Technoscience Journal for Community Development in Africa 3 (2024) 175-183
ISSN 2659-0573

Research Article

Assessment of intestinal parasites of fruits and vegetables sold in selected markets in Ilorin, Nigeria

Ojo Joseph Sunday[1,*], Ifeladun Oyeladun Ojo[1], Opeyemi Gbenga Oso[2]

[1]Department of Zoology, Kwara State University Malete, Nigeria
[2]Department of Zoology, University of Ibadan, Ibadan, Nigeria

Abstract: Fresh fruits and vegetables form an integral part of a healthy and nutritious diet. They are also potential conduits of transmission of gastrointestinal pathogens to hosts. This study aims to evaluate the level of parasitic contamination of selected fruits and vegetables across peri-urban markets in Ilorin metropolis. Fruits and vegetable samples were washed in normal saline solutions. Parasites in the wash solutions were concentrated by sedimentation method. Parasite detection was carried out using a binocular microscope and identification by comparison with the key from atlas of parasitology. The relationship between variables at 5% level of significance was determined by Pearson's chi-square analysis. Two hundred and thirteen (213) fruit and vegetable samples were assessed for parasitic contamination. Thirteen (13) parasites (5 protozoans and 8 helminths), namely: *Giardia lamblia, Entamoeba histolytica, Entamoeba coli, Balantidium coli, Isospora coli, Schistosoma* spp.*, Ascaris lumbricoides, Taenia* spp.*, Trichuris trichura, Strongyloides stercoralis, Fasciola* spp., *Toxocara* spp., and *Ancylostoma duodenale,* were detected and evaluated. Cabbage and lettuce were the most contaminated at 38.5% prevalence each. This is followed by Fluted pumpkin, Tomatoes, Carrot, Cucumber, Spinach and green pepper with 32.4%, 26.9%, 23.0%, 22.2%, 18.8%, and 7.5%, prevalence. The obtained order of prevalence of intestinal parasites was: *G. lamblia* > *S. stercoralis*/*Taenia* spp. > *E. histolytica* > *A. lumbricoides*/*A. duodenale* > *B. coli*/*E. coli*.

Keywords: Fruits, Vegetables, Parasitic Infection, Contamination, Nigeria

1. INTRODUCTION

Intestinal parasites inhabit the gastrointestinal tract (GIT) of their host (Afrin *et al*., 2019). They depend on the host for physiological and metabolic needs. Gastrointestinal parasites have been known to cause major public health problems in tropical countries (Adenusi *et al*., 2018). Children and adults are susceptible to infections from these parasites. An estimated 3.5 billion people were infected with intestinal parasites and 450 million people got ill due to parasitic infection (Tigabu *et al*., 2019). Intestinal parasites are grouped into protozoans and helminths - *Entamoeba histolytica, Entamoeba coli*, *Isospora* spp.*, Cryptosporidium* spp., and *Giardia lamblia* are examples of intestinal protozoan parasites, while *Taenia* spp., *Trichuris trichura*, *Enteribius vermicularis*, *Fasciola* spp.*, Strongyloides stercoralis*, *A. duodenale*, and *Ascaris lumbricoides* are intestinal helminths (Al-Rifai *et al*., 2020). These parasites are referred to as infections of poverty because they are prevalent in low-income regions of the world. GIT parasites are mostly significant for causing diseases in children and immunosuppressed people, who already have their defence mechanisms compromised by sickness, lack of nutrients, stress or any other factor. *Giardia lamblia* is a diarrhoea causing parasite and is the third leading parasite cause of death worldwide (Agbalaka *et al*., 2018). Common alimentary protozoan parasites in humans live in moist environment like fresh water, marine water and soil. *Ancylostoma duodenale*, *Ascaris*

*Corresponding author:
E-mail: ojo.sunday@kwasu.edu.ng

KWASU PRESS AND PUBLISHING

lumbricoides, and Strongyloides stercoralis are the most prevalent soil-transmitted helminth parasites and are estimated to infect one-sixth of the global population. It is most common in tropical and subtropical regions that have water and sanitation problems (Jourdan *et al*., 2018).

Fruits and vegetables have low fat, sodium and calories; hence, the intake of fruits and vegetables equips the body with vitamins, minerals, fibres, and other health-promoting phytonutrients. Dietary fibre and roughage aid digestion; and allow easy passage of bowel movements. Consumption of a diet rich in fruits and vegetables can prevent cardiovascular diseases, reduce the risk of stroke, reduce blood cholesterol levels and treat type 2 *Diabetes mellitus*. A minimum of 400g of fruits and vegetables is recommended for daily consumption by the World Health Organization (WHO) and the Food and Agriculture Organization (FAO) to abate chronic diseases and micronutrient deficiencies (WHO-FAO, 2004).

