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ORIGINAL RESEARCH ARTICLE

Prevalence of Geohelminths Contamination of Selected Fruits and Vegetables in Maiduguri Metropolis Borno State

Usman Ali Bukar[1]*, Daniel Felix[1], Haruna Yahaya Ismail[1], Ummu Habibah Abdulkareem[1], Aminu Yusuf Fardami[2], Umar Alhaji Umar[3] and Muhammad Sanusi Zainab[2].

[1]Department of Microbiology, University of Maiduguri, Borno State, Nigeria.
[2]Department of Microbiology, Usmanu Danfodiyo University, Sokoto State, Nigeria.
[3]Department of Science Laboratory Technology, Federal Polytechnics Kaltingo, Gombe State, Nigeria.

ABSTRACT

Contamination of raw fruits and vegetables with geohelminth eggs or larvae can occur when the produce comes into contact with contaminated soil, water, or fertilizer during growth or post-harvest handling. This research aimed to isolate geohelminths that transmit intestinal parasitic infections to humans from vegetables and fruits in some selected markets in Maiduguri (including Gamboru kasuwa, Monday market, University commercial, and Tashan Bama) Borno state. The selected fruits were *Cucums sativus, Solanum lycoperscum, and Solanum melongena.* The selected vegetables also were *Brassca oleraca, Daucus carota, Allium cepa, Euruca sativa,* and *Amaranthus viridis*. Four (4) samples were collected for each fruit and vegetable from different vendors per location, giving 128 samples. The samples of vegetables and fruits were collected for two weeks to allow different batches of produce to the market. *Solanum lycoperscum* and *Euruca sativa* had the highest levels of 70% and 26% soil-helminths contaminations, respectively. The most prevalent geohelminths in vegetables and fruits were *A. lumbricoides,* with a percentage occurrence of 54.5% in fruits and 59.7% in vegetables. Produce from markets in Gamboru had the highest levels of 63.6% and 53.2% contaminations in fruits and vegetables, respectively. Soil helminths in vegetables and fruits can be prevented or eliminated by effectively removing human and animal waste, using properly treated organic manure/wastewater and effluents as fertilizers for irrigation, thoroughly washing and cooking fruits and vegetables, and training food vendors on food safety practices.

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KEYWORDS

Geohelminths, Contaminations, Fruits, Vegetables.

INTRODUCTION

In a very wide sense, vegetables refer to edible plants that are frequently harvested and grown for their nutritional worth for people. Greens are described botanically as "edible parts of a plant "(FAO and WHO, 2005). As a result, fruits are a subgroup of vegetables. Fruit refers to the mature ovary of a plant that contains the seed (FAO and WHO, 2005). The fleshy seed-associated plant structures that are edible when uncooked are also referred to as fruits (Yoila and Utitofon, 2016).

A raw material or completed product can get contaminated when undesirable impurities, such as chemicals or microbes, are introduced into or onto it. "Hygiene" refers to the circumstances or actions that promote and preserve health. A healthy diet should include fruits and vegetables since they frequently contain a variety of critical minerals and vitamins, dietary fiber, carbohydrates, and phytochemicals, each of which has significant antioxidant activity and is beneficial to human health (Liu, 2003; Davidson and Touger-Decker, 2009; Oranusi *et al.,* 2013).

Incorporating fruits and vegetables into your diet regularly has been linked to a lower chance of developing certain diseases like cancer, cardiovascular diseases, other chronic illnesses, and stroke (Liu, 2003; Theodoratou *et al.*, 2007). The Joint FAO/WHO Expert Consultation on diet, nutrition, and the prevention of chronic diseases recommended eating at least a minimum of 400g of fruits and vegetables daily (excluding potatoes and other starchy tubers) for the prevention of chronic diseases such as cancer, heart disease, diabetes, and obesity as well as for the prevention and alleviation of several micronutrient deficiencies, especially in underdeveloped countries

Correspondence: Usman Ali Bukar. Department of Microbiology, University of Maiduguri, Borno State, Nigeria. ✉ uthmaniyyer@gmail.com. Phone Number: +234 813 470 2846.

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(WHO, 2002). Thus, the suggestion strengthens the already compelling argument for the health advantages of eating fruits and vegetables, and it opens the door to practical measures promoting increased intake of these foods. Vegetables and fruits have been proven to act as carriers for disease-causing agents in humans, notwithstanding the health benefits (FAO, 2008). Any unhygienic practices during the cultivation, processing, transportation, and marketing of plant products could lead to their contamination with STHs, which, on consumption, may cause human infection (Oranusi *et al.*, 2013). There is an increasing number of cases of food-borne illness mainly linked to eating fresh vegetables (Alhabbal, 2015). Nigeria accounts for the highest population infected with STHs in sub-Saharan Africa (WHO, 2014). Considering the important roles of fruits and vegetables in human nutrition, there is a need for routine and periodic investigation on the presence of STHs in edible raw fruits and vegetables sold to the populace. Vegetables and Fruits may be polluted along the routes they take to reach their final consumers, and any unclean methods used in their preparation may increase the likelihood that consumers would become unwell or infected due to consuming contaminated produce. Protozoa cysts, helminthes eggs, and larvae can be transmitted through fresh fruits and vegetables (Erdogrul *et al.*, 2005; Daryani *et al.* 2008; Coelho *et al.* 2001). From the time of planting until consumption, vegetables may get contaminated with parasitic pathogens. The usage of untreated wastewater, animal manure, and water supplies tainted with sewage as organic or agricultural fertilizer and irrigation, respectively, along with unhygienic harvest practices by farmers, post-harvest handling by poverty, vendors, and hygienic conditions of preparation in food service or home settings, can all contribute to contamination to varying degrees (Amoah *et al.*, 2007; Obgolu *et al.*, 2009).

