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Research Article

Contamination of fruits and vegetables sold in Abidjan by human intestinal parasites: Preliminary study

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ABSTRACT

Eating fruit and vegetables is highly recommended for good health. However, they can be a source of transmission of human parasites. The aim of this study was to contribute to our knowledge of the safety of raw fruit and vegetables sold in Abidjan. A cross-sectional study was conducted from April to June 2022, in the autonomous district of Abidjan, to search for human intestinal parasites in 5 fruits and vegetables: Lettuce, parsley, green onion, cabbage and tomato. Parasitological research consisted of direct examination of the rinsing water from the samples, combined with stained smears using the modified Zielh-Neelsen technique. The prevalence of parasitic infestation was 39.2%. Lettuce was the most infested vegetable (77.9%), followed by green onion (75.3%). Helminths were the predominant parasites, led by hookworms (76.8%). Protozoa included *E. nana* and *E. coli*. Samples purchased at production sites were more infested than at markets (p=0.000). This study reveals a high rate of parasitic infestation of fruit and vegetables in Abidjan. As a result, the population is exposed to the risk of contamination. The authorities must therefore take measures to protect traders and consumers.

Keywords: Parasitic contamination, Fruit, Vegetables, Human intestinal parasites, Ivory coast

INTRODUCTION

Food-borne illnesses are varied, ranging from chemical poisoning to infections. However, parasites have not received the same level of attention as other biological and chemical hazards. They have often been neglected (Robertson et al., 2013). According to However et al. (2016) there are three reasons for this neglect. Firstly, notification of foodborne parasitizes to public health authorities is not mandatory and official reports do not reflect the real occurrence and incidence of diseases.

Secondly, incubation periods are quite long and association between food and disease is not always possible.

Finally, detection methods for certain parasites are not easy to implement and require the services of a specialized laboratory.

According to the European Food Safety Authority (EFSA), the prevalence of parasites in food poisoning is underestimated because these agents are not systematically detected. Indeed, in 2016, parasites were incriminated in just 0.4% of food poisoning cases (EFSA, 2017).

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However, in recent years, parasite risk has begun to attract real interest (Robertson et al., 2013).

For example, the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) have drawn up a list of 24 parasite species, genera or families classified as those of greatest concern for global public health (FAO and WHO, 2014).

Among the foods at the origin of human parasitic contamination, fruits and vegetables seem to occupy a significant place (Bekele et al., 2017).

Admittedly, consumption of the latter is strongly recommended by health agencies as they provide essential nutrients such as vitamins, minerals, dietary fiber necessary for good health (Maffei et al., 2016) but, consuming them raw and poorly washed is one of the main modes of transmission of human pathogens (Sunil et al., 2014; WHO, 2015). Indeed, due to poor hygiene practices during cultivation, harvesting, packaging, transport and storage, fruit and vegetables can be easily contaminated by parasites (Bekele et al., 2017; WHO, 2015).

In Abidjan, as in other major cities in Cote d'Ivoire, vegetables are grown either in developed lowlands (FAO, 2015) or near watercourses (rivers, swamps) or wastewater drainage channels to promote plant irrigation. Vegetables are therefore produced in hygienic conditions that are not always controlled or adequate (de-Bon et al., 2018). In addition, vegetables are transported and marketed under equally precarious hygiene conditions. These findings show that vegetables consumed raw or undercooked in Cote d'Ivoire, and particularly in Abidjan, are potential sources of infectious diseases, particularly parasitosis. However, little data is available on foodborne parasitoids and the risk associated with the consumption of raw produce. Consequently, this study was carried out to determine the level of parasitic infestation of certain fruit and vegetables sold in Abidjan markets.

MATERIALS AND METHODS

Study areas

A cross-sectional study was carried out from March 1 to 31 May 2022 to determine the level of parasitic contamination of certain fruits and vegetables sold in selected markets in the Abidjan district in the South-East of Côte d'Ivoire, bordering the Atlantic Ocean. This district covers an area of 422 Km^2 and is 18 m above sea level. Its geographical coordinates are as follows: Latitude 5.3364 and longitude -4.0266. The study specifically covered 3 communes (Figure 1).

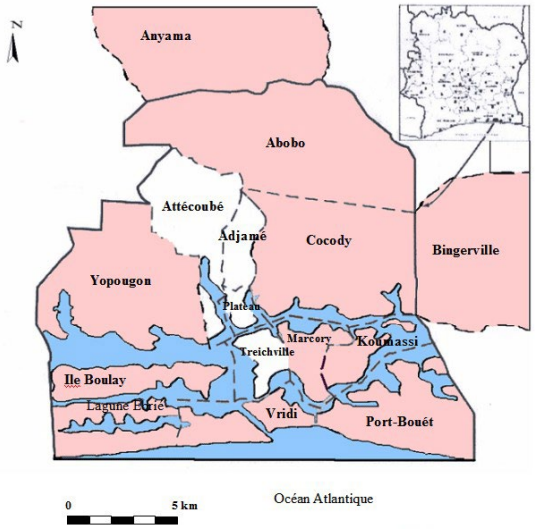

Figure 1. Map of Abidjan showing the survey sites.

