EVALUATION OF PRACTICES AT RISK OF MICROBIAL CONTAMINATION IN THE PRODUCTION CHAIN OF VEGETABLE SALADS SOLD IN PUBLIC CATERING IN THE SUBURBAN AREA OF ABIDJAN, IVORY COAST

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RESEARCH ARTICLE

EVALUATION OF PRACTICES AT RISK OF MICROBIAL CONTAMINATION IN THE PRODUCTION CHAIN OF VEGETABLE SALADS SOLD IN PUBLIC CATERING IN THE SUBURBAN AREA OF ABIDJAN, IVORY COAST

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Abstract

In Côte d'Ivoire, the absence of good hygiene practices in certain sectors is common, especially in the market gardening sector, which could increase the risk of collective food poisoning. The objective of the study was to evaluate the practices and risks of microbial contamination, in the production chain of the suburban area of Abidjan. A survey was carried out using a questionnaire with 575 people involved in the sector, in particular producers, sellers, restaurateurs and consumers on the Anyama, Adiopodoumé, Bonoua and Dabou sites. On the various sites of the study, 70% of market gardening is practiced by men, 80% of whom do not have a level of education for compliance with hygiene rules. The producers use 95% of the untreated water emanating from wells, ponds and lagoons to water the vegetables. The sites lack sanitary facilities (80%), so the producers go to the saddle near the fields. In the markets, saleswomen relieve themselves in public toilets (84.4%) by washing their hands with soap-free water (64.1%). Restaurateurs serve pre-cut vegetables (52%) and stored at room temperature for three to four hours (67.2%) before consumption. Consumers claim to consume vegetable salads (61.7%) preferably at breakfast (57%) and at least once a day (66%). Constant monitoring of the application of hygiene rules must be established from producer passing through the markets to the consumer's plate, in order to prevent the appearance of food poisoning of vegetables and guarantee the health of all.

Introduction:

Vegetables are completely or partially edible herbaceous plants, raw or cooked. They are a good source of protein, vitamins, minerals, trace elements and fiber. Vegetables come in a variety of forms, such as leaves, tubers, roots, bulbs, sprouts, stem shoots, seeds, flowers and fruits **[1] [2].** Vegetables are recognized for their benefits and are recommended for their protective properties a gainst cancer and other chronic degenerative diseases such as cardiovascular diseases and diabetes **[3][4][2].** Thus, the World Health Organization (WHO), the European Food Safety Authority (EFSA), the Food and Agriculture Organization of the United Nations (FAO) and the French Food Safety Agency (AFSSA) recommend and encourage the consumption of at least five servings of fruits and vegetables per day **[5] [6].**

In West Africa, mainly in Côte d'Ivoire, vegetables are consumed in various forms in salads, appetizers or as an accompaniment to a main course. The most consumed form is the vegetable salad as an accompaniment to a main course. The sale of street food is a booming activity because it is a great source of jobs in many cities in developing countries. For the simple reason that these dishes are inexpensive, available at special times and places. They allow

most of the population, especially civil servants, students, artisans, students, to eat easily and easily outside the home and relatively cheaply **[7].**

Despite the benefits associated with the consumption of fruits and vegetables, the food safety of those consumed fresh remains a major concern. In Côte d'Ivoire, a study has proven that the irrigation water used for growing vegetables was contaminated with faecal germs **[8][9].** Also, virulent strains of *E. coli* have been identified in the vegetable sector in urban areas **[9].** Also, the vegetables and vegetable salads marketed in urban areas were of unsatisfactory microbiological quality with rates of 42.7% and 61.7% respectively and therefore represented a risk of consumption **[10].** However, the data in suburban areas are insufficient and some germs must be studied to show the importance of monitoring the production chain of vegetable salads. Faced with this reality, it is necessary to evaluate practices at risk of microbial contamination in the production chain of vegetable salads sold in public catering in the suburban area of Abidjan, Ivory Coast.