Four species are frequently linked to human helminthiasis: *Ascaris lumbricoides* (roundworm), *Trichuris trichura* (whipworm), *Necator americanus,* and *Ancylostoma duodenale* (hookworms) (WHO 2002). When this parasite is transmitted to fruits and vegetables, contamination results, which, when consumed by individuals, may result in sickness. With the priorities of isolating and identifying the geohelminth parasites that contaminate some selected fruits and vegetables as well as figuring out the prevalence of geohelminth parasites in some selected fruits and vegetables sold in some selected markets in Maiduguri metropolis, this study was designed to assess the prevalence of geohelminths contamination of selected fruits and vegetables in selected markets in Maiduguri metropolis, Borno state.

METHODOLOGY

Method of Data Collection

Data for this study were gathered using two different ways. First, a questionnaire interview with farmers, sellers, and buyers of fruits and vegetables is conducted to identify any potential origins or causes of contamination among these individuals (Oranusi *et al.,* 2013). A total of 128 participants, including 41 cultivators, vendors, and consumers of the chosen fruits and vegetables, were questioned. The second technique involves gathering samples of fruits and vegetables for laboratory analysis.

Sample Size and Vegetable Sampling

Between the hours of 9 and 10 a.m., eight samples of fruits and vegetables, including garden eggs (*Solanum melongena*), tomatoes *(Solanum lycoperscum*), cucumbers (*Cucumis sativus*), and vegetables including carrots (*Daucus carota*), cabbage (*Brassca oleraca*), onions (*Allium cepa*), spinach (*Amaranthus speces*), and lettuce, (*Euruca sativa*) were randomly taken from three markets in Maiduguri. Each of the chosen fruits and vegetables was subjected to parasitological research. To account for various batches/stocks of products in the markets, the samples were collected throughout two weeks. Each type of fruit and vegetable received four (4) samples per location, for a total of 128 samples. The samples were sent to the Microbiology Research Laboratory at the University of Maiduguri for pristine, labeled plastic envelopes analysis.

Sample Analysis

To remove the parasite life stages of ova, larvae, and cysts, 100 grams of each vegetable were weighed and washed separately with 100 ml of ordinary saline in a plastic bowl (Oranisu *et al.*, 2013). The mixture was strained to remove extraneous material and given two hours for appropriate sedimentation. The wash water was allowed to sediment for many hours, and then the sediments were strained into a centrifuge tube and spun for five minutes at 3000 rpm to concentrate the parasite stages (Idahosa, 2011). After carefully and silently decanting the supernatant, the sediment was gently stirred to redistribute the sediments (Wilson *et al.,* 2009). The sediments were prepared as wet mounts, and 10x and 40x objectives were used to look for parasite ova, cysts, and larvae.

Iodine Smear

The presence of parasite eggs, cysts, and larva was determined by mixing a drop of the sediment with a drop of Lugol's iodine solution and analyzing the resulting mixture as a direct smear. Several STH eggs and larvae were identified by comparing their morphological characteristics with those in the vivid Atlas of Parasitology as adapted by (Ikpeze and Mesfin 2017).

RESULTS AND DISCUSSION

By comparing their morphology to those in the colorful atlas of parasitology, parasites were isolated using the

sedimentation technique. *Ascaris lumbricoides* eggs, the whipworm *Trichuris trichura*, the hookworm eggs/lava, and *Strongyloides stercoralis* were isolated intestinal parasites. There were also isolated *Enterobius vermicularis* eggs (Table 1).

Table 2 lists the farming practices that might cause produce to be contaminated. 22 farmers (53.66%) use untreated organic manure, while 3 (7.32%) use runoff wastewater for irrigation. About 17 farmers (41.46%) had no formal education. One (2.44%) utilizes water from a pound for irrigation, whereas seventeen (41.46%) use untreated water from rivers or streams. To get their produce to the place of sale, all (100%) of the farmers employ non-dedicated modes of transportation.

Table 3 reveals that 25 vendors (60.98%) do not wash produce before sales, 24 (58.54%) buy their items from intermediaries (Middle men) , and 19 (46.34%) of the vendors have no formal education. In the market, over 24 (58.53%) vendors sell their items by setting out produce on the ground by the roadside, while only 3 (7.32%) advertise their wares from a wheelbarrow. None of the vendors kept leftover produce in the refrigerator to sell it the following day; all (100%) of the vendors use non-dedicated means of transportation to deliver goods to the market for sale.

Only 3 (7.32%) of customers had no formal education, 26 (63.41%) regularly washed fruits and vegetables before eating them, and 1 (2.44%) and 19 (46.34%) chose vegetables that were undercooked or moderately cooked, respectively, according to Table 4. If not processed or cooked the same day, 15 (36.58%) store produce in the refrigerator.