- **Cocody:** Covering an area of 132 km^2.
- **Yopougon:** The largest commune in the Abidjan district.
- **Bingerville:** Located on the banks of the Ebrie lagoon, part of the Abidjan district since 2001.

Sample collection

In each selected commune, samples were collected from production sites and markets.

In Cocody, samples were collected from the Anono vegetable gardens, the Anono market and 2 shopping centers (Casino and Socofrais).
In Yopougon, this involved vegetable gardens in the shallows of Km 17 and the Siporex market.

Finally, in Bingerville, there were the vegetable gardens in

the village of Anan and the new Bingerville market.

On these different sites, 5 types of commonly consumed vegetables were purchased: Tomato, parsley, lettuce, cabbage and green onion. A total of 385 samples were bought from 9 producers and 11 sellers, *i.e.* 77 samples per type of vegetable. Each 200 gram sample was placed in a plastic bag, labeled and transported in a cool box at 4°C to the parasitology-mycology laboratory of the medical sciences training and research unit of the Felix Houphouet Boigny university of Abidjan for parasitological analysis.

Laboratory examination

Once in the laboratory, each sample was washed and rinsed in 0.5 liter of sterile distilled water. The wash water was sediment overnight, and then 15 ml of sediment was transferred to a centrifuge tube using a sieve to remove unwanted material. To concentrate the parasitic stages, the tube was centrifuged at 3,000 revolutions per minute for five minutes. After centrifugation, the supernatant was carefully decanted without shaking. The sediment was shaken slowly by hand to redistribute the parasitic stages. Finally, the sediment was examined under a light microscope using x10 and x40 objectives. To test for certain coccidia, smears made from the centrifugation pellets of the rinsing water were stained using the modified Ziehl-Neelsen technique: first, the smears were fixed with methanol for 5 minutes, rinsed and dried. Next, they were stained with Phenic Fushin for one hour, and then decolorized with sulfuric acid for 20 seconds. Finally, they were stained with malachite green for 5 minutes, then rinsed and dried. The smears were observed under a light microscope at x10 and x40 objective (Tefera et al., 2014, Bekele et al., 2017).

Data analysis

Statistical analysis was performed with EPI-INFO version 3.5.4. Probability values were considered to be statistically significant when the calculated p-value was equal to or less than 0.05. The difference in parasitic contamination among the different categories was compared using the Pearson's *Chi-square* test (χ^2) and Fisher's exact test, where appropriate.

RESULTS

Cultivation conditions

Fruits and vegetables were produced under precarious hygienic conditions with crops irrigated by makeshift wells and wastewater from drainage canals (Figure 2).

Figure 2. Drainage channel water used for watering vegetables.

The producers were young men whose average age was 25 and of primary school level. The latter had received no professional training in market gardening.

Parasitic infestation of fruit and vegetables

In this study, 151 of the 385 vegetable samples were contaminated with one or more intestinal parasites, representing a contamination rate of 39.2%. Of these vegetables, 124 (82.1%) samples were contaminated with helminths, 17 (11.3%) with protozoa and 10 vegetables (6.6%) with both helminths and protozoa.

Helminths were represented by hookworms (76.8%), *Ascaris lumbricoides* (11.3%) and *Strongyloides stercoralis* (0.7%).

The protozoan species isolated were non-pathogenic. These were *Endolimax nana* (11.9%) and *Entamoeba coli* (6.0%). No *Coccidia* species were detected.

Lettuce was the most infested vegetable, 60/77% or 77.9%, while tomato had the lowest infestation level (2.6%). Table 1 shows the prevalence of infestation by type of vegetable.

Type of produce	Positive (%)	Negative (%)	Total	p-value
Lettuce	60 (77.9)	17 (22.1)	77	0
Green onion	58 (75.3)	19 (24.7)	77	
Parsley	24 (31.2)	53 (68.8)	77	
Cabbage	7 (9.1)	70 (90.9)	77	
Tomato	2 (2.6)	75 (97.4)	77	

Table 1. Prevalence of parasitic infestation of different types of fruit and vegetables analyzed.

Helminths were predominant in all types of vegetables (Table 2) and at all sample collection sites. Hookworms, the main species in this study, were observed in all types of vegetables and at all the sites surveyed except in the "casino" shopping centre.