Materials and Methods:

Choice of the investigation site

The study was carried out in the suburban area of the city of Abidjan in Côte d'Ivoire. The study was conducted from September 2023 to January 2024 in four cities in Côte d'Ivoire, the selected cities are those of Dabou, Anyama, Adiopodoume and Bonoua. The questionnaire of the survey was focused on the agricultural practices of the producers, the origin of the water used for watering, the mode of conservation of vegetables in the markets and the places of restorations, the hygiene of the saleswomen, the restorers and the places of production, sale and restoration of vegetable salads finally with consumers to know the frequency and the mode of consumption in collective restorations. Socio-demographic information such as age, gender, level of education and number of years of experience were collected from the various actors (producers, saleswomen, restaurateurs).

Size of the surveyed population

The size of the population to be surveyed was determined on the basis of data from the General Population and Housing Census of 2023 and was calculated using the formula of Dagnelie (1998) **[11].**

Formula of Dagnelie (1998) $$n = \frac{U^2_{1-\frac{\alpha}{2}} \times p(1-p)}{d^2}$$

n: minimum size of the surveyed population
p: prevalence of consumption of dietary supplements collected.
U1-α/2: 1.96 with α = accuracy level of 5 %
d: margin of error set at 0.05

The minimum size calculated for a representative sample is approximately 383 people to be interviewed. The actors along the production chains of vegetable salads were interviewed in the realization of this study. The interviewees were 575 divided as follows, 35 vegetable producers on the sites (Bonoua, Dabou and Adiopodoume), 120 vegetable sellers at a rate of 30 per site (Bonoua, Dabou, Anyama and Adiopodoumé), 120 collective catering saleswomen at a rate of 40 per site (Bonoua, Dabou and Anyama), and 300 consumers at a rate of 100 per site (Bonoua, Dabou and Anyama).

Conduct of the survey and inclusion criteria

On the production sites, the choice of the people surveyed was guided by the choice of mainly cultivated vegetables such as lettuce and tomato. At the level of the sales sites, the merchants whose main activity is the sale of vegetables with mainly leafy vegetables and fruit vegetables and who exercise it all year round were retained for the survey. Producers and traders with an age of at least 20 years were taken into account by this survey. In collective restorations, the restaurateurs serving vegetable salads to accompany their dish were retained for the investigation. This questionnaire was administered to the various actors who wished to answer it without any constraint.

This survey took place from September 2023 to January 2024. The questionnaire focused on the agricultural practices of the producers, the origin of the water used for watering vegetables, the mode of storage of vegetables in markets and in places of catering, as well as the hygiene of saleswomen, restaurateurs, and sites for the production, sale and consumption of vegetable salads. Consumers were also asked questions to determine the frequency and

consumption patterns of vegetable salads in collective restaurants. Socio-demographic information such as age, gender, religion, level of education and number of years of experience were collected from the various actors (producers, saleswomen, restaurateurs).

Data processing

The answers to the questionnaire were coded and recorded using Epi Info 7.2.1.0, then exported to Microsoft Excel to calculate the different scores. The results made it possible to determine the frequency of the modalities for each variable studied. The results were expressed as a percentage and the comparison of the different frequencies observed according to the production and sales sites was carried out by applying the Pearson Chi-square test. A p-value < 0.05 was considered statistically significant

Results:

Characteristics of the different production sites and origins of the irrigation water sources

The type of vegetables grown according to the production site investigated has been presented in **Table 1**. The different vegetable production sites were generally dominated by lettuce and tomato. Figure 1 shows the different water sources and their frequency of use for watering vegetables in the fields. Most vegetable growers use well water (47.5%) for watering vegetables, compared to 25% for ponds and 22.4% for the water of the Ebrié lagoon. Only 5% of producers use borehole water.

Table 1: Type of vegetables grown according to the sites

	Cultivated vegetables				
Production sites	Lettuce	Tomato	Chilli	Eggplant	Cucumber
Adiopodoume	2/3	1/3	1/3	1/3	0/3
Bonoua	2/3	2/3	0/3	0/3	1/3
Dabou	1/3	2/3	1/3	0/3	1/3

