Assessment of microbial contamination and hygiene practices of okra powders in public markets of Yamoussoukro

Abstract

Background: Okra is one of the most consumed fruit vegetables by Ivorians either fresh or powdered. However, due to a lack of supervision, okra powders are sold under conditions that often leave something to be desired.
Objectives: This study aims to assess the level of microbialcontamination of okra powders sold in public markets, with a view to preventing any potential health risks for consumers.
Methodology: The experimental method is based on a survey within the markets of the city of Yamoussoukro in order to describe the conditions of sale. Samples of okra powders sold in these markets were analyzed.
Acquired Results: The survey showed that, most marketers sell their product beyond 10 days. Additionally, okra powders are sold in plastic containers, uncovered. In addition, the analyzes reveal the absence of *Salmonella spp.* but the presence of yeasts, molds, *Staphylococcus aureus* and *Escherichia coli* whose loads varying from 3.5. 103a ± 0.16.103 to 4.8.103a ± 0.49.103 CFU/g, 1.5.104b ± 0.28.104 to 3.2.103a ± 0.32.103 CFU/g and 3.3.103a ± 0.17.103 to 8.103a ± 0.91.103 CFU/g. However, all the okra powders analyzed present an unsatisfactory microbiological quality.
Conclusion and outlook: To avoid any health riskfor consumers, traders must be supervised, organized and made aware of good hygiene practices.

Keywords*: sanitary quality; hygiene; okra powder.*

1. Introduction

Okra is a tropical flowering plant in the Malvaceae family, characterised by a diversity of fruit and stem shape and colour [1]. This vegetable plant is grown in most countries in the tropical, subtropical and Mediterranean regions of Africa, America and Asia.

Nutritionally speaking, okra contains many nutrients (calcium, iron, protein, vitamins A and C, phosphorus, potassium and magnesium) that are food supplements [2]. Rich in fibre, okra aids digestion and also has a laxative effect, mitigated by its antispasmodic properties. It should only be prescribed on medical advice and may be contraindicated in certain cases [3].

Okra is grown throughout Côte d'Ivoire, with annual production in 2021 of around 193,000 tonnes [4]. However, when it is available, okra production exceeds the population's capacity to absorb it. This is why excess production is sun-dried to avoid wastage and loss of income for farmers. In fact, in developing countries with high levels of sunshine throughout the year, sun-drying is one of the methods widely used to preserve foodstuffs. However, sun-drying presents a major problem due to a lack of control over hygienic conditions [5]. In addition, when dried okra is stored in humid conditions, many microbes, particularly fungi, can develop and secrete toxic substances that can pose health risks to consumers [6].

In Côte d'Ivoire, studies on the microbial contamination of pulses have been carried out. Some authors have studied mycotoxins and fungal contamination in dried vegetables. For example, Youssef found evidence of the presence of moulds and their toxins in sun-dried okra sold on markets after 22 weeks' storage [6]. Similarly, Hell et al. determined moulds and aflatoxins in dried okra. They also showed that the mould load was very high [7].

Okra powder is a basic ingredient of the ‘djoumgblé’ sauce and is part of the dietary habits of the inhabitants of Yamoussoukro. It is therefore necessary to assess the microbiological quality of okra powders sold in Yamoussoukro's public markets. Little research has been done on the hygienic quality of these powders sold in markets [8]. However, these powders are sold under conditions that often leave much to be desired. The risk of proliferation of pathogenic micro-organisms, the cause of food poisoning, can be high. This is the background to this study. Its aim is to assess the microbiological quality of okra powders sold on local markets with a view to

guaranteeing their safety. The information obtained could be used to raise awareness among producers with a view to improving the quality and safety of okra powders produced in the town of Yamoussoukro, and indeed throughout the country.

2. Materials and methods

2.1. Material

In the town of Yamoussoukro, two varieties of okra are frequently consumed. These are the Koto variety, known as 'Dioula okra', the powder of which is commonly called 'gbanmougou', and the Tomi variety, known as 'Baoulé okra', the powder of which is commonly called 'djoumblé'. This study focused on 'djoumblé' powder, which is highly prized in the town (Figure 1).

Figure 1: Okra powder (djoumblé)

The biological material consists of okra powder sold on the various public markets (Héléis market, Fondation market, Great Market, Mohfaithai market).