The contamination levels of the fruits and vegetables are depicted in Figures 1 and 2. The highest helminth contamination rates, at 70% and 26% respectively, were found in tomatoes and lettuce. With 54.5% and 59.7% contamination rates on fruits and vegetables, respectively, Figures 3 and 4 illustrate that A. lumbricoides is the most common geohelminth. The produce from the Custom Gamboru market showed the greatest amounts of geohelminth contamination in both fruits and vegetables, as illustrated in Figures 5 and 6.

One cannot overstate how essential fruits and vegetables are to humankind, particularly regarding nutrition, curative medicine, and economic relevance. As a result of this study's findings, it is clear that raw fruits and vegetables play a significant role in the spreading of parasites transmitted through the soil to new hosts. As a result, many locations where these vegetables are grown need to improve their hygienic conditions. *Ascaris lumbricoides, Trichuris trichiura, Strongyloides stercoralis*, and hookworms are among the intestinal parasites that have been isolated. According to isolation data, the most frequent parasitic helminth that contaminates fruits and vegetables is the roundworm *Ascaris lumbricoides*. In Maiduguri Metropolis, other typical parasitic helminths that produce varied degrees of parasite contamination of fruits and vegetables include hookworm, *Strongyloides stercoralis*, and *Trichuris trichiura*. This is consistent with findings by (Oranusi and Etinosa-Okankan, 2013), who observed a significant level of parasite contamination of fruits and vegetables in Owerri, Imo state, Nigeria. According to the research's conclusions, cucumbers are parasite-free. This is also consistent with Agbalaka's findings, which stated that there was no parasite contamination of cucumbers in Jos, Nigeria (Agbalaka, 2019).

Table 1. The total number of parasites isolated from the samples obtained in different markets.

Samples	**The total number of parasites isolated**				
	A. lumbricoides	*T. trichura*	*E. vermicularis*	*S. stacoralis*	Hookworms
Garden egg (*Solanum melongena*)	3	1	0	0	0
Tomatoes (*Solanum lycoperscum*)	3	2	0	1	0
Cucumber (*Cucums satvus*)	0	0	0	0	0
Carrot (*Daucus carota*)	7	2	2	1	0
Cabbage (*Brassca oleraca*)	7	6	0	0	1
Onions (*Allium cepa*)	6	0	3	0	4
Spinach (*Amaranthus species*)	16	2	6	2	1
Lettuce (*Euruca sativa*)	9	3	4	1	3
Total Number of Parasites	51	16	15	5	9

Table 2: Characteristics that lead to Contamination of Farm Produce by Farmers in Percentage (%)

Highest level of education	No education	Primary	Secondary	Diploma	B.Sc./B.A	M.sc/Ph.D.
	17(41.46%)	**10(24.39%)**	**9(21.95%)**	**1(2.44%)**	**3(7.32%)**	**1(2.44%)**
Type of fertilizer used	Inorganic		Treated organic		Untreated organic	
	19(46.34%)		___		**22(53.66%)**	
Reason for choice of fertilizer	Cost	Availability	Safety/sanitary conditions		Better crop yield	
	5(12.19%)	**19(46.34%)**	**3(7.32%)**		**14(34.15%)**	
Source of water for irrigation	Stream/rivers	Pond	Wells	Boreholes	Runoff waste	
	17(41.46%)	**1(2.44%)**	___	**20(48.78%)**	**3(7.32%)**	
Means of transporting produce to the market	Motor vehicles		Tricycles/bicycles		Wheelbarrow	Basket/head
	9(21.95%)		**14(34.15%)**		**13(31.71%)**	**5(12.19%)**

Farmers (**n=41**) relationship with produce.

Table 3: Characteristics of vendors that could lead to contamination of produce (%)

Highest Level of Education	No education	Primary	Secondary	Diploma	B.Sc./B. A	M.Sc./Ph.D.
	19(46.34%)	**5(12.19%)**	**12(29.28%)**	**5(12.19%)**	___	___
Source of Fruits And Vegetables For Vending	From Famer		From Middle Men		From Private Garden	
	13(31.71%)		**24(58.54%)**		**4(9.75%)**	
Produce Washed Before Display For Sale	Yes			No		
	16(39.02%)			**25(60.98%)**		
Means of Display For Sales	In Wheel Barrow	On The Floor By The Road Side		On Shelves In Shops	On Table By Road Side	
	3(7.32%)	**24(58.53%)**		___	**14(34.15%)**	
Means of Transporting Produce to The Market	Motor Vehicles	Tricycle/Bicycle		Wheel Barrow	Basket/Head	
	11(26.83%)	**18(43.90%)**		**9(21.91%)**	**3(7.32%)**	
Means of Preserving Left-Over	Fridge	In Sacks/Leaves		Left In Evening /Night Dew	Other Means	
	___	**20(48.78%)**		**16(39.02%)**	**5(12.19%)**	

Vendors (n=41) relationship with produce

Table 4: Characteristics of consumers that could lead to contamination of produce (%)

