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Parasitic Contamination of Commonly Consumed Fruits and Vegetables Sold in Tomato and Modern Markets within Lafia Local Government Area of Nasarawa State, Nigeria

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1. Abstract

Fruits and vegetables are essential for a healthy diet, but they can also serve as vehicles for parasitic transmission. This study was carried out todetermine the parasitic contamination of commonly consumed fruits and vegetables sold in markets in Lafia, Nasarawa State, Nigeria. One hundred and sixty fruits and vegetables (40 fruits and 120 vegetables) comprising of orange (*Citrulluslanatus*), Garden egg (*Solanum melongena*), Carrot (*Daucuscarota*), Orange (*Citrus sinesis*), tomatoes (*Lycoperisiconesculentum)*, Water leaf (*Talinumfruticosum*), Fluted pumpkin leaf (*Telifairiaoccidentalis*), Spinach (*Spinacia oleracea*), jute leaf (*Talinumfruticosum*) were purchased in the selected markets. The samples were transportedeach in separate polyethene bag to parasitological Laboratory of the National Veterinary Research Institute (NVRI), Vom, and processed using standard parasitological techniques. Of the 160 samples collected, 55 were infected giving a prevalence of 34.38% with Hookworm *spp* (7.50%) and *Entamoebahistolytica* (6.88%) being the most commonly detected parasites followed by *Strongyloides spp* (6.25%). Co-infections were observed in 14 cases (8.75%), with Hookworm *spp* + *Strongyloides spp* being the most common co-infection. There was a significant statistical difference (χ^2 = 26.273, df = 9, p-value = 0.002) among the single and co-infections of the parasites obtained in the study. The tomato market had the highest infection rate (33%) compared to the modern market (28%). The highest contaminated fruits were tomato (45%) followed by garden egg (20%) and orange (20%), while the highest contaminated vegetables were water leaf (50%) followed by spinach (35%), Fluted pumpkin (35%) and Jute leaf (35%) respectively. This study reveals a significant burden of parasitic contamination among fruits and vegetables sold in Lafia markets, highlighting the need for improved hygiene practices and regular monitoring of markets to ensure the safety and quality of produce. Factors such as display location, source of produce, and vendor education level were associated with parasitic contamination. Public awareness campaigns and education programs targeting vendors and consumers are recommended to prevent parasitic transmission through contaminated fruits and Vegetables

2. Keywords
Fruits, Vegetables, Parasitic contamination, Geo-Helminths, Protozoans, Lafia

3. Introduction
Fruits and vegetables are essential to a healthy diet, providing vital nutrients and health benefits [1,2]. The significance of consuming fruits and vegetables daily does not only helps prevent specific nutritional deficiencies but also reduces the risk of cardiovascular diseases and strokes [3]. However, these fruits and vegetables, can act as significant sources of infection to various parasitic infections especially when consumed raw [4]. Parasitic contamination of vegetables can occur at various stages, from pre-harvest to post-harvest and during storage. In many developing countries, the use of untreated fecal matter, known as nightsoil, in farming practices increases the vulnerability of vegetables to contamination [5]. Additionally, vegetables may come into contact with infectious parasite stages when irrigation water or water used for preservation contains contaminants. The practice of consuming raw or lightly cooked vegetables further heightens the risk of hand-to-mouth transmission of these parasites [5]. It's worth noting that fruits and vegetables have the potential to act as carriers for the transmission of protozoan cysts, oocytes of organisms such as *Giardia lamblia*, *Entamoeba histolytica*, *Toxoplasma gondii*, *Cryptosporidium species, Cyclosporacayetanensis*, and *Isospora* species. Additionally, they can harbor eggs and larvae of various helminths, including *Hymenolepis nana*, *Taenia spp., Fasciola spp., Toxocara spp., Trichostrongylus spp., Ascarislumbricoides, Trichuristrichiura, Strongyloidesstercoralis*, and various species of hookworms [6]. The extent of contamination and the types of parasitic organisms involved can vary significantly from one region to another due to variations in environmental conditions and human behaviors. poor personal hygiene and inadequate healthcare systems in many developing nations, including Nigeria, contribute to the high prevalence of intestinal parasitic infections. These factors create an environment conducive to the spread of infections, burdening the healthcare system and impacting the overall well-being of the community [6,7].

The impact of intestinal parasite infections on morbidity varies depending on factors such as the type, quantity, and intensity of the parasites, along with host-related factors. Specific populations, such as preschool- and school-aged children and women of reproductive age, are particularly vulnerable to these infections [8]. However, Information on the level of contamination by parasites on vegetable and fruits from farms are lacking, especially in developing countries including Nigeria where parasitic diseases are endemic in the population. The consumption of parasite-contaminated fruits and vegetables can lead to gastrointestinal infections, nutrient deficiencies, and other health problems [9].

Despite the significance of this public health concern, there is a lack of comprehensive studies on the prevalence and diversity of parasites in fruits and vegetables in Lafia Markets. This study aims to investigate the presence and distribution of parasites in commonly consumed fruits and vegetables in Lafia Local Government Area of Nasarawa state, providing valuable insights into the potential health risks associated with their consumption.