2.2. Methods

2.2.1. Sociological survey

A survey was carried out between April and May 2022 to assess the conditions under which okra powder is sold in Yamoussoukro. It took place in various markets in the city, namely the Héléis, Fondation, Habitat (Great Market) and Mohfaithai markets. After taking stock of the women selling okra powder, they were asked semi-open-ended questions with suggested answers. These questions concerned the identification of the respondent and the conditions of sale. The shopkeeper was then given a score on a scale of 1 to 5 after a visual assessment of the hygienic conditions of the commercial environment. 1 was considered to be an 'unhygienic environment', 2 was considered to be an 'unacceptable environment', 3 was considered to be an 'acceptable environment', 4 was considered to be a 'healthy environment' and 5 was considered to be a 'very healthy environment'.

2.2.2. Sampling

This took place after the survey phase. Five (5) shopkeepers per market were selected for sampling on the basis of the number of customers. That is a total of twenty (20) traders. Three (3) samples were taken from each shopkeeper. A total of sixty (60) samples were taken during this period. The samples were packaged in Stomacher bags and transported to the laboratory in coolers for analysis.

2.2.3. Microbiological analysis

Yeasts and moulds were counted on Sabouraud agar with Chloramphemicol, in accordance with French standard NF/ISO 7953. Staphylococcus aureus and Escherichia coli were isolated and counted on Baird-Parker agar with added egg yolk and potassium tellurite, respectively, in accordance with French standard NF/ISO 6888: 2004, and on TBX agar, a selective medium designed for the enumeration of E. coli in food products (Biokar Diagnostics, France) in accordance with standard V 08-053. Salmonella spp. were detected by pre-enrichment in Buffered Peptone Water (Merck, France), followed by enrichment in MOSSEL broth (Merck, France) and isolation on Xylose-Lysine-Deoxycholate (XLD) agar (Biokar Diagnostics, France) in accordance with standard V 08-013.
All tests were performed in duplicate. Results were expressed as colony-forming units per gram (CFU/g).

2.2.4. Microbiological assessment criteria

The microbiological quality criteria adopted were taken from the publication concerning food microbiology published by a French journal in 1998 as shown in Table I [9]. The following standards (m, M) were used: 'm' was defined as the permissible level of bacterial count and 'M' as the maximum permissible number per gram of product. The number 'n' of sampling units is 5 and the tolerance 'c' is 2. The hygienic quality of the dried okra is satisfactory if the load is less than or equal to m. It is acceptable if the load is between m and M for 2 sampling units. It is unsatisfactory if the load is greater than M or if Salmonella spp. are present in 25 g (Table I).

Table I: Microbiological criteria for dried vegetables [9].

Microorganisms	m	M
Salmonella spp	Absence in 25 g	
Staphylococcus aureus	10^1 CFU/g	10^2 CFU/g
E. coli	10^1 CFU/g	10^2CFU/g
Levures et moisissures	10^3CFU/g	10^4 CFU/g

m = criteria; M = maximum threshold

2.2.5. Statistical analysis

The data collected were analysed using a one-factor analysis of variance (ANOVA) at a significance level set at p = 0.05. This analysis was performed using STATISTICA 7.1 software.

3. Results and discussion

3.1. Sociological survey

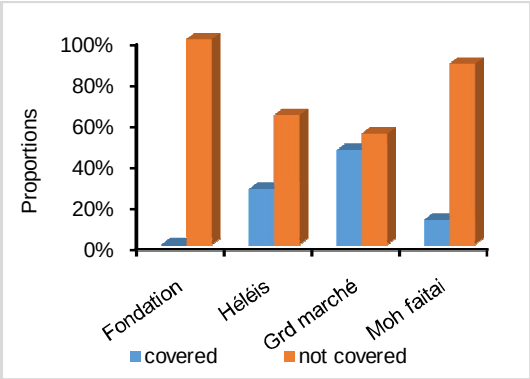
One hundred and twenty (120) traders were identified during this survey. Table 2 shows that all the traders (100%) were women. This activity was practised by 56% of the indigenous population, represented by the Baoulé people. Of the respondents, 52% had no schooling, 40% had primary education and 8% had secondary education (Table 2).
Most of the traders surveyed had little knowledge of good hygiene practices. The okra powders were packaged in plastic bags or bowls, most of which were not covered (Figure 2).

The survey revealed that most traders sold out of their stock of okra powder in less than 10 days. However, for some of them, it could take more than that, or even 30 days to sell out (Figure 3).

In all the markets surveyed, okra powders were sold in an environment where hygiene conditions were mostly acceptable, particularly in the MohFaitai market (87% of traders). However, unacceptable hygiene conditions were observed in all markets, mainly in the Great Market (60%), the Héléis market (50%) and the Fondation market (45%) (Figure 4).