Despite the benefits embedded in fruits and vegetables, their consumption without standard hygiene conditions can serve as a potential route of transmission for harmful parasites to animal and human hosts. Several factors could be responsible for the contamination of fruits and vegetables, including the use of untreated waste water containing eggs of intestinal parasites for irrigation (Berger *et al*., 2010), direct application of waste water and animal manure as fertilizer, open defecation, and poor hygiene in handling fruits and vegetables. When human hosts eat fruits or vegetables contaminated with gastrointestinal parasites, they acquire infection. Open defecation is a reservoir of infection. Water can wash the parasites in the stool to nearby farmlands and playgrounds. When children are in contact with contaminated soil or water, the transmission of parasitic infection is triggered (Alemu *et al*., 2016). Mild to severe symptoms of these parasites can be seen in an infected individual; symptoms may vary with the parasite species and intensity, which depends on host size and nutritional status. Apart from the poor conditions caused by these parasites, they also reduce the daily productive working hours. Although there are some studies regarding parasitic contamination of fruits and vegetables in Nigeria (Alade *et al*., 2013; Amaechi *et al*., 2016; Auta *et al*., 2017), there are scanty of recent report of similar study on Ilorin metropolis. Therefore, in this report, we evaluate the level of parasites contamination of some selected fruits and vegetables in peri-urban markets in Ilorin metropolis.

2. MATERIALS AND METHODS

2.1 Study Location

The study was conducted in the peri–urban markets of Ilorin, Kwara State. The state is located between latitudes 8°05' N and 10°15' N and longitudes 2°73' E and 6°13' E (Figure 1). It has a tropical wet and dry climate with a prolonged dry season, with an average annual rainfall of 1200 mm and an average temperature of 26.2 °C. Ilorin comprises three local government areas: Ilorin West, Ilorin South and Ilorin East. Six markets were randomly selected, two per local government area-Ilorin East Local Government Area (Sango and Ipata markets), Ilorin West Local Government Area (Mandate and Oja Tuntun markets) and Ilorin South Local Government markets (Yoruba Road and Obbo Road markets). The selection of the markets was based on their proximity to consumers and the availability of fruits and vegetables.

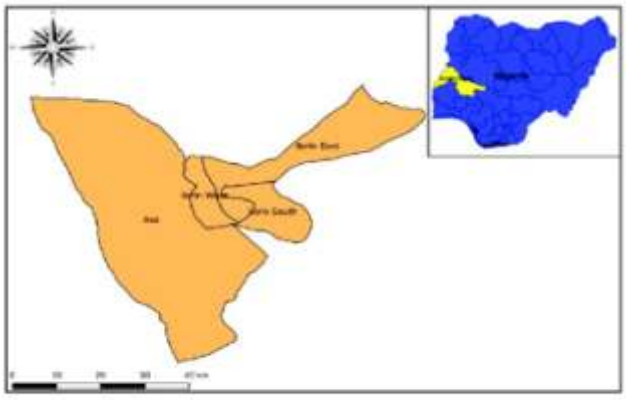

Fig. 1: Map of Ilorin

2.2 Sample Collection

A total of 213 fruits and vegetables purchased for this research were fresh samples devoid of physical infestation by pests. The samples were purchased across the six markets within Ilorin metropolis between May and June 2022 (Table 1). The samples collected were leaves of lettuce (*Lactuca sativa*), spinach "Efo Tete" (*Amaranthus viridis*), Fluted Pumpkin "ugu" (*Telfaira occidentalis*) and cabbage (*Brassica oleracea*). The fruits are Tomato (*Solanum lycopersicum*), Green Pepper (*Capsicum annuum*), Cucumber (*Cucumis sativus*) and the taproot of Carrot (*Daucus carota*). Individual samples collected were kept in sterile polythene bags to avoid cross-infection of the samples by parasites. Samples were transported to the Zoology Laboratory of Kwara State University, where they were analysed.

Table 1: Classification of the Studied Fruits and Vegetables

Common Name	Kingdom	Order	Family	Genus	Species
Cabbage	Plantae	Cucurbitales	cucurbitaceae	*Brassica*	*oleracea*
Carrot	Plantae	Apiales	Apiaceae	*Daucus*	*Carota*
Cucumber	Plantae	Cucurbitales	Cucurbitaceae	*Cucumis*	*Sativus*
Fluted pumpkin	Plantae	Cucurbitales	Cucurbitaceae	*Telfaria*	*Occidentalis*
Green pepper	Plantae	Solanales	Solanaceae	*Capsicum*	*annuum*
Spinach	Plantae	Caryophyllales	Amaranthaceae	*Amaranthus*	*viridis*
Tomatoes	Plantae	Solanales	Solanaceae	*Solanum*	*lycospersicum*
Lettuce	Plantae	Asterales	Asteraceae	*Lactuca*	*Sativa*

2.3 Laboratory Analysis

The parasites were harvested and concentrated by sedimentation method 200 g of each vegetable and fruit were measured, washed, and soaked in 500 ml of 0.9% normal saline solution for 1 hour to detach the parasitic stages (ova, larvae, cysts, and oocysts) of helminths and protozoan parasites from the samples. After one hour, the solution was sieved and the filtrate was allowed to sediment for 12 hours before being decanted to obtain the sediment. Then, the sediment was centrifuged for five minutes at 1600 revolutions per minute. The supernatant was decanted, and the sediment was agitated to redistribute the parasites (Khan *et al*., 2022). Two drops of the sediment were placed on a clean oil-free glass slide. One drop of Lugol's iodine was added to the sediment and a clean oil-free cover slip was placed on it for its examination under a light microscope, using 10X and 40X objectives with oil immersion. The eggs and cysts were identified based on morphological details, according to Adogo *et al*. (2021). For each preparation, three slides (one direct and two iodine smears) were prepared to increase the chance of parasite detection.