Therefore, it is crucial to assess local contamination prevalence and contributing factors to effectively address infections transmitted through the consumption of these food items [4].

4. Materials and Methods
4.1. Study area
This study was carried out in Lafia Local Government Area of Nasarawa State. Nasarawa state is located in the middle belt region of Nigeria. It lies between Latitude 80 34 13, 8544 N and Longitude 80 18 31, 8388 E the state shares boundary with Benue state and Kogi state at the South. It shares the North boundary with Kaduna state. The West boundary it shares with the Federal Capital Territory Abuja and the East boundary it shares with Taraba state and Plateau state. The major occupation of the people in this area is farming.

4.2. Questionnaire administration
Structured questionnaire was used to collect information from both the fruit and the vegetables market sellers and consumers such as student, workers, farm, and artisans. The Structured questionnaire was used to obtained biodata of respondents and also get information about their knowledge on parasites contamination of fruits and vegetables, the associated risk factor of consuming raw fruits and vegetables.

4.3. Sample collection
One hundred and sixty (160) different types of fruits and vegetables were randomly purchase at the Tomato and Modern markets of Lafia, Nasarawa state from September to October 2023. Each of the samples collected were put in plastic bags, properly labeled, and transported to parasitological section of the National Veterinary Institute (NVRI), Vom for analysis.

The fruits are namely, (*Citrulluslanatus*), Garden egg (*Solanummelongena*), Carrot (*Daucuscarota*), Orange (*Citrussinesis*) and tomatoes (*Lycoperisiconesculentum*). The vegetables are namely, Water leaf (*Talinumfruticosum*), Fluted pumpkin leaf (*Telifairiaoccidentalis*), Spinach (*Spinacia oleracea*), jute leaf (*Talinumfruticosum*).

4.4. Sample processing and parasitological analysis
Sedimentation method according to Okunlola [6,10] was employed in the study. Two hundred grams (200 g) of each fruit and vegetable were washed separately in 500 mL of normal saline to detach the parasitic stages (ova, larvae, cysts, and oocysts) of helminths and protozoans. The washing solution was allowed to sediment overnight. Following sedimentation, 15 mL of the sediment was sieved to remove undesirable matter and transferred in a centrifuge tube. The tube was centrifuged at 3,000 rpm for 5 minutes to concentrate the parasitic stages [11]. After centrifugation, the supernatant was decanted carefully without shaking and the sediment was examined under a light microscope using x10 and x40 objectives (Figure 1).

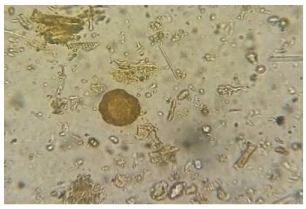
4.5. Data analysis
Data was analyzed using Minitab Statistical Software version 21.2. The descriptive analysis of the data was done using frequencies and percentages. Chi-square was used to determine the level of significance of contamination of fruits and vegetables at different markets. Statistical significance was set at $p < 0.05$.

Figure 1: Images of the parasites recovered from fruits and vegetables in tomato and modern markets of Lafia, Nasarawa state.

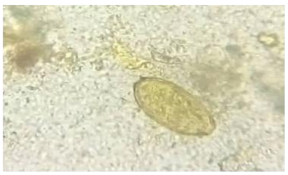

Egg o Cyst *Entamoeba histolytica*


Cyst of *Giardia lamblia*


Larva


Egg o Ova of *Ascaris lumbricoides*


Egg o Ova of Hookworm


Egg of *Trichuris trichuria*


Hookworm larva

5. Results

The study examined the frequency of parasitic contaminations among fruits and vegetables sold in markets in Lafia. A total of 160 samples were examined, comprising 40 fruits and 120 vegetables. The results of this study reveal a significant burden of parasitic contamination among the sampled fruits and vegetables, with an overall positivity rate of 34.38% (Table 1). The most commonly detected parasites were Hookworm *spp*. (7.50%) and *E. histolytica* (6.88%), followed by *Strongyloides spp* (6.25%) and *Giardia lamblia* (1.88%). *Ascarislumbricoides* and *Trichuristrichiura* were less prevalent, with rates of 1.88% and 1.25%, respectively. Co-infections were observed, with 14 cases (8.75%) showing concurrent infections with two or more parasites. The most common co-infection was Hookworm *spp* + *Strongyloide spp*, observed in 6 cases (3.75%).

Table 1: Parasites species abundance on fruits and vegetables sold in tomato and modern markets of Lafia LGA Nasarawa state.

Parasite types	Parasites species (160)	No. Positive	% Positive
Protozoans	*E. histolytica*	11	6.88%
	G. lamblia	3	1.88%
Nematodes	*Ascaris lumbricoides*	3	1.88%
	Hookworm spp	12	7.50%
	T. trichiura	2	1.25%
	Strongyloides spp	10	6.25%
Co-infection	*E. histolytica + G. lamblia*	2	1.25%
	E. histolytica + Strongyloides spp	2	1.25%
	G. lamblia + Strongyloides spp	4	2.50%
	Hookworm spp + Strongyloides spp	6	3.75%
	Total (%)	**55**	**34.38%**

(χ^2 = 26.273, df = 9, p-value = 0.002).