Table 2: Socio-demographic characteristics of women selling okra powder

	Features	Frequency	Percentage (%)
Gender	Male	0	0
	Female	120	100
Ages (years)	18 – 30	15	12,5
	31 – 40	66	55
	> 40	39	32,5
Level of education	Not enrolled	62	52
	Primary	48	40
	Secondary	10	8
Ethnics groups	Aboriginal people	67	56
	Natives	43	36
	Allogens	10	8



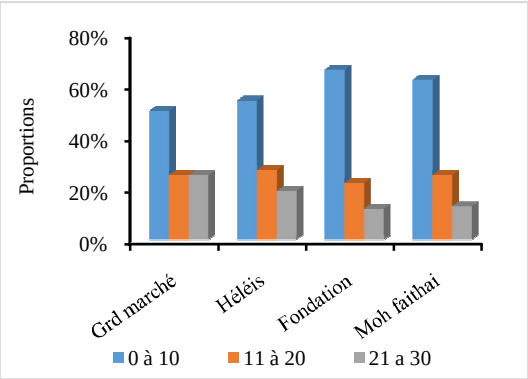


Figure 2: Presentation of okra powders**Figure 3:**Run-off time for okra powders

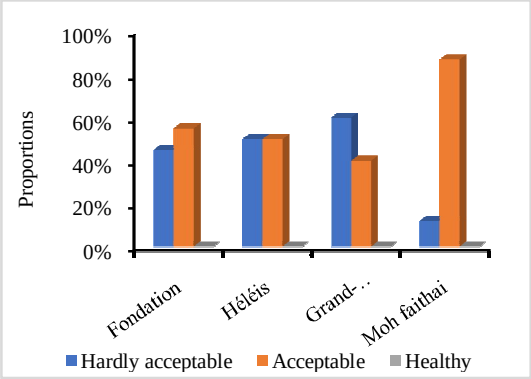


Figure 4: Hygiene in the commercial environment

3.2. Microbiological analyses

The average loads of the various germs determined are summarised in Table 3. The aerobic mesophilic flora (yeasts and moulds) in all the samples analysed showed high levels ranging from 3.5 x 103 ± 0.16 x 103 CFU/g to 4.8 x 103 ± 0.49 x 103 CFU/g. The average S. aureus and E. coli loads varied respectively from 2.5.103 ± 0.16.103 CFU/g to 2.02.104 ± 0.49.104 CFU/g and from 3.3.103 ± 0.17.103 CFU/g to 6.105 ± 0.99.105 CFU/g with considerable standard deviations (Table 3).

Statistical analysis showed a non-significant difference ($p > 0.05$) between okra powder samples from different markets with regard to yeasts and moulds. However, there was a significant difference ($p < 0.05$) between the samples from the foundation market and those from the other markets with regard to E. coli. There was also a significant difference between samples from the Fondation and Great Market markets and those from the Héléis and Mohfaithai markets with regard to S. aureus. Salmonella spp. were not detected in any of the samples analysed (Table 3).

Table 3: Average load of microorganisms determined in samples of okra powder according to the different markets

Parameters microbiological	**Markets**			
	Fondation	**Héléis**	**Largemarket**	**Mohfaithai**
Yeasts andmoulds (CFU/g)	$3,6.10^{3a} \pm 0,63.10^{3}$	$4,2.10^{3a} \pm 0,41.10^{3}$	$4.8.10^{3a} \pm 0,49.10^{3}$	$3,5.10^{3a} \pm 0,16.10^{3}$
S. aureus (CFU/g)	$1,5.10^{4b} \pm 0,28.10^{4}$	$3,2.10^{3a} \pm 0,32.10^{3}$	$2,02.10^{4b} \pm 0,49.10^{4}$	$2,5.10^{3a} \pm 0,16.10^{3}$
E. coli (CFU/g)	$6.10^{5b} \pm 0,99.10^{5}$	$8.10^{3a} \pm 0,91.10^{3}$	$7.10^{3a} \pm 0,58.10^{3}$	$3,3.10^{3a} \pm 0,17.10^{3}$
Salmonella spp	Absence in 25 g			

With : CFU = colony forming unit

Values are mean ± standard deviation (n=3). Levels with different alphabetical letters on the same line are significantly different (P < 0.05), according to Tukey's test.

3.3. Microbiological assessment criteria

Figure 5 shows the microbiological quality of the okra powder samples from the different markets. According to the microbiological criteria, on the Mohfaithai market, most of the okra powder samples (67%) were of unsatisfactory quality. Only 13% of okra powders were of satisfactory quality and 20% were of acceptable quality. As for the samples from the Héléis market, only 7% were of satisfactory quality and 13% were of acceptable quality. The remaining 80% of samples were of unsatisfactory quality. At the Fondation market, none of the samples were of satisfactory quality. Only 7% were of acceptable quality. All the rest (93%) were of unsatisfactory quality. However, at the Great Market, all the okra powder samples analysed were of unsatisfactory microbiological quality (Figure 5).