2.4 Data Analysis

SPSS software (version 24) was used in analysing the data and Pearson's chi-square was used to determine the association between variables. A p-value of less than 0.05 was considered statistically significant.

2.5 Ethical Approval

Ethical approval (MOH/KS/RERC/777/58) was obtained from the Kwara State Ministry of Health Ethical Review Committee before the commencement of the study.

3. RESULTS

Two hundred and thirteen (213) fruit and vegetable samples were analysed for parasite contamination, and an overall prevalence of (49/213) 23.0% was recorded in the study (Figure 2). Forty-nine (49) samples were found infected with Protozoan and helminth parasitic stages. In the contaminated fruits and vegetables, 13 parasites (5 protozoans and 8 helminths), comprising *Giardia lamblia, Entamoeba histolytica, Entamoeba coli, Balantidium coli, Isospora coli, Schistosoma* spp., *Ascaris lumbricoides, Taenia* spp., *Trichuris trichura, Strongyloides stercoralis, Fasciola* spp., *Toxocara* spp., and *A. duodenale,* were detected and evaluated. Cabbage and Lettuce were the most contaminated of all samples; out of thirteen (13) samples of Cabbage and Lettuce examined, five (5) were infected with at least one parasite, while Green Pepper had the smallest fraction of parasite contamination. Thus, the order of parasite contamination was: Cabbage and Lettuce > Flumpkin > Tomatoes > Carrot > Cucumber > Spinach > Green Pepper.

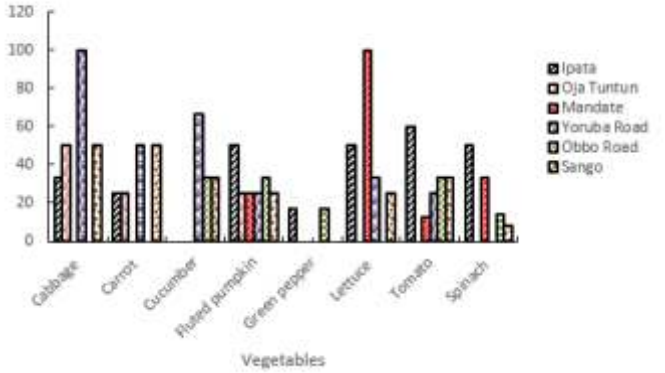

Fig. 2: Prevalence of Intestinal Parasites on Selected Fruits and Vegetables across Peri-Urban Markets in Ilorin, Kwara State

Polyparasitism was evident in some samples (Table 2). Cabbage from Yoruba Road had more than four (4) parasites. Fluted Pumpkin, Lettuce, Spinach and Tomato, which were obtained from Ipata market, and Fluted Pumpkin from Obbo Road had three (3) parasites each. Carrot, Cucumber and Fluted Pumpkin from Yoruba Road market; Cabbage from Ipata; Spinach from Obbo Road, and Lettuce from Mandate market harboured two (2) parasites each. Carrot from Ipata market; Cabbage, Carrot, Cucumber, Fluted Pumpkin, Lettuce, Spinach and Tomato from Sango market had only one parasite each. Also, Green Pepper, Cucumber and Tomato from Obbo Road market had only one parasite.

Table 2: PolyParasitism on Fruits and Vegetables across Peri-Urban Markets in Ilorin, Kwara State

Vegetable	Ipata	Sango	Obbo Road	Yoruba Road	Mandate	Oja Tuntun
Cabbage	*Ascaris lumbricoides* and *Taenia* spp.	*Balantidium coli*	-	*Balantidium coli, Schistosome* cercaria, *Entamoeba coli, Giardia lamblia*	-	*Giardia lamblia*
Carrot	*Strongyloides stercoralis*	*Giardia lamblia*	-	*Entamoeba histolytica* and *Giardia lamblia*	-	*Taenia* spp.
Cucumber	-	*Isospora* spp.	*Ancylostoma duodenale*	*Ascaris lumbricoides. Entamoeba histolytica*	-	
Green pepper	*Strongyloides stercoralis*	-	*Taenia* spp.	-	-	-
Fluted pumpkin	*Toxocara* spp., *Ancylostoma duodenale*, *Strongyloides stercoralis*	*Ancylostoma duodenale*	*Entamoeba histolytica, Fasciola* spp. *Ancylostoma duodenale*	*Ancylostoma duodenale* and *Entamoeba histolytica*	*Entamoeba histolytica*	*Strongyloides stercoralis*
Lettuce	*Balantidium coli, Ascaris lumbricoides, Entamoeba histolytica*	*Entamoeba coli*	-	*Taenia* spp.	*Entamoeba histolytica, Taenia* spp.	-
Spinach	*Ascaris lumbricoides, Giardia lamblia Taenia* spp.	*Taenia spp*	*Strongyloides stercoralis, Giardia lamblia*	-	*Ascaris lumbricoides*	-
Tomato	*Trichuris trichura, Giardia lamblia, Strongyloides stercoralis*	*Giardia lamblia*	*Entamoeba coli*	*Giardia lamblia*	*Trichuris trichura*	-

Giardia lamblia, with a prevalence of 17.5%, was the most prevalent of all the parasites evaluated (Table 3), followed by *S. stercoralis,* and *Taenia* spp., with 14.0%. *E. histolytica* had a prevalence of 12.1%, *A. lumbricoides* and *A. duodenale* had a prevalence of 10.5% each, while *B. coli* and *E. coli* had a prevalence of 5.3% each.

