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ORIGINAL RESEARCH

Comparative Study of Parasite Contamination in *Daucus carota* and *Solanum melongena* from Open Markets in Lokoja Metropolis, Kogi State

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ABSTRACT

Vegetables are good substrates for transmission of intestinal parasites because they are often not properly washed and also consumed raw. Therefore, the study investigated parasitic contamination in *Daucus carota* and *Solanum melogena* across three major open markets in Lokoja, Nigeria. Therefore, this study investigated the contamination of parasites in vegetables. The two vegetables were selected because they are often consumed raw. A total of 90 samples; 45 of each vegetable were collected from the different markets. 100 grams of each vegetable was taken randomly at each sampling attempt and were washed in 0.9% sodium chloride in a shaker for 15 minutes, followed by sedimentation overnight and centrifugation (2000 rpm for 10min). 10mls of each sediment were examined under a light microscope to detect parasitic stages. The result showed high contamination rates ranging from 80% in *Solanum Melogena* (garden eggs) and 73% in Carrot (*Daucus Carota*). Seventeen parasite species were identified, with Hookworm (31.1%) and *Ascaris lumbricoides* (24.4%) being the most frequently encountered parasites. Vendors practices assessed through questionnaire, revealed poor sanitary conditions, including the use of unclean water and sometimes failure to even wash the vegetables before display to consumers. These findings underscore the role of vegetables in transmitting intestinal parasites and highlight the need for better public health

practices because the parasitic stages identified could cause infections among people with poor food hygienic practices.

Keywords: Parasite contamination, *Daucus carota, Solanum melogena*, Foodborne parasites, Nigeria

Introduction

The World Health Organization advocates daily consumption of vegetables and fruits because of the micro-nutrients such as vitamins, minerals and antioxidants contained in them. These micro-nutrients have reportedly protected people from chronic diseases, and have been ultimately helpful in maintaining a healthy lifestyle (Li et al., 2020; Alemu et al 2019; Olza et al., 2017). *Solanum melongena* commonly known as garden egg has been shown to offer health benefits in managing metabolic disorders such as type 2 diabetes, due to its high content of antioxidants and bioactive compounds. These have been reported to regulate blood sugar levels by inhibiting key enzymes involved in carbohydrate digestion and reducing oxidative stress (Yarmohammadi et al., 2021). The vegetable is commonly consumed raw or slightly cooked in Nigeria. *Daucus carota* (Carrot) a root vegetable high in carotenoids, are also frequently part of the Nigerian diet (Que et al., 2019; Endale et al., 2018). However, these vegetables when eaten raw or undercooked can serve as vehicle for food-borne parasites, especially when irrigated with contaminated water or sold under unhygienic conditions.

Contamination occurs through exposure to soil or water, contaminated with parasites particularly in areas lacking sanitation. Poor social amenities such as poor sanitary and waste disposal facilities and poor personal hygiene play very critical roles in facilitating transmission of these parasites via food and water (Badaki et al., 2018; Akogun et al., 1996,). Parasites such as *Ascaris*,*Strongyloides*, *Trichuris trichiuria*, *Entamoeba histolytica* and *Giardia lamblia* have been identified in soils in public places in Lokoja, Nigeria. (Badaki et al., 2018) and several studies (Mogaji et al., 2021; Umeanaeto et al., 2021) elsewhere.

Yet limited research has been conducted on Garden egg and Carrot in Lokoja. These vegetables are not cultivated in the State but brought in from other regions of the country where the almost temperate climate permits their cultivation. This study focused on investigating parasitic contamination of Garden egg and Carrot in Lokoja Markets, while examining contributing factors through vendors practices

Materials and Methods

Study Area

The research was a cross sectional study conducted in open markets located in Lokoja metropolis. Lokoja, Kogi State, Nigeria (6.57°E–6.63°E, 7.74°N–7.79°N). Lokoja lies in a tropical region with an average temperature of 26°C and annual rainfall of 870 mm. Two of the markets Kpata and Felele popularly known as International markets are located along River Niger floodplains while Lokongoma, market is in the central part of Lokoja town.