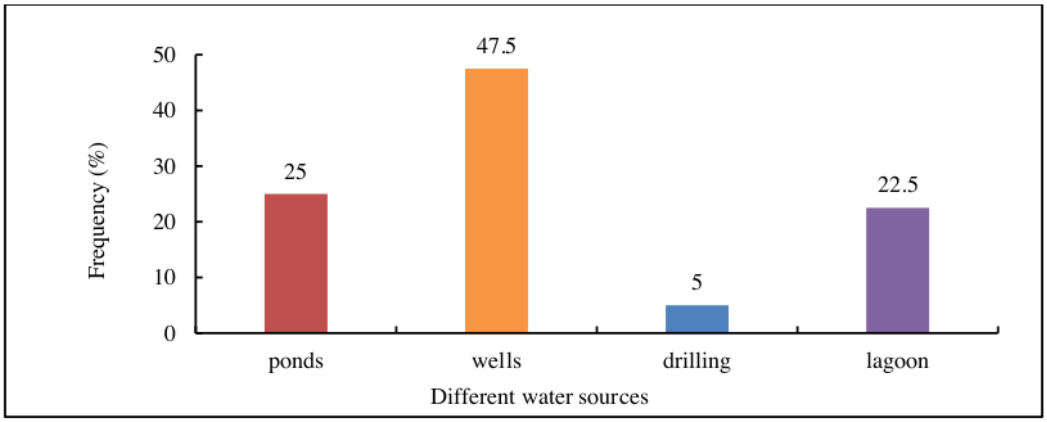


Figure 1: Water used for watering vegetables

Socio-demographic characteristics of vegetable growers

The farms were medium-sized (87.5% and the main crops grown were tomato and lettuce. The production of vegetables on the different sites shows that market gardening is practiced á 70% by men whose age varies between 30-45 years (50%) who 80% have no knowledge of good hygiene practices **(Table 2).**

Table 2: Socio-demographic characteristics of vegetable producers in the peri-urban area of Abidjan, Ivory Coast

Characteristic	Distribution (%)			
	Adiopodoumé	Bonoua	Dabou	Total
	(N= 10)	(N= 15)	(N= 15)	(N= 40)
Age				
Less than 30 years old	40	26,67	20	27,5 (11)
30-45 years old	50	46,67	53,33	50 (20)
More than 45 years	10	26,67	26,67	22,5 (9)
Sex				
Male	60	66,67	80	70 (28)
Female	40	33,33	20	30 (12)
Level of study				
No education	40	93,3	93,3	80 (32)
Education	60	6,67	6,7	20 (40)
Size of the holding				
Small	-	20	13,33	12,5 (5)
Average	100	80	86,67	87,5 (35)
Type of vegetable grown				
Lettuce	60	53,33	40	50 (20)
Tomato	40	46,67	60	50 (20)

Practices at risk of contamination of vegetables in the fields

In general, **Figure 2** presents the practices and risks of contamination of vegetables in the fields on the different sites where the study was conducted, it appears that 40% of the producers did not clean the harvesting equipment. Also, in the event of injuries, protective measures are not applied (39%), most farms did not have sanitary facilities (80%). In addition, the use of manure and untreated irrigation water represent respectively 75% and 80% in these farms. In addition, the fields do not have a fence (95%), which gives access to animals (43%) and to the presence of household waste observed in 92.5% of these different farms.