Highest level of education	No education	Primary	Secondary	Diploma	B.Sc./B. A	M.Sc./Ph.D.
	3(7.32%)	**2(4.88%)**	**9(21.95%)**	**9(21.95%)**	**11(26.83%)**	**7(17.07%)**
Produce washed before consumption?	Yes always		Yes sometimes		No	
	26(63.41%)		**12(29.27%)**		**3(7.32%)**	
Preferred treatment/processing before consumption	Fully cooked	Moderately cooked		Undercooked		Raw f can be eaten raw
	8(19.51%)	**19(46.34%)**		**1(2.44%)**		**13(31.71%)**
How often are fruits and vegetables consumed as part of a meal?	Regularly (at least 2-3 times a week)		Not regularly (at least 1-2 times in a month)		Once in a while	
	17(44.46%)		**22(53.66%)**		**2(4.88%)**	
Reasons for eating fruits/vegetables	Nutritional needs		Medicinal		Luxury	
	24(58.54%)		**9(21.95%)**		**8(19.51%)**	
Means of preservation if not cooed/processed the same day	Fridge	Wrapped In sacs/leaves		Left in evening/night dew		Other means
	15(36.58%)	**13(31.71%)**		**13(31.71%)**		___

Consumers (**n=41**) relationship with produce

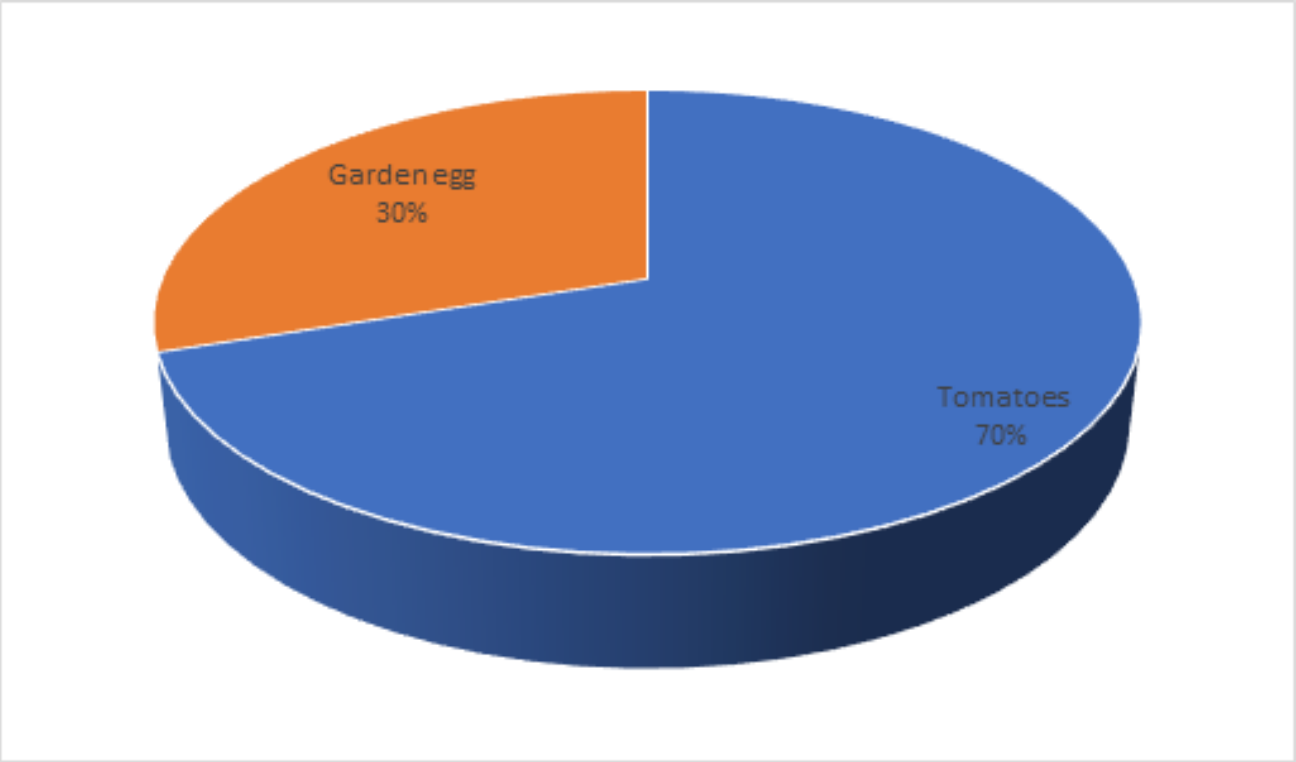

Figure 1 displays the percentage of fruits that are geohelminth-contaminated. One of the fruits looked into, cucumber, has zero percent contamination.

