Research Article

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Evidence of Helminthic Contamination of Fruits and Vegetables in Kaduna, Nigeria

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ABSTRACT

This study was carried out to assess the helminthic contamination of fruits and vegetables within Kaduna metropolis between January 2021 and April 2021. Fourteen (14) types of fruits and vegetables were obtained from three randomly selected markets and examined using sedimentation and microscopy methods of the 406 samples examined, 79 (19.5%) were contaminated with at least one parasitic helminth out of the four species; *Strongyloides stercoralis* (51.9%); *Fasciola* sp (27.8%); *A. lumbricoides* (11.3%) and Hookworm (9.0%) observed. Vegetables were more contaminated (21.1%) than fruits (17.2%) while Lettuce, alongside onions, had the highest prevalence of contamination (34.5%) and Cabbage was the least contaminated (10.3%).

Prevalence of helminthic contamination was related to various parameters such as market location, handling by vendors, source, etc. Samples gotten from Station Market were the most contaminated (22.1%) while Central Market (19.0%) and Monday Market (17.1%) had lower prevalence of contaminations. Fruits and vegetables collected from open market vendors who display them on sacks on the floor were more contaminated (19.8%) than those collected from grocery stores where they are displayed on aluminum trays (18.3%). The fruit and vegetable samples purchased directly from farmers within the markets were also more contaminated (20.0%) than those purchased from vendors (19.4%). However, there was no significant relationship between contamination and the source.

The findings of this study are very vital for policy formation and implementation, both in Nigeria and anywhere else, in preventing transmission of helminths via fruits and vegetables, which may result in disastrous epidemic outbreaks in the future. It is therefore pertinent that fruit and vegetable farming, transportation, sale and consumption be monitored and regulated, to forestall the spread of pathogenic parasites contaminating this nutritional food.

KEYWORDS: Fruits and vegetables; Helminth; Contamination; *Strongyloides stercoralis; Fasciola sp; A. lumbricoides; Hookworm*

INTRODUCTION

Fruits and vegetables are essential part of a healthy human diet owing to their enormous nutritional and medicinal value. They constitute vital sources of energy that are depended upon by people of all race and culture, as food supplements or nutrients, substantially enhancing the quality of food as rich sources of water, antioxidants, vitamins (A, B1, B6, B12, C, K) carotene and mineral elements [1,2]. The regular consumption of fruits and vegetables has been associated with reduction in the risk of non-communicable diseases such as obesity, cardiovascular diseases, and certain cancers. This has therefore increased the demand and consumption of fruits and vegetables, either in its raw form or minimally cooked [3].

Despite the great benefits derived from fruits and vegetable consumption, raw or minimally processed fruits and vegetables (without adequate washing and/or cooking) can be significant vehicles of food-borne parasites [4]. Globally, it is estimated that 33 million years of healthy lives are lost as a result of consuming contaminated foods each year. In 2010, the World Health

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Organization (WHO) presented a global report of 600 million foodborne illnesses and recorded 420,000 deaths worldwide. Thirty-two (32) important foodborne diseases were reported globally, of these, 10 are caused by helminthes WHO 2015.

Fruits and vegetables become contaminated with parasitic helminths at different points from farming to harvesting and selling. The use of untreated organic manure and wastewater on farmlands as growth booster and for irrigation are major sources of contamination on farms. Unhygienic practices during harvest, transportation, processing and preparation by farmers, vendors and consumers also contribute to fruit and vegetable contamination Gupta 2010. In addition, some fruits and vegetables possess large surface areas or surface structures that enable parasitic helminth to adhere easily to them thus increasing their chances of contamination. There has been an increasing epidemiology of food-borne diseases resulting from the consumption of raw fruits and vegetables in the last decade with helminthic parasites of medical importance such as *Ascaris lumbricoides, Fasciola* sp., *Hymenolepis* sp., *Taenia* sp., *Trichuris trichiura, Strongyloides stercoralis* and *Toxocara* sp. [5-8]. All have emphasized the role and impact of fruits and vegetables, particularly those consumed raw or unwashed, in the transmission of medically important parasitic helminths [9].