Type of produce	Hookworms	*A. lumbricoides*	*S. stercoralis*	*E. nana*	*E. coli*
Lettuce (n=60)	50	5	0	5	3
Green onion (n=58)	47	6	1	3	2
Parsley (n=24)	13	4	0	7	3
Cabbage (n=7)	4	2	0	2	1
Tomato(n=2)	2	0	0	1	0
Total (n=151)	116	17	1	18	9

Table 2. Distribution of parasitic species by type of vegetable.

Compared to vegetables purchased from markets, vegetables collected from production sites were more infested (86.4% versus 30.7%) with a statistically significant difference (p=0.000).

On all the production sites surveyed, the vegetables had a high level of parasitic infestation (>60%) although those of the municipality of Bingerville were more infested (p=0.001) (Table 3).

Variables	Positive (%)	Negative (%)	Total	p-value
Shopping sites				
Production	51 (86.4)	8 (13.6)	59	0
Markets	100 (30.7)	226 (69.3)	326	
Total	151	234	385	
Production sites				
Bingerville	19 (100)	0 (0)	19	0.001
Yopougon	19 (95)	1 (5)	20	
Cocody	12 (60)	8 (40)	20	
Total	50	9	59	
Type of markets				
Open markets	64 (33.2)	129 (66.8)	193	0.293
Shopping centers	36 (27.1)	97 (72.9)	133	
Total	100	226	326	
Different markets				
Supermarket socofres	27 (40.9)	39 (59.1)	66	

Supermarket casino	9 (13.4)	58 (86.6)	67	0.006
Bingerville markets	24 (36.9)	41 (63.1)	65	
Cocody market	22 (34.4)	42 (65.6)	64	
Yopougon market	18 (28.1)	46 (71.9)	64	
Total	100	226	326	

Table 3. Prevalence of parasite infestation according to sample collection sites.

Concerning the markets, the vegetables were bought both in open markets (193 samples) and in shopping centers or closed markets (133 samples). In these two types of markets, infestation levels were almost similar: 33.2% in open markets versus 27.1% in shopping centers (p=0.293). However, the "Socofrais" shopping center had the highest level of infestation (p=0.006) with 40.9% of contaminated vegetables. Table 3 summarizes the prevalence of infestations observed at the various purchasing sites.

DISCUSSION

Consumption of fresh produce is highly recommended by health agencies as it provides essential nutrients such as vitamins, minerals, dietary fiber necessary for good health (Maffei et al., 2016).

Nutrition experts from the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations (FAO) recommend a minimum intake of 400 g of fruit and vegetables per day (WHO, 2003). However, the raw mode of consumption can expose consumers to health risks, especially as they are not always grown, transported and sold under adequate hygienic conditions.

The aim of this study was to look for human intestinal parasites on certain fruit and vegetables for direct consumption which are part of the eating habits of the Ivorian population in order to assess the level of parasitic infestation.

Fruit and vegetable production conditions

The producers met were young men whose average age was 25 with an educational level limited to primary studies.

This profile of market gardeners is described in other studies, in particular those by Kouakou in Cote d'Ivoire (Kouakou, 2008, 2019) by the FAO which covered the whole of Africa and by the Center for International Cooperation in Agronomic Research for Development (CIRAD) (FAO, 2015; FAO and CIRAD, 2021). These young people had not received professional training in market gardening. This observation might suggest that they have limited knowledge of hygiene concepts, optimal growing conditions and the risks linked with not mastering methods that are suitable for their health and that of the population.

This conclusion was noted by Bekele, who found a link between level of education and product contamination rates.

The water used to irrigate crops came from precarious wells and drainage canals. Elsewhere, the same practices are observed; crops are grown either in developed lowlands or near watercourses (rivers, swamps, etc.) or wastewater drainage channels to promote plant irrigation (Ancellin et al., 2002; Beuchat , 2002; FAO and CIRAD, 2021).

These precarious methods favor the contamination of cultures by microbiological agents.

Amoah and Bekele have also reported this in their various studies. However, market gardening is an important activity that not only generates income for populations but also provides nutrients for consumers, thus ensuring food security. It is therefore necessary to encourage our states to become more involved in giving these market gardeners the appropriate training and the necessary means in order to better organize the sector and work in a healthy way.

Prevalence of parasite infestation

Human parasites were isolated in 151 out of 385 samples, *i.e.* 39.2%. This is a relatively high infestation rate. This result is in the line with those of several authors who have worked on fruits and vegetables. Thus, Alemu in Ethiopia, Abe in Nigeria and Haq in Pakistan found contamination rates of 39.1%, 37.5% and 31.2% respectively.

Our prevalence indicates a high level of contamination of fruits and vegetables by human faeces. These fruits and vegetables are therefore potential sources of transmission of human parasitosis to consumers. Moreover, this observation also suggests that these fruits and vegetables could be sources of contamination by other non-parasitic human intestinal microorganisms. These could include enteric viruses responsible for severe diarrhoea; bacteria such as *Salmonella typhi* responsible for typhoid fever, *Shigella dysenteriae* responsible for dysentery and *Vibro cholerae*, pathogenic agent of cholera. There is therefore a real problem related to the consumption of fruits and vegetables without prior hygiene.