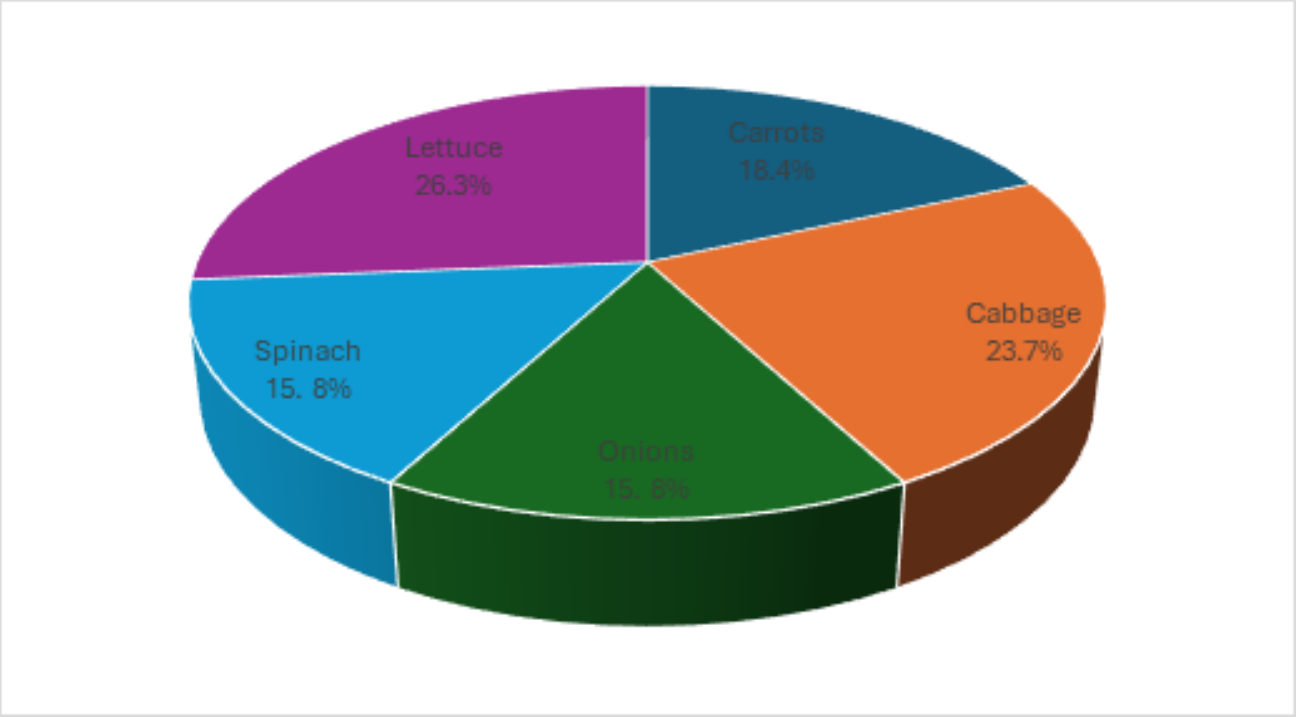

Figure 2 shows the percentage level of contamination of vegetables with geohelminths.

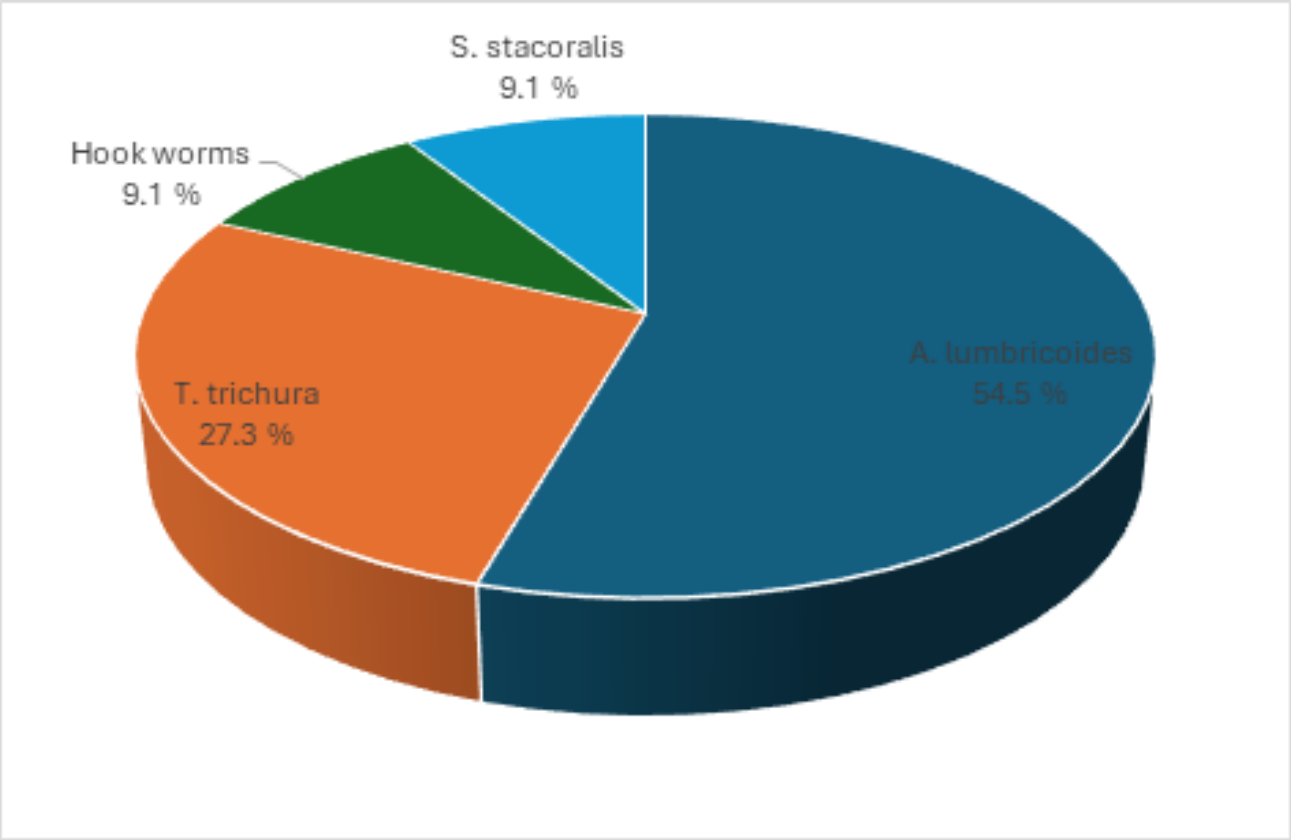

Figure 3 shows the prevalence of geohelminths on fruits in the markets investigated.