Food-borne infections by parasitic helminths are widely distributed and particularly concentrated in the Sub-saharan region, endangering public health and constituting a major cause of morbidity throughout the world. Prevalence of these food-borne infections have been reported to be closely linked with ignorance, poverty, lack of sanitation and hygiene, consumption of unsafe water and crowded living conditions [10,11].

Though not immediately fatal, helminthic infections cause a wide range of abdominal complications, iron-deficiency anaemia and diarrhoea in children, pregnant women and immunosuppressed individuals. Parasitic helminthic infections impact heavily on the physical growth and cognitive development of infected children. Most of the burden of these diseases results to disability, affecting the child's school attendance and activity, child development, in some few cases, premature death. In general, this could also negatively affect the overall economic productivity of a community, thus resulting in disease driven poverty traps [12].

Despite the public health importance being enormous, the control of food borne parasitic infection is often overlooked a rarely a priority in endemic countries [13]. The 54th World Health Assembly in May 2001, passed a resolution affirming that the control of fruits and vegetable transmitted helminths should be considered a public health priority [14].

Contamination of fruits and vegetables can be prevented through: Health education for farmers, as well as fruits and vegetable vendors, health workers, government organizations and the general public; Improved diagnosis of parasitic infections and contaminations; Prompt treatment of infected persons through mass drug administration; Encouraging proper sanitation and personal hygiene and the Provision and use of basic amenities, such as toilets and potable water.

Therefore, this research was designed with the aim to provide epidemiological data which will be useful for the national database, policymakers and stakeholders, in setting priorities that are appropriate and evidence-based in the area of food safety intervention and disease control. Likewise, the study will promote awareness, among community residents and the general public, on the risk of consuming unwashed, inadequately washed or improperly cooked fruits and vegetables.

MATERIALS AND METHOD

Study Area

Kaduna is the Capital city of Kaduna State in North-West Nigeria. The State is located between 10° 20'N 7°45'E (Figure 1) and has an area of 46, 053km^2 (17,781sq.mi). Kaduna is about 209 km from the Federal Capital, Abuja and 634 km from Lagos. It has a population of 6,113,503 residents Census 2006 and is regarded as the third most populated State in Nigeria. There are about 59 to 63 ethnic groups resident in Kaduna, dominant ones being: Gbagyi, Adara, Hausa, Fulani, Atyap-Bajju, Ham, Yoruba, Kanuri and Nupe. The State has a Sudan savannah vegetation with scattered short trees, shrubs and grasses. The average annual temperature is about 25 °C, with 1211mm of precipitation annually and the peak rainfall in August. The State predominantly consists of Christians and Muslims, while majority of indigenes are involved in farming, fishing and civil service jobs.

Study Design

This was a cross-sectional study that attempted to examine helminthic contamination of fruits and vegetables made available or prepared for sale, in different parts of Kaduna. The study was carried out between january and april 2021 on raw fruits and vegetables that are commonly consumed and/or sold within the period of study. Randomly selected major fruit and vegetable markets within Kaduna metropolis were selected for this study. They include monday market, located in Kurmin Gwari area of Kaduna metropolis, station fruits and vegetable market located at Kaduna's Railway Station, and the central market located at Bakin Dogo area of Kaduna metropolis. The fruits selected and examined include watermelon (*Citrus lanatus*), banana (*Musa* sp), oranges (*Citrus sinensis*), pineapple (*Ananas cosmosus*), tomato (*Lycopersicon esculentum*) and cucumber (*Cucumis sativa*). While the vegetables include carrot (*Daucus carota*), spinach (*Spinacia oleracea*), lettuce (*Lactuca sativa*), cabbage (*Brassica denceal*), pumpkin (*Curcurbita pepo*), ginger (*Zingiber officinale*), onion (*Allium cepa*) and water leaf (*Talinum triangulare*).