Data Collection

Thirty vegetable samples (15 per vegetable type) were collected from each of the three markets surveyed giving a total of ninety vegetable samples for the entire study. Samples were placed in sterile polythene bags and transported promptly to the Biology Laboratory of the Federal University Lokoja, Nigeria. Additionally, the study also assessed hygiene practices and environmental conditions that could contribute to contamination using structured questionnaires.

Laboratory Analysis

In the laboratory, samples, each weighing 100 grams, were processed following the sedimentation technique described by Eberemu et al. (2023). Samples were washed in 100 ml of 0.9% sodium chloride to detach parasites. Filtration and sedimentation overnight were used to concentrate parasites, followed

by centrifugation at 2000 rpm for 10 minutes. The resulting sediment was examined microscopically after staining with Lugol's iodine.

Data Analysis

Data were entered into a Microsoft Excel worksheet, and data analysis performed using the IBM SPSS software package (Version 24.0). Chi-square tests were used to determine the association between parasite contamination rate in vegetable types and the prevalence of various parasitic species across markets. The significant p-value threshold was set at 0.05.

Results

Out of 90 total vegetable samples analyzed, 36 (80%) of the garden egg samples and 33 (73.3%) of the carrot samples were contaminated with at least one intestinal parasite (Table 1). When data was analyzed by market, the highest parasite contamination of 86.66% was recorded in garden eggs sampled from Lonkogoma, while Kpata market recorded the lowest contamination rate (73.3%) for the vegetable (Table 1). Similarly, 80% of the Carrot samples examined from Felele market were contaminated with parasites, with Lokongoma market recording 66.66% (Table 1). Statistical analysis showed that the variations in these contamination rates across the markets ($\chi 2= 1.034$; $P>0.05$) was insignificant.

Table 1: Presence of Parasites in Vegetables Samples across Markets in Lokoja

Market	Vegetables					
	Carrot			Garden Eggs		
	Present **(%)**	Absent **(%)**	Total	Present **(%)**	Absent **(%)**	Total
Lokongoma	10(66.66)	5(33.33)	15	13(86.66)	2(13.33)	15
Felele	12(80.0)	3(20.0)	15	12(80.0)	3(20.0)	15
Kpata	11(73.33)	4(26.66)	15	11(73.3)	4(26.7)	15
Total	33(73.33)	12(26.66)	45	36(80.0)	9(20.0)	15

Seventeen parasite species were identified during the study, and these included Hookworm spp., *Taenia* spp., *Hymenolepis diminuta*, *Trichinella spiralis*, *Giardia lamblia*, *Trichuris trichiura*, *Strongyloides stercoralis*, *Toxocara canis*, *Entamoeba histolytica*, *Entamoeba coli*, *Diphyllobothrium latum*, *Balantidium coli*, and *Platynosomum fastosum*. The most relatively abundant parasites in carrots were Hookworm (16.87%) followed by *A. lumbricoides* (13.25%) and *S. stercoralis* (12.05%). *H. nana*, *S. haematobium* and *T. hominis* were not observed in carrots sampled from all the three markets surveyed (Figure 1). A disaggregation of data by market showed that Felele has the highest relative abundance of hookworm (31.57%) and it was the only market where *T. spiralis* was observed in carrots (Figure 1). *T canis* was also relatively abundant (15.79%) in Lonkogoma market (Figure 1). The vegetable recorded a 6.67% relative abundance in Kpata market and was not encountered at Felele market [Figure 1]. *H.dimuta* was observed only in Felele market and it recorded a relative abundance of 5.26% (Figure 1).

