru, A., Chidiebere, O. and Ayuba, A.S. (2020) Microbiological Quality Assessment of "*fura da nono*" Production in Kebbi State, Nigeria. *Equity Journal of Science and Technology*, **7**, 45-48.

[7] Confidence, N. and Anyanwu, J. (2019) Analyse microbiologique et comparative des boissons lactées fermentées indigènes et semi-industrielles ("*fura da nono*" et Fura da Yoghurt) vendues dans la capitale du Nigeria. *International Journal of Bioassays*, **8**, 5716-5723.

[8] Eluchie, C.N., Chukwu, M.N., Amandikwa, C. and Umelo, M.C. (2019) Microbiological Quality of a Locally Fermented Milk-Cereals Mixture (*fura de nunu*) Sold in

Owerri Metropolis, Imo State, Nigeria. *Advances in Food Science and Engineering*, **3**, 77-84.

[9] Edem, V.E., Abubakar, A.W., Etukakpan, M.N. and Elijah, A.I. (2022) Microbial Assessment of Fura-Nunu Sold in Eiyenkorin, Kwara State, Nigeria. *International Journal of Natural Sciences Research*, **10**, 30-42. https://doi.org/10.18488/63.v10i1.3000

[10] Organisation mondiale de la santé (2022) Liste des agents pathogènes fongiques prioritaires de l'OMS pour guider la recherche, le développement et l'action de santé publique. 48 p.

[11] Omola, E.M., Kawo, A.H., and Bukar, A., (2019) Microbiological Quality of Traditionally Fermented Fresh Cow Milk (Nono) Retailed in Selected Local Government Areas of Kano State, Nigeria. *UMYU Journal of Microbiology Research* (*UJMR*), **4**, 45-52. https://doi.org/10.47430/ujmr.1941.008