Sample size:

The sample size for this study was determined using the method of Thrush field, 1997.

$$n=(Z^2\ pq^2)/d^2$$

Where;

n = sample size,

z = standard normal distribution at 95% Confidence Interval = 1.96

p = expected prevalence = 50%

q = 1 – p = (1- 0.5) = 0.5

d = the allowable error, which is taken as 5% = 0.05

Substituting the values in the formula:

$$n=(1.962\times0.5(1-0.5))/0.052$$

$$n = 384.$$

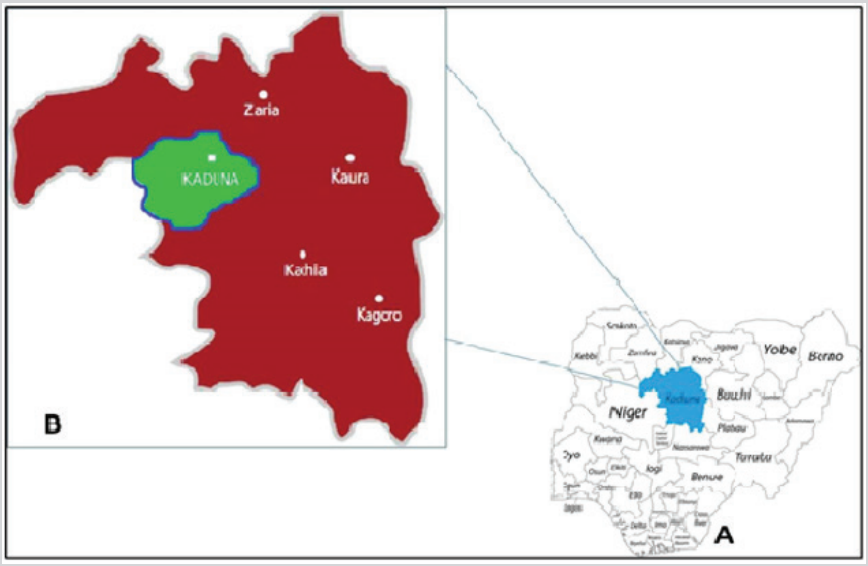

Figure 1: A: Map of Nigeria showing Kaduna State (shaded blue); B: The Map of Kwara state, showing the study area (shaded green).

Sampling Technique: Sampling of fruits and vegetables from the markets were done randomly. At each market, samples were collected under normal purchase conditions from fruit and vegetable vendors that were available.

Sample Collection: Fruit and vegetable samples were collected into clean, labeled polythene bags and transported to the laboratory within 3 hours of collection for examination. Each of the 3 markets (Monday, Central and Station Markets) were visited once within a week. On each visit, 14 different types of fruits and vegetables, as mentioned above, were collected. A total of 42 fruits and vegetables were collected and examined weekly. In total, Monday and Station Markets were surveyed weekly for 10 weeks while Central market was surveyed for nine (9) weeks. A total of 406 fruits and vegetables were examined.

Data Collection

Factors associated with parasitic contamination of fruits and vegetables such as the condition, means of display, source of produce, location of market, etc. were noted during interview sessions with the vendors and by simple observation.