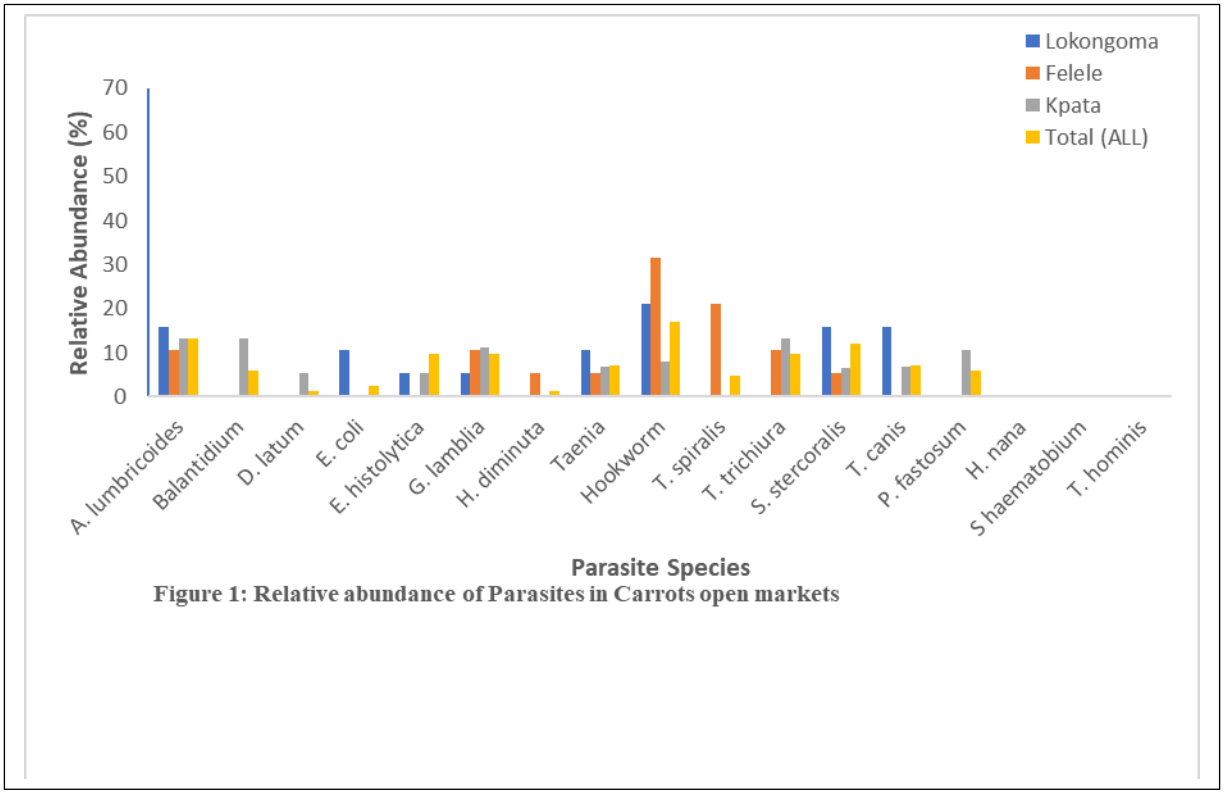

Figure 1: Relative abundance of Parasites in Carrots open markets

The overall abundance of parasites in garden eggs was relatively lower with *Entamoeba histolytica* recording 12.14% followed by *T. canis* (11.43%) and *H. nana* (10.71%) [Figure 2]. At market level, the highest relative abundance of *T. canis* was recorded in garden eggs sampled from Kpata (30.0%) and Lonkogoma (14.29%) markets [Figure 2]. The relative abundance of protozona parasites such as *E. histolytica* (15%), *E. coli* (20%) and *B. coli* (15%) were very high in Kpata market (Figure 2). *H. nana* (20%) was also the most predominant parasite in garden eggs tested from Lokongoma market [Figure 2]. *E. histolytica* (17.14%) and *T. hominis* (8.57%) were also relatively abundant in Lokongoma market