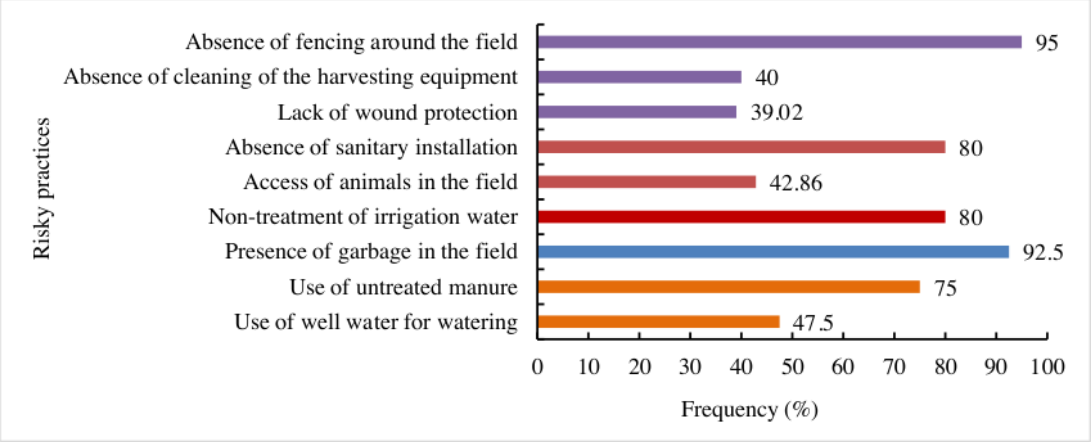
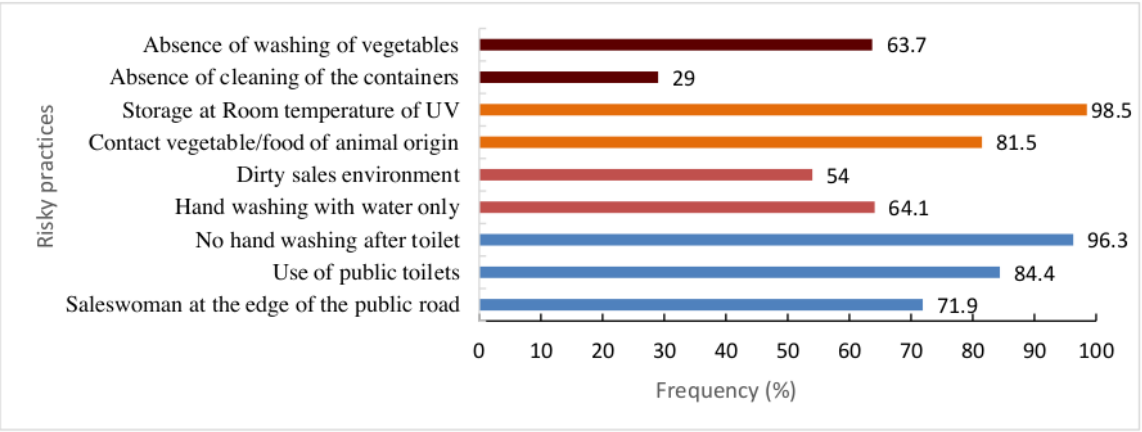


Figure 2: Agricultural practices and risks of contamination

Practices at risk of microbial contamination of vegetables in the markets

With regard to the sale of vegetables in the markets of Anyama, Bonoua and Dabou, the practices and risks likely to be a source of contamination of vegetables sold in the markets are, among others, the absence of washing of vegetables (63.7%) before the sale and cleaning of containers containing vegetables. vegetables. Also, at the end of the day, unsold vegetables are stored at room temperature (98.5%). The saleswomen are located along public roads (72%) in an unhealthy sales environment (54%) in which vegetables come into contact with food of animal origin (81.5%). To relieve themselves, the saleswomen use public toilets (84.4%), of which 64.1% wash their hands with water only and 96.3% do not wash their hands after using these toilets **(Figure 3).**



UV: unsold vegetables

Figure 3: Practices at risk of contamination of vegetables in the markets investigated

Practices and risks of contamination of vegetable salads in public catering

In general, in the three cities, restaurant owners do not disinfect vegetables before cutting (46%). Vegetables come into contact with fresh fish (85.7%) and the water used for washing vegetables is not changed by 76% of restaurateurs. The vegetables are cut by young girls (76%) and with bare hands (87%). The dressing containers (85.6%) are not cleaned, the equipment used for cutting vegetables is also used for cleaning fish (67.2%). Restaurateurs serve pre-cut vegetables (52%) and stored at room temperature for three to four hours (67.2%) before consumption **Figure 4**.