Laboratory Examination

During laboratory analysis, samples of the fruit and vegetable (200g) were weighed and then washed vigorously in 500ml of distilled water for 15 minutes in a clean plastic container for the removal of any parasitic ova or larva. Afterwards, the water was allowed to settle overnight. 15ml of the sediment was taken, sieved to remove undesirable matter, and transferred to a centrifuge tube. This was centrifuged at 3000rpm for 15 minutes. After centrifugation, the supernatant was decanted carefully by quickly inverting the tube, and the deposit was mixed and examined as described by Hajjami et al. [15]; Ani [16] as follows: A drop of the sediment was applied on the center of a clean grease-free slide and gently covered with clean cover slip avoiding air bubbles and over flooding. The preparation was examined under a light microscope using x10 and x40 objectives. The whole area under the cover slip was systematically screened. This procedure was repeated until the sediment in each test tube was completely exhausted. The parasitic helminths found under the microscope were identified as described by "The Bench Aids for the Identification Intestinal Parasites" by the World Health Organization (1994). A calibrated microscope was used to measure the helminth eggs and larva in order to enhance identification of the helminths.

Statistical Analysis

Data obtained from questionnaires and laboratory analysis were entered into Microsoft excel and analyzed using SPSS 20.00 California, USA. Statistical analysis was carried out at the significance level of ($p<0.05$) and presented using simple tables and percentages and bar chat. The chi - square test was used to find out the association between categorical variables which include status of fruits and vegetables, means of display, structure and location of the market.

RESULTS

Overall Prevalence of Contamination Among Fruits and Vegetables Examined

A total of four hundred and six (406) fruits and vegetables were examined for helminthic contamination in this study. Of these, 79 (19.5%) were contaminated with different parasitic stages of Helminths, ranging from eggs to larvae (Table 1).

The vegetables were more contaminated (21.1%) than fruits (17.2%), however, there was no statistically significant difference observed in the rate contamination between fruits and vegetables ($P>0.05$) (Figure 2). Of all fruits and vegetables examined, lettuce and onions similarly had the highest percentage of contamination (34.5%), while Cabbage had the least (10.3%).

Rate of Contamination by Helminth Species

Four different species of helminths were identified from the fruits and vegetables examined in this study, they include: *Ascaris lumbricoides*; Hookworms; *Strongyloides stercoralis* and *Fasciola* sp. *S. stercoralis*, (10.1%), was the most prevalent, while hookworms, (1.7%), were the least. The prevalence of contamination for *A. lumbricoides* and *Fasciola* sp were 2.2 % and 5.4% respectively (Table 2). The relationship between Helminth species and their contaminated fruits or vegetables were observed to be statistically significant ($P<0.05$).

Table 1: Distribution of fruits and vegetables examined.

	Number Examined	No. (%) Contaminated
Fruits		
Banana	29	4 (13.8)
Cucumber	29	4 (13.8)
Orange	29	7 (24.1)
Pineapple	29	4 (13.8)
Tomatoes	29	7 (24.1)
Watermelon	29	4 (13.8)
Vegetables		
Cabbage	29	3 (10.3)
Carrot	29	4 (13.8)
Ginger	29	8 (27.6)
Lettuce	29	10 (34.5)
Onions	29	10 (34.5)
Pumpkin	29	5 (17.2)
Spinach	29	5 (17.2)
Water leaf	29	4 (13.8)
Total	406	79 (19.5)

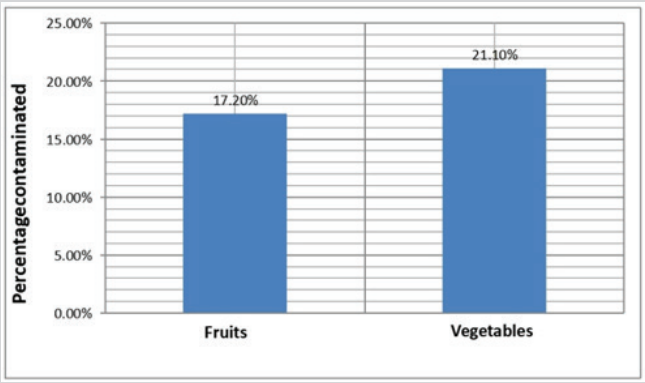

Figure 2: Prevalence of contamination among fruits and vegetables.

Table 2: Prevalence of contamination by helminth species.