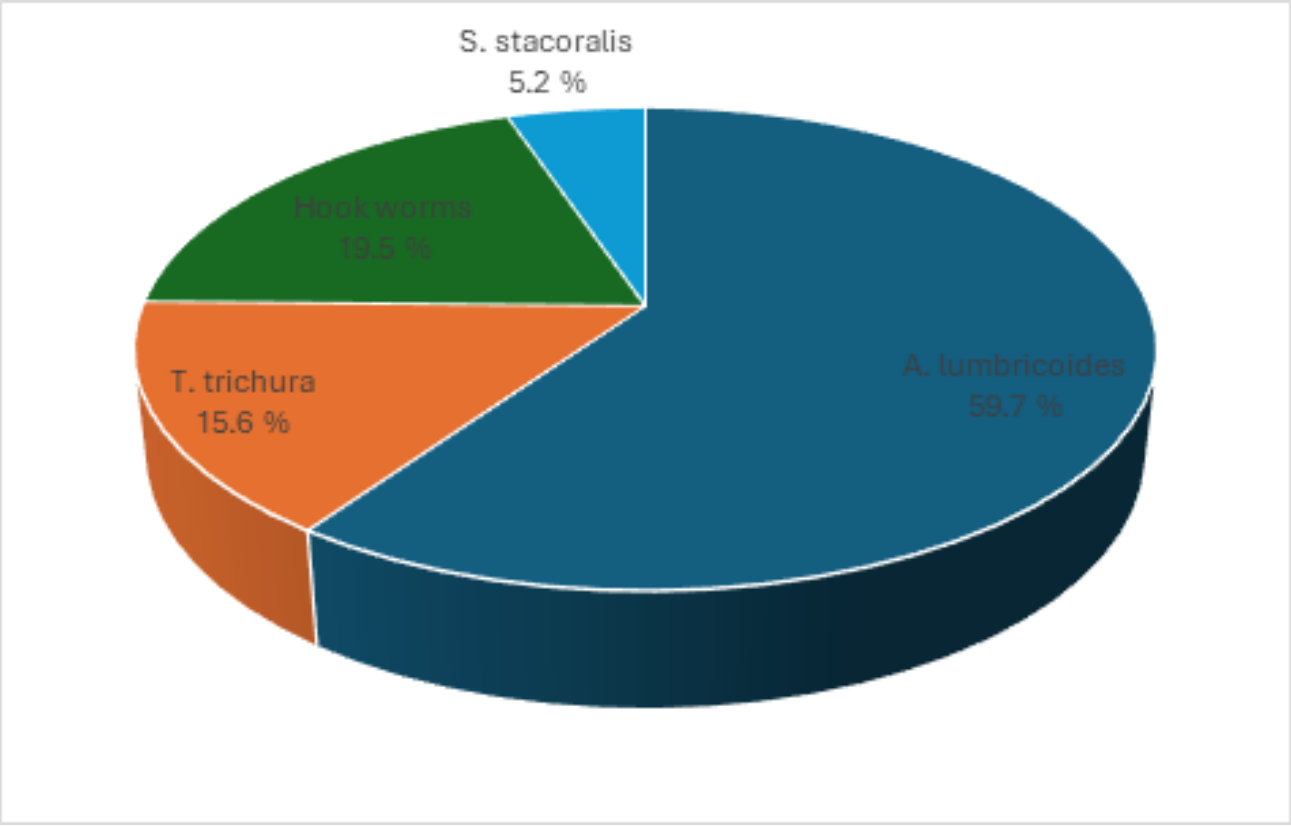

Figure 4 shows the prevalence of geohelminths on vegetables in the markets investigated.