Other studies found lower prevalence than ours. Eraky (2004), in Egypt noted a parasitic infestation of 29.6%, while Folahan (2022) in Nigeria observed 19.5% and Mohamed in Sudan 13.5%. However, it should be pointed out that these authors only worked on vegetables taken from markets, unlike the present study, which concerned both sales and production.

Prevalence of contamination at purchasing sites

Specifically on the purchasing sites, the infestation rate at Production site was higher than that observed on the markets (86.4% versus 30.7%), with a significant difference ($p=0.000<0.05$). This very high production rate can be explained by the fact that the vegetables are directly harvested and served without undergoing any pre-washing. On the other hand, at the point of sale, traders take care to wash the products at least once in order to eliminate sludge residues and make it look attractive to customers. This practice could reduce the parasite load; hence the relatively low rate of contamination in the markets. However, according to other authors, washing could be a source of product contamination if the water used is dirty (Damen et al., 2007; Bekele et al., 2017).

Furthermore, there was no link between the level of contamination of the samples and the type of market (open markets or shopping centers): $p=0.293>0.05$. In addition, speaking specifically of shopping centers, we noted that the level of infestation was higher at " Socofrais " (40.9%) than at "Casino" (13.4%) with a statistically significant difference ($p=0.006$). This rate would be due to the fact that “Socofrais” behaves in reality like an ordinary market, whereas at the Casino supermarket, the products are more carefully prepared. However, this low level of infestation observed at the casino should not be overlooked. We feel it is necessary to draw consumers' attention to the fact that it is important to wash fruits and vegetables well before consumption, regardless of where they are purchased. Our results are in line with those of previous studies which have highlighted cases of contamination of fresh fruits and vegetables stored and sold in supermarkets (Johnston et al., 2005; Cardamone et al., 2015).

Prevalence according to samples

Lettuce was the most contaminated vegetable (77.9%); followed by green onions (75.3%). Tomatoes were the least contaminated (2.6%). There was a link between the level of parasitic infestation and type of vegetable ($p=0.000$). In short, leafy vegetables had a higher level of contamination. This could be explained by the fact that the leaves consumed are in direct contact with irrigation water and fertilizers. Also, the spongy aspect of these leafy vegetables would allow the fixation of microorganisms and protect against conditions unfavorable to their survival (Sunil et al., 2014). These results corroborate those reported by authors such as Stein and Dssouli, who also found high contamination rates for leafy vegetables.

Isolated parasites

After examination of the samples, helminths were predominant among the isolated parasites. They represented 82.1% against 11.3% for protozoa. Other studies using the same methodology as ours found similar results (Bekele et al., 2017; Auta et al., 2017; Khan et al., 2021). There was no link between the parasites isolated and the place of purchase. Helminths predominated both in production and in markets.

In the group of helminths, it acted nematodes including hookworms (76.8%), *Ascaris lumbricoides* and *Strongyloides stercoralis*. This predominance of hookworms is consistent with the results of Soni (1992), who observed 60.3%. Given the transcutaneous mode of contamination of this parasite, its high prevalence represents a contamination risk for the various handlers of the products. Thus, producers could be exposed during field work (cleaning and harvesting); sellers, during the various operations (washing and displaying) and consumers, at the time of purchase and during all the manipulations before consumption. Our results differ from those of several authors in whom *Ascaris lumbricoides* and *Strongyloides stercoralis* were the most isolated helminths (Elom et al., 2012; Tefera et al., 2014; Bekele et al., 2017). These variations could be attributed to different geographical locations, climatic conditions and soil types (Eraky et al., 2014). It would be interesting to carry out an identical study over the whole year and in different localities to look for a possible link between the isolated parasites and the seasons and/or the localities.

The protozoa were *Endolimax nana* (11.9%) and *Entamoeba coli* (6%). Although non-pathogenic, these protozoa indicate faecal contamination of our samples. Unlike the study by Bekele (2017), we did not isolate Giardia intestinalis or *Coccidia* (*Cryptosporidium* spp, *Cyclospora* spp, *Cystoisospra bell*).

CONCLUSION

This study showed that certain fruits and vegetables marketed in Abidjan have a high rate of parasitic infestation. As a result, they are potential sources of contamination and spread of human parasitoids. It would be advisable to focus on training market gardeners and raising public awareness of personal and food hygiene measures, such as washing hands with drinking water and soap before eating, and carefully washing fruit and vegetables that are to be eaten raw. This study must be continued throughout the territory with greater financial and logistical resources in order to take stock of foodborne diseases in Cote d'Ivoire.

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