Fruits and Vegetables	S. Stercoralis	Hookworms	Fasciola sp.	A. lumbricoides
Fruits				
Pineapple	0 (0.0)	1 (0.2)	2 (0.5)	1 (0.2)
Tomatoes	2 (0.5)	0 (0.0)	0 (0.0)	2 (0.5)
Watermelon	2 (0.5)	0 (0.0)	1 (0.2)	1 (0.2)
Cucumber	5 (1.2)	0 (0.0)	0 (0.0)	0 (0.0)
Banana	2 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)
Orange	1 (0.2)	1 (0.2)	3 (0.7)	2 (0.5)
Vegetables				
Cabbage	2 (0.5)	0 (0.0)	1 (0.2)	0 (0.0)
Carrot	3 (0.7)	0 (0.0)	0 (0.0)	0 (0.0)
Ginger	6 (1.5)	1 (0.2)	0 (0.0)	0 (0.0)
Lettuce	3 (0.7)	3 (0.7)	5 (1.2)	1 (0.2)
Onion	10 (2.5)	0 (0.0)	1 (0.2)	0 (0.0)
Pumpkin	0 (0.0)	1 (0.2)	3 (0.7)	0 (0.0)
Spinach	1 (0.2)	0 (0.0)	6 (1.5)	2 (0.5)
Water leaf	4 (1.0)	0 (0.0)	0 (0.0)	2(0.5)
Total	41 (10.1)	7 (1.7)	22 (5.4)	9 (2.2)

Df=52, X_2= 84.2, P = 0.0

Identification of Single and Mixed Contamination among Fruits and Vegetables

Banana, carrot and cucumber all had single contamination each, with *S. stercoralis* while mixed contamination of two helminths were predominant. Howbeit, spinach and watermelon were contaminated with more than two parasites (*A. lumbricoides, Fasciola sp* and *S. stercolaris*), while orange had contamination with four (*A. lumbricoides, Fasciola* sp, hookworms and *S. stercolaris*); (Figure 3).

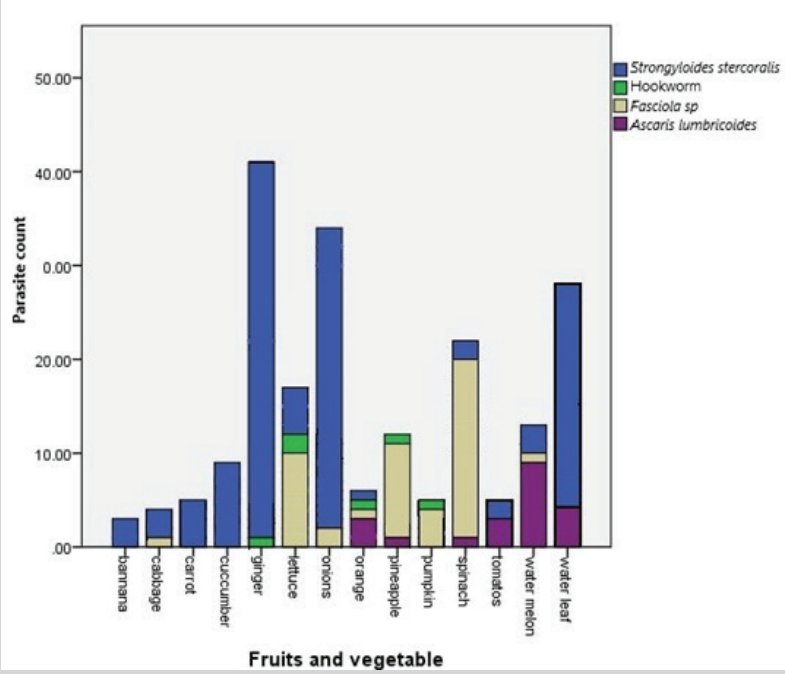

Figure 3: Fruits and vegetable contamination by helminth species.