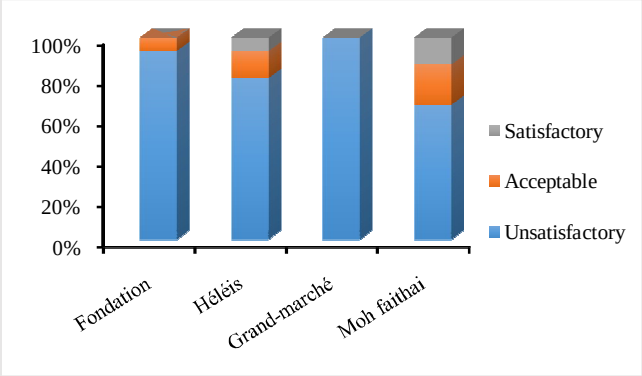


Figure 5: Microbiological quality of okra powder samples from different markets.

3.4. Discussion

In Africa, particularly in Côte d'Ivoire, the handling of vegetable crops, from the field to the plate, is most often reserved for women. This is clear from the fact that all the traders in okra powder were women. According to the National Agricultural Investment Programme (PNIA), vegetable production in Côte d'Ivoire involves a large proportion of the population, almost 60% of whom are women and young people. What's more, in the traditional vegetable production system, the activities are devolved to the women and young people in the family [10]. Researchers have also made this observation in a study of the economic importance of okra in Chad. They noted that okra represents a major source of income, and that almost 75% of women have been involved in these activities since sowing [11].

The large proportion of local people (Baoulé) represented on the markets may be linked to the study area. Yamoussoukro is a town where the majority of the inhabitants are Baoulé. In addition, the speculation studied (Baoulé okra) would be a factor. According to Fondio's work in central Côte d'Ivoire in 2005, Tomi-type okra (Baoulé okra) is recognised as being that of the Baoulé people [12].

On the whole, the sellers had little knowledge of hygiene rules. This could have an impact on the sanitary quality of the okra powders. The presence of yeasts and moulds in the samples may be due to the relative humidity of the air and the water content of the product, as well as to inappropriate storage methods, often associated with poor hygiene [13]. In fact, on the markets, sellers are in the habit of storing dried vegetables in warehouses where the temperature is not controlled and where there is a lack of ventilation, which encourages humidification of the dried vegetables and therefore microbial development [14]. For example, Youssef isolated moulds in the following products: dried okra and dried mallow leaves with a load of 4.8.104 CFU/g and 1.7.104 CFU/g respectively [6].

Most retailers did not cover their products when they were marketed. This could lead to contamination of the product. Indeed, according to Hell et al, contamination of foodstuffs by spoilage fungi is the result of foreign natural pollution by dust particles containing spores during storage [7].

The presence of S. aureus in samples of okra powder is not consistent with Mpuchane and Gashe who did not identify S. aureus in dried leafy vegetables purchased from street vendors in Botswana [5]. However, the absence of Salmonella spp. is in line with recent studies which did not identify these germs in okra powders sold on markets in Abidjan [8]. The absence of this germ reduces the health risk from consuming okra powders. However, the presence of S. aureus could present a risk. S. aureus and Salmonella spp. are pathogens that can spoil food [15; 16].

Most of the samples were of unsatisfactory microbiological quality, especially those from the Great Market. This was partly due to the unacceptable hygiene conditions in the commercial environment (60%). The considerable standard deviations observed reveal the variable nature of okra powder production conditions and parameters from one product to another from the same trader. These results point to a serious problem with the sanitary quality of okra powders, as germs can secrete toxins[17]. This observation was also made by Agbo et al. on okra powders sold in public markets in Abidjan [8].

4. Conclusion and outlook

The results of this study showed that okra powder was marketed by women, most of whom had no education and little knowledge of food hygiene. On the markets, the powders were packaged in uncovered plastic containers, in hygienic conditions that often left much to be desired. The microbiological quality of the okra powders produced and sold in Yamoussoukro did not comply with standards. The high levels of E. coli and S. aureus indicate that the powders were of poor quality, so consumption of these products could constitute a major public health risk. The lack of training for traders and the absence of hygiene measures in the markets would explain the bacterial proliferation observed in these powders. Observing good hygiene practices could help to reduce the microbial load. To achieve this, shopkeepers need to be made aware of good catering practices. The conditions under which okra powder (djoumblé) is produced, particularly drying and storage, need to be examined with a view to reducing the risks to consumers.

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