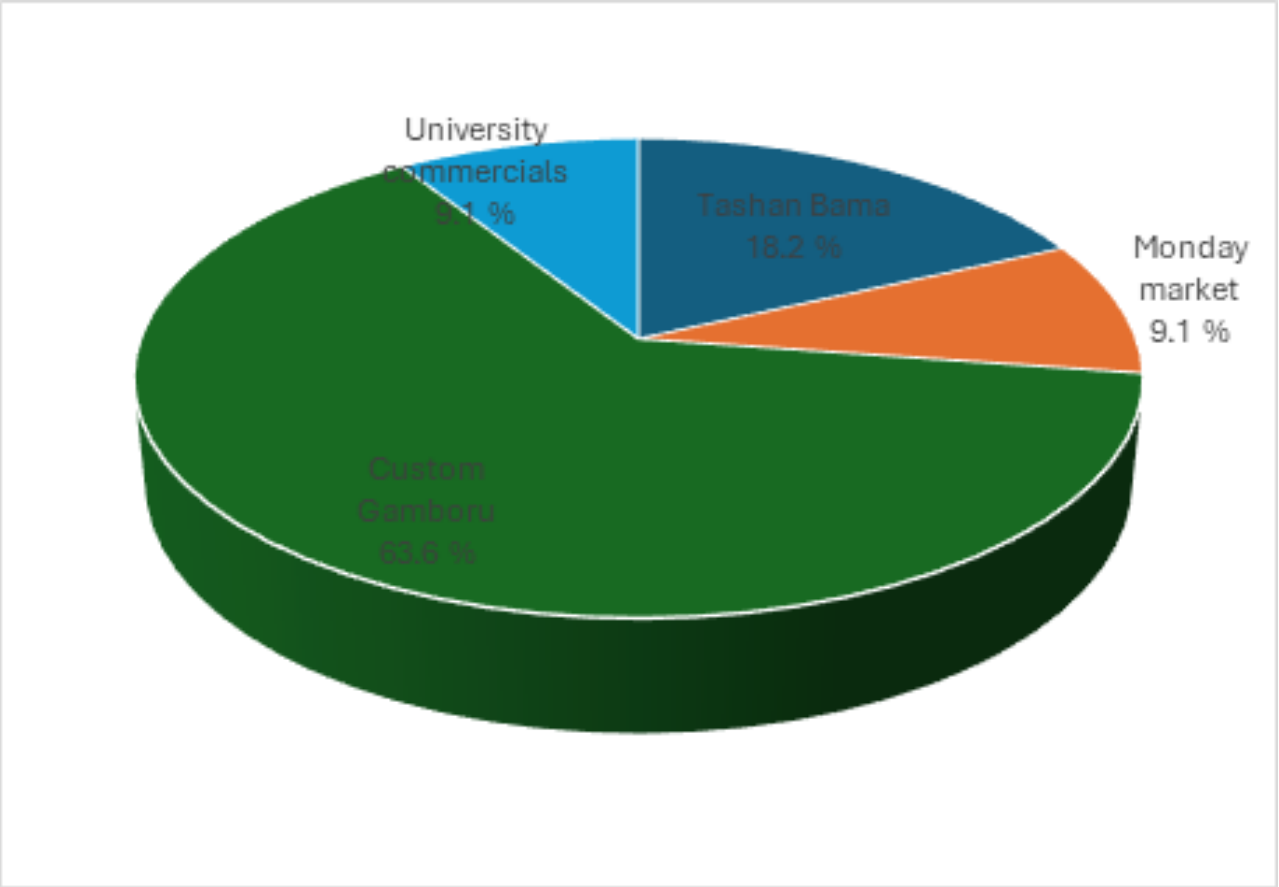

Figure 5 shows the geohelminths contamination level of fruits from different markets.