Prevalence of Fruit and Vegetable Contamination by Market Location (Point of Sale)

The highest prevalence of fruit/vegetable contamination was observed at Station Market (39.2%), while Monday and Central Markets both have similar prevalence of contamination (30.4%). In total, 40 (50.6%) of all contaminated fruits/vegetables were purchased from open markets while 39 (49.4%) were from fruit kiosk. Nevertheless, there was no statistically significant association between location of sale and the rate of contamination.

Prevalence of Fruit and Vegetable Contamination by Source

Majority of the fruits and vegetables examined in this study (84.0%) were purchased from large scale vendors while a few portions (16%) were purchased directly from Farmers who grow directly on the farm. Those purchased directly from farmers had higher percentage of helminthic contamination (20.0%) than those purchased from large scale vendors (19.4%) (Table 3).

Table 3: Prevalence by source of fruits and vegetables.

Source	Number Examined	No. (%) contaminated
Farmers	65	13 (20.0)
Large Scale Vendors	341	66 (19.4)
Total	406	79 (19.5)

Df = 1, X_2 = 0.7, P. value = 0

However, source of fruits and vegetables had no significant relationship with the rate of contamination.

DISCUSSION

Overall Prevalence of Contamination among Fruits and Vegetables Examined

The overall contamination prevalence of fruits and vegetables for this study is at 19.5%, indicating that the rate of contamination of fruits and vegetables in Kaduna is of concern. Similar findings have also been reported in Bauchi (14.1%) and Akure (16.3%) by Istifanus [17] and Simon-Oke et al. [18], respectively while lower contamination prevalence was reported in Benin (4.2%) and Kogi (11%) [19,20]. However, Abe et al. [21] reported a strikingly high prevalence of contamination (37.5%) in Nasarawa.

Although the exact point of contamination is unknown, contamination could occur at different points before, during and after harvest. Possible sources of fruit and vegetable contamination could be attributed to the use of untreated organic manure and wastewater for irrigation, contact with faeces of grazing or wild animals, cross contamination during storage, washing and preparation, improper display as well as bad hygienic practices by farmers and fruit and vegetable vendors. Vegetables had higher percentage of contamination (21.1%) than fruits (17.2%). This could be related to the fact that many vegetables have rough surfaces

which facilitate attachment of parasitic helminths, whereas most fruits are smooth skinned, and provide a less conducive surface for parasites attachment. Also, by nature, most vegetables have close proximity to the soil, where it becomes easier for soil-transmitted helminths to contaminate it.

As observed in this study, lettuce (*Lactuca sativa*) and onions (*Allium cepa*) were the most contaminated vegetables, agreeing with the findings by Eraky et al. [22], Mohammed et al. [23] and Luz et al. [24], whose studies recorded lettuce as the most contaminated farm produce. On the other hand, we observed that cabbage (*Brassica denceal*) was the least contaminated, and this could be as a result of the practice of removing the outermost leaves when withering or drooping, by farmers and vendors, in order to keep the vegetable clean and fresh. Contamination of fruits and vegetables is clearly a problem in various parts of Nigeria, prompting the need for proactive actions on the part of regulatory bodies and public health officials, in order to forestall the continuous contamination of fruits and vegetables, as well as an outbreak of food-borne diseases.

Prevalence of Contamination by Helminth Species

The most prevalent helminthic contaminant observed in this study was the larvae of *Strongyloides stercoralis* (10.1%). This is consistent with the other studies in Nigeria and other parts of Africa where *S. stercoralis* had the highest prevalence of contamination [5]; Duedu et al. [25]; Tefera et al. [26]. The high rate of Strongyloides contamination might be due to the fact that the parasite has a complex life cycle with a free-living stage in the environment which does not require a host for its proliferation.