Fruits and vegetable samples that were washed and refreshed with water from the stream had a higher contamination fraction of 40.0% (Figure 3). Well water and borehole water had the highest contamination fractions of 34.5% and 20.8%, while tap water had the lowest contamination fraction of 9.1%. Ipata market had the highest parasitic sample contamination (Figure 4) of 37.0%, followed by the Yoruba road market with a prevalence of 18.0%, while Oja tuntun had the least (6.0%) parasitic fruits and vegetables.

Table 3: Parasite Distribution in Fruits and Vegetables across Peri-Urban Markets in Ilorin, Kwara State

Detected Parasites	Frequency	Prevalence (%)
Protozoans		
Giardia lamblia	10	17.5
Entamoeba histolytica	7	12.3
Entamoeba coli	3	5.3
Balantidium coli	3	5.3
Isospora sp	1	1.8
Helminthes		
Schistosome cercaria	1	1.8
Ascaris lumbricoides	6	10.5
Hookworm	6	10.5
Taenia spp.	8	14.0
Trichuris trichura	2	3.5
Strongyloides stercoralis	8	14.0
Fasciola spp.	1	1.8
Toxocara spp.	1	1.8
Total	**57**	**26.8**

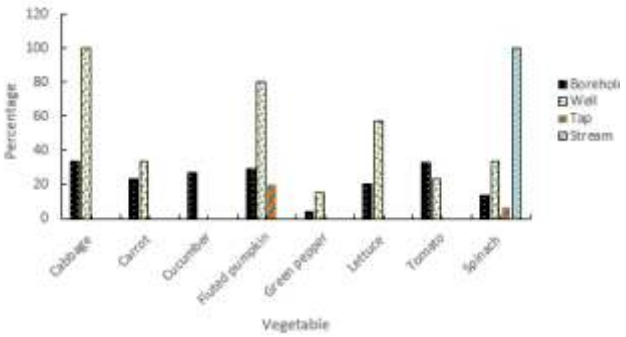

Figure 3: Water Source for Washing and Refreshing Fruit and Vegetables in the Study Site

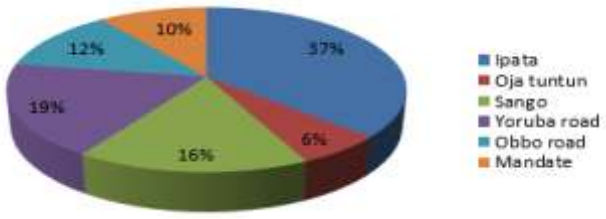

Fig. 4: Parasitic Prevalence Per Market in the Study Area

In order to make fruits and vegetables look fresh, the vendors usually sprinkle water on them. Vendors who used well water had a fraction of infection of 67.3%; those who used borehole water had 60.0%; and those who used old refreshing well water had the least contamination level of 32.7% (Table 4). Samples displayed on the wooden wheelbarrow had the highest contamination (19/76) followed by the tray (15/32) while the pavement had the lowest contamination (Figure 5). The vendors with secondary educational levels had the fewest (52) infected samples in this study (Figure 6).

Table 4: Sprinkling Water Source by Vendors

Vegetable	Borehole		Well		Tap		Total	
	New (%)	Old (%)	New (%)	Old (%)	New (%)	Old (%)	New (%)	Old (%)
Cabbage	2(22.2)	7 (77.8)	2(100.0)	0(0.0)	0(0.0)	2(100.0)	4(3.8)	9(69.2)
Carrot	7(41.2)	10 (58.8)	3(100.0)	0(0.0)	0(0.0)	1(100.0)	10(47.6)	11(52.4)
Cucumber	7(46.7)	8 (53.3)	3(100.0)	0(0.0)	-	-	10(55.6)	8(44.4)
Fluted pumpkin	11(64.7)	6(35.3)	5(100.0)	0(0.0)	6(60.0)	4(40.0)	22(64.7)	12(35.3)
Green pepper	4(17.4)	19 (82.6)	5(13.5)	8(61.5)	0(0.0)	4(100.0)	9(22.5)	31(77.5)
Lettuce	1(20.0)	4 (80.0)	3(42.9)	4(57.1)	-	-	4(30.8)	9(69.2)
Tomatoes	5(41.7)	7 (58.3)	7(53.8)	6(46.2)	1(100.0)	0(0.0)	13(50.0)	13(50.0)
Spinach	11(50.0)	11 (50.0)	9(100.0)	0(0.0)	5(33.3)	10(66.7)	25(52.1)	23(47.9)
Total	**48 (40.0)**	**72 (60.0)**	**37 (67.3)**	**18 (32.7)**	**12 (36.4)**	**21 (63.6)**	**97 (45.5)**	**116 (54.5)**