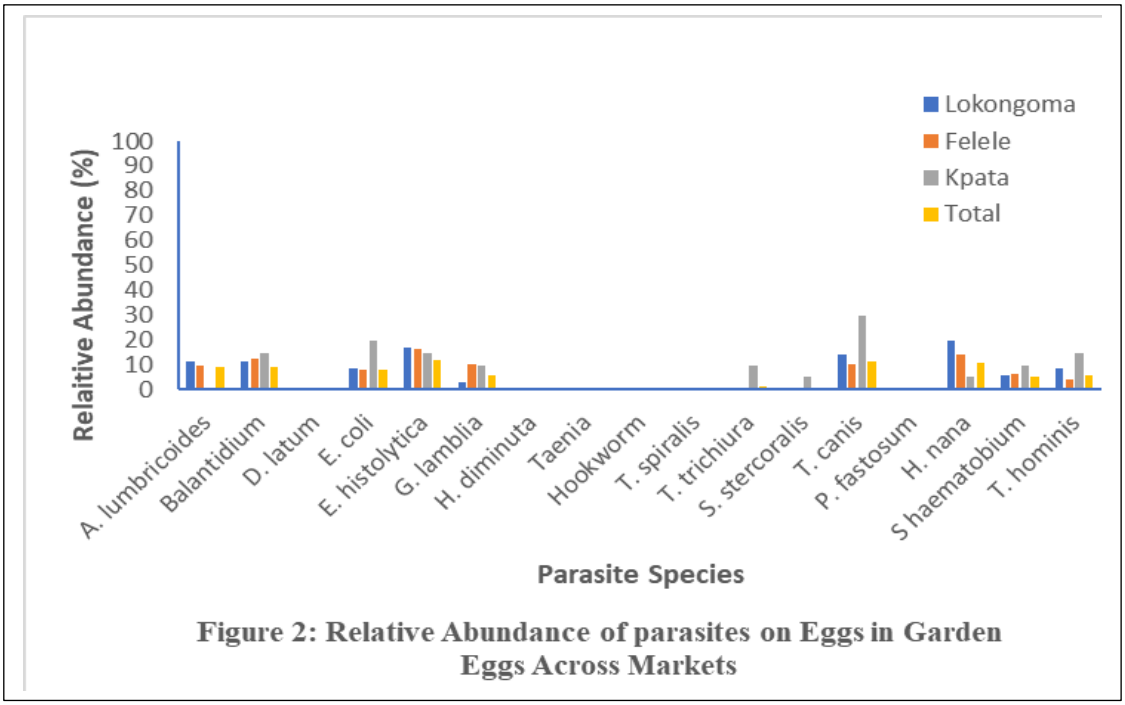

Figure 2: Relative Abundance of parasites on Eggs in Garden Eggs Across Markets

Multiple contamination refers to a vegetable being contaminated with three or more parasite species, while single contamination refers to a vegetable being contaminated by only one parasite. In Kpata market, 81.82% of the contaminated Carrots had multiple parasite contamination, while carrots sampled from Felele market recorded only 8.33% cases of multiple parasite contamination (Table 2). However, same market (Felele) recorded the highest occurrence of 83.33% parasite contamination in Garden eggs

while Kpata recorded 45.5% for the vegetable (Table 2). Statistical analysis revealed a significant difference in the incidence of single, double, and multiple parasite contamination across markets (χ^2 = 7.917; P<0.05).

Table 2: Occurrence of Single and Multiple Parasite Contamination across Markets

Market/Vegetable	**Positive Samples**	**Single**	**Double**	**Multiple**
Carrot				
Lokongoma	10	6 (60.0)	15	13 (86.66)
Felele	12	6 (50.0)	15	12 (80.0)
Kpata	11	2 (18.18)	15	11 (73.33)
Total	**33**	**14 (42.42)**	**45**	**36 (80.0)**
χ^2=17.714; P>0.05				
Garden Egg				
Lokongoma	13	5 (38.46)	2 (15.38)	6 (46.15)
Felele	12	1 (8.33)	1 (8.33)	10 (83.33)
Kpata	11	3 (27.27)	3 (27.77)	5 (45.45)
Total	**36**	**9 (25.0)**	**6 (16.66)**	**21 (58.33)**
χ^2=7.917; P>0.05				

Table 3: Predisposing Factor for presence of Parasites in across Markets

Variable	Market		
	Lokongoma (n=20)	**Kpata (n=20)**	**Felele (n=25)**
How available is water in the market?			
Readily	0	0	0
Rarely	100.0	100.0	100.0
Source of water			
Tap	60.0	25.0	0
Borehole	25.0	0	100.0
River	0	75.0	0
How often do you replace wash water?			
Once daily	50.0	50.0	20.0
Twice daily	0	50.0	60.0
Rarely replaced	50.0	0	20.0
How do you display your vegetables?			
On the floor	0	50.0	40.0
On the table	80.0	15.0	40.0
On the wheelbarrow	20.0	35.0	20.0
What type of toilet do you use?			
Pit	0	10.0	52.0
Water closet	75.0	25.0	28.0
Bush	25.0	50.0	20.0
How often do you wash your hands?			
Occasionally	70.0	50.0	60.0
Regularly	30.0	50.0	40.0
Do you wash your vegetables before selling them?			
Yes	40.0	35.0	52.0
No	60.0	65.0	48.0