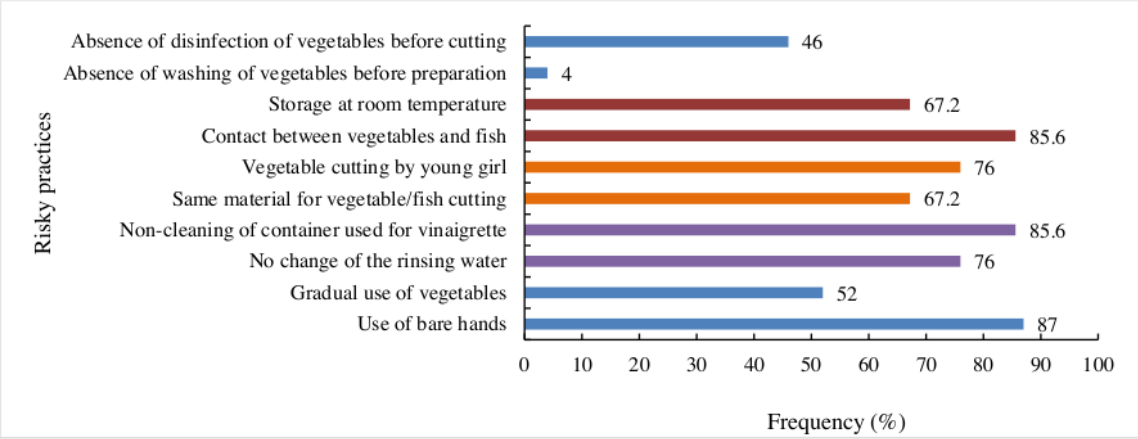


Figure 4: Practices and risks of contamination of vegetable salads

Mode and place of consumption of vegetable salads

At the end of the survey, it emerges that vegetable salads are generally consumed in collective restaurants (61.7%) against (38.3%) at home **(Table 3).** Preferably, vegetable salads in collective catering were consumed for breakfast (56.9%). Consumers claim to consume vegetable salads in various forms at least once a day (66%).

Table 3: Mode and place of consumption of vegetable salads

Characteristic	**Distribution (%)**			
	Anyama (N= 140)	**Bonoua (N= 140)**	**Dabou (N= 140)**	**Total (N= 420)**
Place of consumption				
House	37,8	35,7	41,4	38,3 (161)
Restaurant	62,1	64,3	58,6	61,7 (259)
House + Restaurant	64,3	53,6	67,9	61,9 (260)
Moment of consumption				
Breakfast	44,3	74,3	52,1	56,9 (239)
Lunch	22,9	6,4	15,7	15 (63)

Dinner	32,9	19,3	32,1	28,1 (118)
Frequency of consumption				
At most once	50,7	20	31,4	34 (143)
At least once	49,3	80	68,6	66 (277)

Discussion

The study conducted in a suburban environment revealed a predominance of leafy vegetables, such as lettuce, and fruit vegetables, such as tomatoes. This observation has been made by various authors, including **[13]** and **[14]** who affirms that the climate is favorable to the requirements related to the cultivation of these vegetables. Indeed, the preference for growing these vegetables can be attributed to the importance of lettuce and tomatoes in African culinary habits. But also, these crops made it possible to supply local markets in order to meet the needs of the population.

The results of the survey on socio-demographic characteristics revealed that 80% of the market gardening activity is carried out by people who do not have knowledge of good hygiene practices, which could justify the absence of hygiene practices on farms. Studies conducted in the city of Abidjan, have shown that more than 60% of the operators were illiterate **[9] [13],** 80% in **[10],** 92% in Lomé **[15].** With regard to practices at risk of contamination, it emerges that the harvesting equipment was not cleaned before each working day, which could carry pathogenic germs that can contaminate the vegetables during and after harvesting. It should also be noted that farmers work on production sites in extremely precarious conditions without the minimum necessary protective equipment (gloves, boots, overalls). The study conducted on the suburban market gardening in Gabon, **[16]** noted that producers did not have the basic equipment to effectively manage crops. Well water, ponds and lagoon can vary in quality. If they are contaminated with pollutants, heavy metals or pathogens, they can affect the health of consumers and even the growth of vegetables. Watering with untreated water can lead to contamination of vegetables with pests and pathogens. According to **[17],** the often-lower sanitary quality of surface waters in suburban areas, linked to various pollutions, may contain heavy metals and bacteria. For example, eggs and larvae of parasites can be found on vegetables ready for sale and especially eaten raw. Indeed, studies conducted have proven the presence of *E. coli* and *Salmonella* strains in irrigation water **[13].**

The lack of hygiene of the producers, the absence of sanitary facilities and the proximity to the farms could be an important source of contamination of the producers but also of the crops. Indeed, the work carried out by **[18]** supports the idea that digestive disorders could be observed in vegetable growers. These include, among other things, diarrhea, dysentery, typhoid fever, intestinal bilharzia, parasites. Vegetable growers use large quantities of chicken droppings and cow dung to amend their fields, while others resort to the use of household waste (composting). The manure used by vegetable growers contain pathogens that can persist in these environments and be transmitted to marsh products, these observations were the same made by **[8]** and [9] in their studies conducted on the market gardening sites of Port-Bouët, Abidjan. In Congo, however, urban producers believe that organic manure does not affect the quality of groundwater or surface water. Conversely, peri-urban and rural producers argue that excessive use of manure can lead to water pollution **[19].**