New = changed water; old = unchanged water

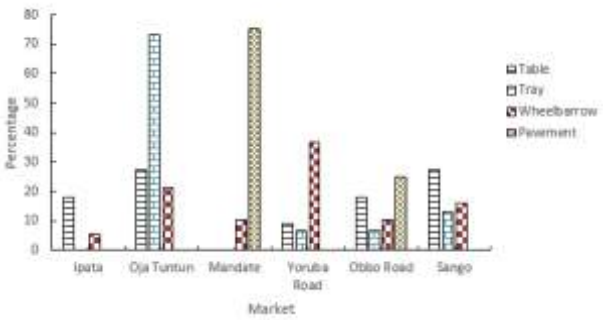

Fig. 5: Prevalence of Infection in Relation to Materials Used for Vegetable Display across the Markets

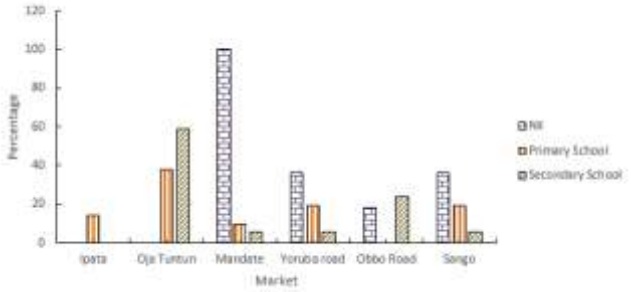

Fig. 6: Infection and Educational Status of Vendors across the Markets

4. DISCUSSION

This study recorded a parasite prevalence of 23.0% among fruits and vegetables sampled from six markets in Ilorin, Kwara State, Nigeria. The fraction of parasite infection is lower than that obtained in a similar study by Yahaya and Bishop (2022), who recorded a prevalence of 26.0% in Samaru-Zaria. However, the result is slightly higher than some of those reported by Agabalaka *et al*. (2018) in Jos, Klapec and Borecka (2012) in Poland, where 21.6% and 20.3% were reported. Amaechi *et al*. (2016) and Alade *et al*. (2013) had previously worked on vegetable contamination by intestinal parasites in Ilorin and had recorded a prevalence of 40.0% and 41.0% respectively. Fluted Pumpkin, white Cabbage, Lettuce, Spinach, and Tomatoes were additions to the fruits and vegetables that were reportedly examined by Agbalaka *et al*. (2018) and Yahaya and Bishop (2022). The authors detected *S. stercoralis, A. lumbricoides, E. histolytica, G. lamblia, T. trichura,* and *A. duodenale*, while the latter recovered *A. lumbricoides, S. haematobium, S. stercoralis, T. trichura,* and *A. duodenale* in their study. But in the present study, *Giardia lamblia, Taenia* spp., *Strongyloides stercoralis, Entamoeba histolytica, Entamoeba coli, Balantidium coli, Isospora* spp., *Trichuris trichura, Ascaris lumbricoides, Fasciola* spp., *Toxocara* spp., *Schistosoma* spp., and *A. duodenale* were detected. *G. lamblia*, which is the most common parasite encountered, was found in 17.5% of vegetable samples examined. This was followed by *Taenia* spp. and *S. stercoralis* with a prevalence of 14.0%. This result is similar to the results obtained by Nazemi *et al*. (2012) in Iran and Eraky *et al*. (2014) in Egypt, where *G. lamblia* was the most prevalent parasite.

The environment becomes contaminated with *G. lamblia* through the human faeces. Vegetables become infected when in contact with soil or water infested with *G. lamblia* (Tigabu *et al*., 2019). *G. lamblia* infestation of vegetables tends to take place post-harvest, during transportation, and through the use of infested water by vendors. It causes the disease giardiasis in Africa, Asia, and Latin America. High cases of giardiasis occur annually and it cause chronic and acute diarrhoea in children (Buhari *et al*., 2020).

Taenia spp. and *S. stercoralis*, with a prevalence of 14.0% each, are similar to 13.5% recorded by Alemu *et al*. (2020). A high prevalence of *S. stercoralis* (58.1%) was reported in Jos by Agbalaka *et al*. (2018). *S. stercoralis* has a free-living stage and does not require a host for multiplication. Also, its larval stage can penetrate the skin of the vegetable handlers, and dogs could also serve as reservoir hosts; hence, the presence of *S. stercoralis* indicates poor sanitation and open defecation into the environment. *Taenia* spp. causes taeniasis, and there are reported cases in Nigeria (Akanbi *et al*., 2021). This could be a result of using faeces containing *Taenia* spp. as manure by local farmers.