Discussion

The identification of a wide range of seventeen parasite species in just two types of vegetables (*Daucus carota* and *Solanum melongena*) underscores the intensity and diversity of parasitic contamination in the vegetable supply chains of Lokoja metropolis. The detection of both soil-transmitted helminths (e.g., *Ascaris lumbricoides*, *Hookworm spp.*, *Trichuris trichiura*) and protozoan parasites (e.g., *Entamoeba histolytica*, *Giardia lamblia*, *Balantidium coli*) indicates contamination from multiple sources ranging from feacally polluted soils and water used either during cultivation to unhygienic handling during transport and marketing. The presence of zoonotic parasites such as *Toxocara canis* and *Trichinella spiralis* is also particularly worrisome, because it is suggestive of environmental contamination by animal feaces (Njise et al., 2015). This points to potential transmission between animals, the environment, and humans.

The breadth of species diversity reported here is consistent with studies in other settings in Nigeria (Gboeloh and Sounyo, 2021; Rabiu et. al., 2021; Agbalaka et al., 2019; Badaki et al., 2018) and East Africa (Zeynudin et al., 2024). This signals a public health risk exacerbated by weak regulatory oversight, limited hygiene infrastructure, and informal vegetable marketing systems. Additionally, the diversity and co-occurrence of these parasites further could suggest the possibility of poly-parasitism in exposed consumers, particularly among populations with poor immunity, such as children and immunocompromised individuals (Mekonnen et al., 2016; Asma et al., 2022). Although contamination rates were broadly similar across Lokoja markets, variations in parasite types and contamination patterns can be attributed to specific environmental and hygienic factors at each site. For instance, whilst Lokongoma is at the central part of the metropolis, Kpata and Felele markets are located along the Niger-Benue river confluence. The markets that are convergence points for traders and fishermen from different parts of the country most especially Kpata market which is a very popular fish market in the country. The flood plains which are adjacent to the markets are very fertile vegetable farms coupled with intense anthropogenic activies ferrying of wares across the river

on market days. On market days traders coming in from riverine communities display their wares often vegetables and fish on the bare ground by the shore of the river, sell off so that they can get back to their communities. The same river shore served as defecating grounds and washing of the vegetables with untreated river ware could be routes of contamination of the vegetables. This explains why a market like Felele with a seemingly safer water source (e.g., borehole) still recorded parasite contamination rate of vegetables. The situation reflects findings by Asfaw et al. (2023) in Debre Berhan, Ethiopia, where vegetable contamination persisted despite access to safe water due to unhygienic handling and display conditions. Conversely, markets like Lokongoma, despite having slightly better display methods (use of tables), suffer high contamination due to complete lack of clean water access. Besides, Felele and Kpata marketsfeed Lokongoma market in terms of supply of goods. Studies (Samah, et al., 2023; Agbalaka et al., 2019) in other regions confirm that proximity to contaminated water sources, display conditions, and hygienic practices of vendors play critical roles in determining contamination levels. The predominance of *Toxocara canis*, a zoonotic helminth, further suggests environmental contamination by dog feaces, as was similarly observed in studies from Plateau State (Dawet et al., 2019).

The notable presence of protozoan parasites such as *Entamoeba histolytica*, *E. coli*, and *Hymenolepis nana* especially in Lokongoma are similar to the findings of Zeynudin et al. (2024) in peri-urban markets of Jimma, Ethiopia, where protozoan parasite prevalence was highest in markets lacking sanitation infrastructure and regular water supply.

Conclusion

The findings from this study affirm that access to clean water alone is not sufficient to prevent contamination if not coupled with appropriate hygiene behaviors. The presence of multiple parasites in vegetables even in markets using borehole water highlights the critical role of vendor practices, frequency of water replacement, and cleanliness of display surfaces in determining the extent of parasitic contamination. Moreover, these findings underline the importance of site-specific public health interventions. For instance, while Felele may benefit from hygiene training and improved handling practices, markets like Lokongoma and Kpata require infrastructural improvements to ensure reliable access to clean water. In all three markets, enforcement of food safety standards, health education, and periodic microbial assessments of fresh produce are recommended to reduce the risk of food-borne parasitic infections.

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