Fasciola species was second to *S. stercoralis* as the most parasitic contaminant in this study, showing a high prevalence of 5.4%. Similar report on Fasciola sp. was made by Ani [16], with a prevalence of 5.3%. This level of contamination by *Fasciola* sp. could be as a result of the fluke's reproductive ability, which enables it to produce as much as 20,000-24,000 eggs per fluke per day [27].

Ascaris lumbricoides and hookworms had very low level of contamination and could be as a result of the parasites being lost during transportation from farm to market. Findings from other studies have reported various level of contamination of *Ascaris lumbricoides* and hookworms in Nigeria and Africa at large [8]. Hajjami et al. [15]; Oranusi et al. [28]. The presence and species of parasitic helminthic contamination of fruits and vegetables from a certain community could possibly be a reflection of the parasitic fauna of such community.

Identification of Single and Mixed Contamination Among Fruits and Vegetables Examined

Contamination with more than one species of helminth was observed in all kinds of fruits and vegetables in this study apart from banana, carrot and cucumber (which had single contaminations). This agrees with studies carried out by Bekele et al. [29] and Ikepeze [30]. Multiple contaminations might indicate the possibility of a high level of contamination of fruits and vegetables which probably may result in multiple infections in individuals that consume or come in contact with these contaminated fruits and vegetables.

Prevalence of Fruit and Vegetable Contamination by Market Location (Point of Sale)

Fruits and vegetables from open markets were more contaminated (50.6%) when compared with those from the fruit kiosk (49.4%). Similarly, Bekele et al. [29] also recorded open markets as a type of market where fruits and vegetables are exposed to dusts, soils, flies and other unhygienic conditions which could be the reason for the higher percentage of helminths contaminants in fruits and vegetables sold in such markets.

Prevalence of Contamination by Source

Fruits and vegetables purchased directly from farmers had higher percentage of helminthic contaminants (20.0%) as compared with those supplied by large scale vendors (19.4%). There was no statistical difference between source of fruits and vegetables and parasitic helminthic contamination, however, the low percentage of contamination on fruits and vegetables sourced from large scale vendors could be as a result of transporting fruits and vegetables from one location to another, especially from very distant farms. In the process, some parasites could be lost due to weather conditions, handling methods and time factors. In a similar study, Alemu et al. [31] showed that vegetables sourced directly from farmers were more than 3 times likely to be contaminated with parasites as compared to those supplied by large scale vendors.

CONCLUSION

We identified a 19.5% prevalence of parasitic helminth contamination of fruits and vegetables in this study, which could imply that, approximately, one out of every five fruit or vegetable was contaminated with helminths. This therefore highlights the significance of raw fruits and vegetables as potential transmission means for parasitic helminths to humans; either through the consumption of parasites' eggs (e.g. *Ascaris lumbricoides*) or through skin penetration (e.g. *Strongyloides stercoralis larvae*). The percentage of fruits and vegetables contaminated with parasitic helminths may be higher and more than what was revealed in this study, hence there is need for further studies to be carried out throughout Kaduna State, as well as other parts of Nigeria, where no study of this kind has been conducted. The prevention of farm produce contamination remains the most effective way of reducing food borne parasitic infections. This can be made possible through awareness and regular health education of farmers, vendors and the general public. In addition, legislative laws should be designed to prohibit the use of untreated organic manure and wastewater in agriculture, while the provision of basic amenities such as potable water and sanitary facilities, be made a priority as it will improve personal and environmental hygiene. Finally, consumers of fruits and vegetables need to be educated on the harms and medical impact of not properly cooking or washing the fruits or vegetables before eating. In addition, the dangers of open defecation and need for proper composting of manure of human and animal origin before application must be emphasized to the public. It is important that hygienic practices and topics that will increase the awareness of pupils and students on infectious agents are included in school curriculum, and as well ensure that hygienic processes are followed observed by food handlers in the national school feeding program across schools in the country. Likewise, hospitality and food providers at various Internally Displaced Persons (IDP) camps across the nation should be greatly encouraged to practice good hygienic processes.

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