In this study, a prevalence of 2.3% was recorded for *E. histolytica*. A similar result was reported by Agbalaka *et al*. (2018). *A. lumbricoides* and *A. duodenale* have a prevalence of 10.5% each in this study. This is lower, compared to the 28% and 21.3% prevalences reported by Amaechi *et al*., (2016) and Ajakaye *et al*. (2021), respectively. On the other hand, the result for *A. duodenale* was higher than the 7.7% reported by Khan *et al*. (2022). *A. lumbricoides* causes the disease ascariasis, and it is the most common and largest worm in humans. One-sixth of the human population is estimated to be affected by *A. lumbricoides*, or roundworm (Alade *et al*., 2013). *A. lumbricoides* can produce 200,000 eggs daily for a year (Umbrello *et al*., 2021). Their eggs are environmentally resistant and can live up to 2 years at 5-10˚C, even in the absence of oxygen, and desiccation does not affect them in the environment for 2-3 weeks, where conditions are favourable (moist and sandy soil). *A. duodenale* and other hookworm infections are mostly associated with anaemia and they are the leading cause of maternal and child morbidity in developing countries (Umbrello *et al*., 2021).

B. coli and *E. coli* each had a prevalence of 5.3% in this study, which is consistent with the findings of Auta *et al*. (2017). The presence of *B. coli* suggests pig or human waste contaminated irrigation water. *T. trichura* occurred twice at a prevalence of 5.3%. A similar result was reported by Agbalaka *et al*. (2018). However, Punswadd *et al*. (2019) recorded a lower percentage (2.6%). *Isospora* spp., *Schistosoma* spp., *Fasciola* spp., and *Toxocara* spp., all recorded a prevalence of 1.8% each in this study. The presence of schistosome cercariae suggests that either the irrigation water or the water used by the vendors in washing fruits or vegetables was contaminated with urine (Tian-Bi *et al*., 2018). *Toxocara* eggs can survive for up to 10 years because they can resist harsh environments (Silva *et al*., 2020).

Of all fruits and vegetables examined, Lettuce and Cabbage were the most contaminated, with a prevalence of 38.5% each; this aligns with other studies such as (Ajakaye & Obimakinde, 2021; Amaechi *et al*., 2016). Fluted Pumpkin had a prevalence of 32.4% in this study; a lower percentage was recorded by Ejike *et al*. (2018) and Obebe *et al*. (2020) in Aba and Ibadan respectively. Lettuce, Cabbage, and Fluted Pumpkin are leafy vegetables with irregular surfaces; Parasites have been reported to attach easily to uneven surfaces as they can hide there; however, Opara and Udoidung (2003) believe that Cabbage, Lettuce, and other leafy vegetables do not get contaminated because of uneven surfaces alone, but the height of the vegetable plays an important role. They propose that the shorter the plant above the soil level, the higher the risk of contamination, especially when the leaves are broad.

Tomatoes in this study, had a prevalence of 26.9%; higher prevalences have been reported within Nigeria. Agbalaka *et al*. (2018) reported 67.5%, while a lower percentage (7.8%) was recorded by Ejike *et al*. (2018). Tomatoes were contaminated by *G. lamblia, T. trichura, Entamoeba Coli,* and *S. stercoralis.* The prevalence recorded for Carrots in this study was similar to the study by Agbalaka *et al*. (2018). Carrot has a smooth surface, which could make it difficult for a parasite to attach to them with ease; therefore, Carrot is not likely to be contaminated at a high prevalence. However, some works showed that Carrot had a high percentage of contamination prevalence (Patrobas *et al*., 2018). The prevalence of the parasite in Cucumber from this present study is in deviance from another study where no infection was recorded in cucumber (Agbalaka *et al*., 2018). Green Pepper is the least contaminated from this study with a prevalence of 7.5%. This could be due to the smooth surface, which could make it difficult for parasites to penetrate it (Agbalaka *et al*., 2018).

The sources of water for washing and sprinkling vegetables determine contamination. Stream was the most contaminated with 40%, followed by well 34.5%, borehole 20.8%, and tap water at 9.1%. Since stream water does not receive any treatment, it can harbour contaminants from wastes and faecal matters. Similarly, water from a well without a lid is prone to contamination. Also, well water close to dumpsites and faecal disposal sites is prone to contamination, especially during the rainy season (Haile & Gabbiye, 2022). The low prevalence of parasites, when tap water is used could be due to the fact that few vendors use it and not necessarily because it is a treated water source. The borehole water, which is a clean source of water, had an infection of 20.8% in the study. This could be linked to unhygienic practices by the vendors because borehole water remains one of the ideal water sources. Vendors who do not change the water for washing and sprinkling had a higher level of contamination than vendors who changed the water frequently. However, Agbalaka *et al*. (2018) reported that rarely changed water had higher contamination.

Point of display plays an important role in the parasitic transmission route (Punsawad *et al*., 2019). Samples placed on wooden tables and wheelbarrows had more contamination and transmission than in others. Wooden platforms could create a conducive environment for a parasite to survive; metallic platforms, on the other hand, could resist the development of a suitable environment for parasites to thrive. Education is meant to improve behaviour and enhance performance (Anwar *et al*., 2020). The low prevalence observed among vendors with secondary education is an indication that a combination of education and commerce could result in better output and performance. Ipata market has

the highest contamination prevalence. This is in agreement with a study by Amaechi *et al*. (2016), while Oja Tuntun has the lowest prevalence from this study. Ipata market has unclean surroundings, no proper waste disposal system, and is generally unhygienic, which favours contamination of the environment.