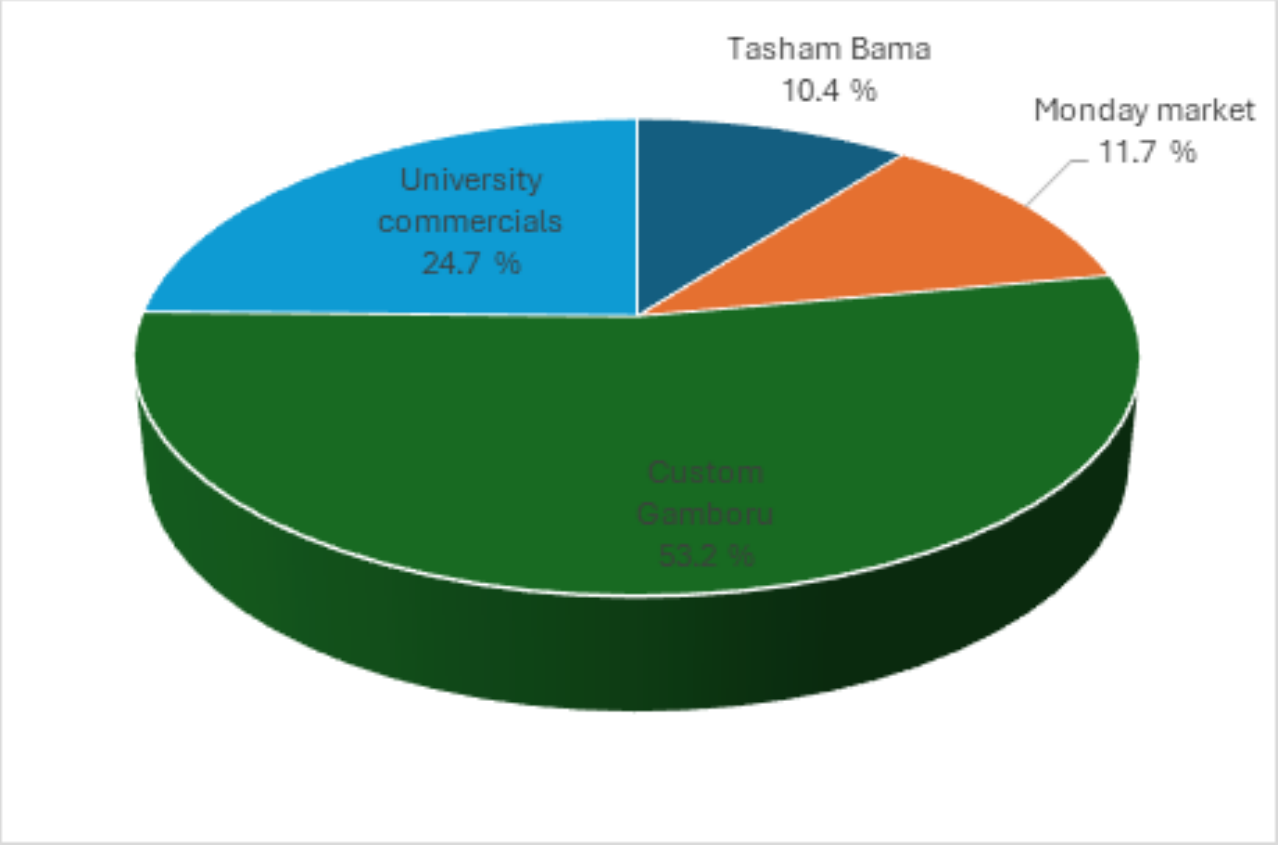

Figure 6 shows the geohelminths contamination level of vegetables from different markets.

This study also shows that some Maiduguri locations have higher intestinal parasite contamination levels in fruits and vegetables than others. This may be explained by the concentration of uneducated or poorly educated vendors in one area, leading to inadequate or nonexistent hygienic practices in maintaining productivity and preventing illness. Table 2 outlines the possible ways that produce from farmers may be polluted. Utilizing a questionnaire to conduct an interview provided information on some fundamental ways farmers, vendors, and consumers can contaminate fruits and vegetables. Approximately 53.66% of farmers under investigation use untreated organic manure as fertilizer, while 46.34% use inorganic fertilizer to grow fruits and vegetables. The decision to use one fertilizer over another was primarily influenced by cost, availability, and crop yield. Farmers use untreated organic fertilizers because of the exorbitant price and limited availability of inorganic fertilizers. The intrinsic usage of untreated organic manure has the drawback of a significant risk of fecal helminth eggs or larvae contaminating fruits and vegetables (Beuchat, 2002; Erdogrul and Sener, 2005; Daryani *et al.*, 2008). Another risk factor for fruit and vegetable contamination is transporting products to the market. All farmers employ vehicles that are not specifically intended to transport farm products, which could result in cross-contamination from other uses for which these vehicles have been used.

The findings show that, on average, 58.54% of sellers purchase their produce from intermediaries, while just 31.71% do so directly from farmers. Because intermediaries's main goal is profit maximization, they frequently use the cheapest methods of produce transportation, employ shady business strategies, and completely disregard the sanitary quality of their products, which is a primary cause of food contamination. According to this study, 60.98% of vendors don't wash their produce before putting it out for sale. This is because washing produce that won't be sold that day could cause it to spoil. 58.53% of vendors exposed their wares to sand on the side of the road. 34.15% of people display different veggies (including leafy fruits and root vegetables) bought from different sellers on the same table by the road, which can also lead to cross-contamination of the produce. The vendors' chosen preservation techniques might be a factor in the contamination or spread of pollutants in the fruits and vegetables. About 31.71% keep their leftovers in a moist environment, and another 31.71% wrap them in leaves and stems to keep them fresh. Using fresh leaves with unknown hygienic conditions and a humid environment may stimulate the preservation and development of geohelminths and raise the parasite burden of the product (Beuchat, 2002).

Given that 46.34 percent of the vendors lacked a formal education, it is likely that most of them are unaware of the standards for food safety (Oranusi *et al.*, 2013). Therefore, eating raw or undercooked vegetables promotes the spread of parasites and may be a primary factor in human parasitic illness. Because of this, the recovery of parasites from fruits and vegetables also reveals the prevalence of intestinal parasites in a region. Risk factors such as low socioeconomic position, inadequate sanitation, unhygienic behaviors, open defecation, and eating improperly washed fruits and vegetables are significant routes by which geohelminths parasite infestation of fruits and vegetables can be transferred.

CONCLUSION

This study revealed the fruits and vegetables contamination of geohelminth parasites in Maiduguri, which was linked to poor sanitary or hygienic practices by farmers and vendors of fruits and vegetables. *Ascaris lumbricoides, Trichuris trichiura, Strongyloides stercoralis,* and hookworms are among the intestinal parasites isolated from the contaminated fruits and vegetables.

RECOMMENDATIONS

It is recommended that:

1. The consumption of unwashed fresh fruits and vegetables and using untreated human and animal waste as manure should be firmly discouraged.
2. Regardless of the source, the consumer should always follow basic food safety precautions such as washing their hands before handling raw produce, practicing basic personal hygiene, soaking their vegetables for 10 minutes in vinegar or a salt solution, and properly cooking them before eating them.
3. In addition to following rigorous personal hygiene guidelines and safely disposing of manure, sanitation should be practiced to prevent the transmission of intestinal parasites, which is important for the epidemiology and management of soil-transmitted helminthiasis.
4. To ensure a good sanitary system in different markets, it is also advised that open-air markets be furnished with contemporary conveniences like toilets, running taps, and good drainage. This is because contamination prevention continues to be the most efficient method of lowering food-borne parasitic infections.

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