For the marketing of vegetables in the markets, at the reception the saleswomen do not wash vegetables before they are put on sale. In rare cases of washing, sellers' resort to the use of water from public toilets located near the markets. It is important to note that these places are known for their unsanitary conditions, making the water a potential source of contamination by pathogenic bacteria. A study conducted by **[20]** in Mauritania highlighted the direct impact of water and sanitation on improving hygiene and health. Due to the distance between their home and their place of work, sellers often use public toilets to relieve themselves. However, very few of them take the necessary step to wash their hands after using public facilities, and even if they do, it is usually only with water and sometimes without soap. Failure to do so could lead to fecal contamination due to the use of water contaminated with feces **[21] [22].**

The storage containers used by vegetable sellers are not properly cleaned, which represents a potential health risk. In addition, at the end of the day, unsold vegetables are left at room temperature in crates under the sales table, thus

increasing the risk of contact with animals such as mice and cats that roam the market. Failure to keep vegetables at an adequate temperature during the storage of vegetables can lead to bacterial growth and cause potential food poisoning. Research has shown that the method of conservation directly impacts the quality of lettuce sold on the markets of Abidjan. The results reveal that more than half of women (58%) selling lettuce keep unsold products at room temperature on their stalls **[13].** The location in the market and the storage at room temperature of unsold vegetables, ignorance of good hygiene practices by saleswomen plays a crucial role in the contamination and spread of foodborne diseases. Unsanitary conditions are widespread due to the random installation of vendors, often located near gutters and uncovered garbage cans. According to studies conducted by **[13]** and **[10],** it has been observed that the marketing of food products in unhygienic environments favors the risk of biocontamination of these vegetables. These unregulated areas can be infested with flies, mice and cockroaches which are potential carriers of pathogenic bacteria.

During the preparation of these vegetable salads, several practices and risks of microbial contamination have been observed. In these establishments, washing vegetables without changing the water can be a critical step in the contamination of vegetables before they are processed into salads. Most restaurants do not disinfect vegetables after washing them. In addition, young girls cutting vegetables did not comply with the hygienic conditions for preparing vegetable salads. Poor personal hygiene can have serious implications for public health due to food contamination by the hands of food handlers. Also, the lack of hygiene in the public catering sector could open the door to gastrointestinal diseases. These results are similar to those of **[23]** who stated that most food handlers have less knowledge about food safety, personal hygiene and food handling. According to the result obtained in Gauteng in South Africa, it was demonstrated that the hand hygiene of food service employees in collective restaurants was unsatisfactory and would be vectors for the spread of foodborne diseases. Mainly, due to poor personal hygiene and accounted for about 97% of foodborne illnesses in catering establishments and households **[24].**
In this study, it emerges that vegetable salads are consumed by the vast majority of the population on the different sites. The eating habits of the suburban population are the same as that of the population of the city of Abidjan. Indeed, the vegetable salad is an essential accompaniment appreciated by consumers **[25] [26].**

Conclusion:

The study shows that vegetable salads are consumed by the vast majority of the population located in the peripheral cities of Abidjan. Vegetables are exposed to enormous practices and risk of contamination by potentially biological agents. The water intended for watering vegetable crops in the investigated areas emanating from wells, ponds and untreated lagoons could be unsuitable for watering vegetables because potentially contaminated by pathogens. A health education of the producers would be necessary to prevent the health risks linked to the practice of market gardening and to avoid possible epidemics. Public catering establishments in urban and peri-urban areas have revealed that the contamination of these foods can pose a potential risk to the health of the consumer.

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EVALUATION OF PRACTICES AT RISK OF MICROBIAL CONTAMINATION IN THE PRODUCTION CHAIN OF VEGETABLE SALADS SOLD IN PUBLIC CATERING IN THE SUBURBAN AREA OF ABIDJAN, IVORY COAST

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