5. CONCLUSION

The overall prevalence of parasites in fresh fruit and vegetable samples collected from Ipata, Oja Tuntun, Mandate, Yoruba Road, Obbo Road, and Sango markets in this study is relatively high. *Giardia lamblia, Taenia* spp.*, Strongyloides stercoralis, Entamoeba histolytica, Entamoeba coli, Balantidium coli, Isospora* spp.*, Trichuris trichura, Ascaris lumbricoides, Fasciola* spp.*, Toxocara* spp.*, Schistosoma* spp.*,* and *A. duodenale* were detected during the study. Vegetable and fruit types have varied contamination prevalence. Vegetables and fruits directly supplied to vendors were more susceptible to parasite contamination. Hence, the public health sector at the state and local government level is encouraged to establish an adequate system for monitoring vegetables and fruits sold at local markets. In addition, community members must be sensitized to the need to adequately wash fruits and vegetables before consumption. It is better to wash fruits and vegetables with tap water compared to stream water since tap water is less contaminated. We therefore recommend that vegetables be washed more than twice with clean water and in clean vessels to reduce the risk of parasites.

References

Adenusi, A. A., Akinyemi, M. I., & Akinsanya, D. (2018). Domiciliary cockroaches as carriers of human intestinal parasites in Lagos Metropolis, Southwest Nigeria: Implications for public health. *Journal of Arthropod-Borne Diseases*, *12*(2), 141–151.

Adogo, L. Y., Yakubu, H. D., & Maikenti, J. I. (2021). Parasites on vegetables sold at masaka market, Karu, Nasarawa State, Nigeria. *Nigerian Journal of Parasitology*, *42*(1), 115–121.

Afrin, T., Murase, K., Kounosu, A., Hunt, V. L., Bligh, M., Maeda, Y., Hino, A., Maruyama, H., Tsai, I. J., & Kikuchi, T. (2019). Sequential Changes in the Host Gut Microbiota during Infection with the Intestinal Parasitic Nematode *Strongyloides venezuelensis*. *Frontiers in Cellular and Infection Microbiology*, *9*(JUN).

Agbalaka, P. I., Obeta, M. U., & Daniel, K. R. (2018). Food-Safety regarding intestinal parasites on edible fruits and vegetables. *The Diagnostics*, *1*(2), 13–24.

Ajakaye, O. G., & Obimakinde, E. T. (2021). How consumption of unwashed fresh vegetables continued to serve as transmission avenues for Intestinal parasites in man. *Nigerian Journal of Parasitology*, *42*(1), 167–174.

Akanbi, O. B., Jegede, H. O., Adam, M., Oludairo, O. O., Aiyedun, J. O., Rimfa, A. G., Ahmed, J., Barde, I. J., Hanga, A. B., Ajadi, A. A., Atata, J. A., Taiwo, V. O., & Shoyinka, S. V. O. (2021). Disease and mortalities in selected zoological gardens in Nigeria. *Comparative Clinical Pathology*, *30*(5), 743–753.

Alade, G. O., Alade, T. O., & Adewuyi, I. K. (2013). Prevalence of Intestinal Parasites in Vegetables Sold in Ilorin, Nigeria. *American-Eurasian Journal of Agriculture & Environmental Science*, *13*(9), 1275–1282.

Alemu, A., Tegegne, Y., Damte, D., & Melku, M. (2016). *Schistosoma mansoni* and soil-transmitted helminths among preschool-aged children in Chuahit, Dembia district, Northwest Ethiopia: Prevalence, intensity of infection and associated risk factors. *BMC Public Health*, *16*(422), 1-9.

Alemu, G., Nega, M., & Alemu, M. (2020). Parasitic Contamination of Fruits and Vegetables Collected from Local Markets of Bahir Dar City, Northwest Ethiopia. *Research and Reports in Tropical Medicine*, *11*, 17–25.

Al-Rifai, R. H., Loney, T., Sheek-Hussein, M., Zoughbor, S., Ajab, S., Olanda, M., & Al-Rasbi, Z. (2020). Prevalence of, and Factors Associated with Intestinal Parasites in Multinational Expatriate Workers in Al Ain City, United Arab Emirates: An Occupational Cross-Sectional Study. *Journal of Immigrant and Minority Health*, *22*(2), 359–374.

Amaechi, E. ., Ohaeri, C. ., Ukpai, O., & Adegbite, R. A. (2016). Prevalence of Parasitic contamination of salad vegetables in Ilorin, North Central, Nigeria. *Momona Ethiopian Journal of Science*, *8*(2), 136.

Anwar, N., Nik Mahmood, N. H., Yusliza, M. Y., Ramayah, T., Noor Faezah, J., & Khalid, W. (2020). Green Human Resource Management

for organisational citizenship behaviour towards the environment and environmental performance on a university campus. *Journal of Cleaner Production*, *256(1)*, 1-13.

Auta, T., Bawa, J., & Suchet, C. (2017). Parasitic Contamination of Common Fresh Fruits and Vegetables Sold in Markets within Dutsin-Ma Town, Katsina State, Nigeria. *Journal of Advances in Biology & Biotechnology*, *14*(2), 1–8.

Berger, C. N., Sodha, S. V., Shaw, R. K., Griffin, P. M., Pink, D., Hand, P., & Frankel, G. (2010). Fresh fruit and vegetables as vehicles for the transmission of human pathogens. In *Environmental Microbiology 12*(9), 2385–2397

Buhari, Y., Dabai, S. M., & Abdulazeez, A. (2020). A review on the prevalence of Human Giardiasis in some selected States in Nigeria. *Communication in Physical Sciences*, *5*(1), 7–13.

Ejike, B. U., Ejike, E. N., Ogbonna, C. R., & Onu, E. O. (2018). Geohelminth contamination of vegetables sold in some markets in Aba North, South-East Nigeria. *Nigerian Journal of Parasitology*, *39*(2), 194–198.

Eraky, M. A., Rashed, S. M., Nasr, M. E. S., El-Hamshary, A. M. S., & Salah El-Ghannam, A. (2014). Parasitic contamination of commonly consumed fresh leafy vegetables in Benha, Egypt. *Journal of Parasitology Research*, *2014*.

Haile, D., & Gabbiye, N. (2022). Assessment of Nutrients and Heavy Metals in the Groundwater and Surface Water in the Zeber Watershed: The Case of the Bahir - Dar City Waste Disposal Site. *Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST*, *411 LNICST*, 87–105.

Jourdan, P. M., Lamberton, P. H. L., Fenwick, A., & Addiss, D. G. (2018). Soil-transmitted helminth infections. In *The Lancet*. 39(10117), 252–265.

Khan, W., Rafiq, N., Nawaz, M. A., Kabir, M., Farooqi, Z., Romman, M., Parvez, R., Alfarraj, S., Noor, A., & Ujjan, A. A. (2022). Parasitic contamination of fresh vegetables sold in open markets: a public health threat. *Brazilian Journal of Biology*, *84*(e242614).

Kłapec, T., & Borecka, A. (2012). Contamination of vegetables, fruits and soil with geohelminths eggs on organic farms in Poland. *Annals of Agricultural and Environmental Medicine*, 19(3), 421-425.

Nazemi, S., Raei, M., Amiri, M., & Chaman, R. (2012). *Parasitic Contamination of Raw Vegetables in Shahroud, Semnan*. Zahedan Journal of Research in Medical Sciences. https://www.researchgate.net/publication/281939198_Parasitic_Contamination_of_Raw_Vegetables_in_Shahroud_Semnan

Obebe, O. O., Aluko, O. O., Falohun, O. O., Akinlabi, K. B., & Onyiche, T. E. (2020). Parasitic contamination and public health risk of commonly consumed vegetables in Ibadan-Nigeria. *Pan African Medical Journal*, *36*, 1–9.

Opara, K. N., & Udoidung, N. I. (2003). Parasitic contamination of leafy vegetables: a function of the leaf area index (lai). *Global Journal of Pure and Applied Sciences*, *9*(1).

Patrobas, M. N., Okubanjo, O. O., Lawal, I. A., Kudi, C. A., Balami, A. G., & Dunka, H. I. (2018). Occurrence of parasite eggs and oocysts in commonly consumed vegetables collected from selected markets in Zaria, Kaduna State Nigeria. *Sokoto Journal of Veterinary Sciences*, *16*(1), 79.

Punsawad, C., Phasuk, N., Thongtup, K., Nagavirochana, S., & Viriyavejakul, P. (2019). Prevalence of parasitic contamination of raw vegetables in Nakhon Si Thammarat province, southern Thailand. *BMC Public Health*, *19*(1).

Silva, V., Silva, J., Gonçalves, M., Brandão, C., & Vieira e Brito, N. (2020). Epidemiological survey on intestinal helminths of stray dogs in Guimarães, Portugal. *Journal of Parasitic Diseases*, *44*(4), 869–876.

Tian-Bi, Y. N. T., Ouattara, M., Knopp, S., Coulibaly, J. T., Hürlimann, E., Webster, B., Allan, F., Rollinson, D., Meïté, A., Diakité, N. R., Konan, C. K., N'Goran, E. K., & Utzinger, J. (2018). Interrupting seasonal transmission of *Schistosoma haematobium* and control of soil-transmitted helminthiasis in northern and central Côte d'Ivoire: A SCORE study protocol. *BMC Public Health*, *18*(186), 1-12.

Tigabu, A., Taye, S., Aynalem, M., & Adane, K. (2019). Prevalence and associated factors of intestinal parasitic infections among patients attending Shahura Health Center, Northwest Ethiopia. *BMC Research Notes*, *12*(1).

Umbrello, G., Pinzani, R., Bandera, A., Formenti, F., Zavarise, G., Arghittu, M., Girelli, D., Maraschini, A., Muscatello, A., Marchisio, P., & Bosis, S. (2021). Hookworm infection in infants: a case report and review of literature. *Italian Journal of Pediatrics*, *47*(1).

WHO-FAO. (2004). Fruit and vegetable for health: report of a joint FAO/WHO workshop, 1-3 september 2004, Kobe, Japan. *Handbook of Plant Food Phytochemicals*, *September*, 105–137.

Yahaya, O., & Bishop, H. G. (2022). Parasitic contamination of fresh vegetables sold in some major markets and farms in Zaria. *Science World Journal*, *17*(1), 1597–6343.