The study also observed co-infection from four parasites namely *E. histolytica* + *G. lamblia*, *E. histolytica* + *Strongyloides spp*, *G. lamblia* + *Strongyloides spp*, and *Hookworm spp* + *Strongyloides spp* which had the prevalence percentage of 1.25%, 1.25%, 2.50% and 3.75% respectively. However, there was a significant statistical difference (χ^2 = 26.273, df = 9, p-value = 0.002) among the single and co-infection of the parasites obtained in the study.

The prevalence of parasitic contamination of fruits and vegetables sampled in Tomato and Modern markets in Lafia was the same (P > 0.05). However, the tomato market had the highest infection rate of 33% out of the 80 fruits and vegetables sampled than the modern market (28%) out of the 80 fruits and vegetables sampled (Table 2).

Table 3 shows the frequency of distribution of parasitic contaminations among fruits and vegetables sold in markets in Lafia. There was no significant difference (χ^2 = 2.941, df = 2, p-value = 0.230) between fruits items, despite having tomato (45%) as the most frequently contaminated item followed by garden egg (20%) and orange (20%) respectively. Also, there was no difference (χ^2 = 0.947, df = 4, p-value = 0.918) between vegetables in which water leaf (50%) was the most frequently contaminated item followed by spinach (35%). Fluted pumpkin (35%), jute leaf (35%), and carrot (35%) had similar rates of contamination. However, there was no significance difference (χ^2 = 4.491, df = 7, p-value = 0.722) in the overall prevalence of parasitic contaminations among fruits and vegetables sold in markets in Lafia.

Table 2: Prevalence of parasitic contamination of fruits and vegetables sampled in tomato and modern markets in Lafia.

Kind of produce	Items	Tomato market		Modern market	
		Number examined	% positive	Number examined	% positive
Fruits	Tomato	10	4 (40)	10	4 (40
	Garden egg	10	3 (30)	10	1 (10)
	Orange	10	3 (30)	10	1 (10)
Vegetables	Spinach	10	2 (20)	10	4 (40)
	Fluted pumpkin	10	3 (30)	10	3 (30)
	Jute leaf	10	3 (30)	10	2 (20)
	Carrot	10	4 (40)	10	3 (30)
	Water leaf	10	4 (40)	10	4 (40)
	Total	**80**	**26 (33)**	**80**	**22(28)**

(χ^2 = 0.410, df = 1, p-value = 0.522).

Table 3: Frequency of distribution of parasitic contaminations among fruits and vegetables sold in markets in Lafia.

Kind of produce	Items	Number examined	% positive
Fruits	Tomato	20	9 (45)
	Garden egg	20	4 (20)
	Orange	20	4 (20)
Vegetables	Spinach	20	7 (35)
	Fluted pumpkin	20	7 (35)
	Jute leaf	20	7 (35)
	Carrot	20	7 (35)
	Water leaf	20	10 (50)
	Total	**160**	**55 (34.4)**

Between fruits (χ^2 = 2.941, df = 2, p-value = 0.230).
Between Vegetables (χ^2 = 0.947, df = 4, p-value = 0.918).
Overall (χ^2 = 4.491, df = 7, p-value = 0.722).

Factors Associated with Parasitic Contamination of Fruits and Vegetables in Table 4 revealed that there was no significant difference (P = 0.225) in the infestation levels of fruits and vegetables collected between male and female vendors despite recording higher infestation on fruits and vegetable collected from females (40.30%) vendors than their male counterpart (30.11%).

Also, those who attainedsecondary education had the highest infestation of their fruits and vegetables (40.00%) than those who attained primary education (34.78%) and those with no formal education (31.82%). However, there was no difference observed in the contamination level of the fruits and vegetable in respect the level of education of the vendors (P > 0.05). Vendors who displayed produce on the floor had a higher infestation rate (41.18%) compared to those who displayed on the table (50%) or in buckets (21.05%) (p-value = 0.003). Similarly, Vendors who sourced produce from farms had a higher infestation rate (38.33%) compared to those who sourced from local scale vendors (22.50%) (p-value = 0.042).

Associated factors such as marital status, frequent sanitation of the market, washing before display, means of transportation, and awareness of transmission through the fecal-oral route had no significant difference (P > 0.05) with less parasitic contamination. There is no significant difference in knowledge and attitudes between single and married individuals (p-value = 0.232).

Table 4: Knowledge, attitudes and practice of people on the infestation of fruits and vegetables in the study.

Variable	Categories	Number Examined	Number of Fruits and Vegetables Infected (%)	χ^2	df	p-value
Sex	Male	93	28 (30.11)	1.475	1	0.225
	Female	67	27 (40.30)			
Educational Status	None	66	21 (31.82)	0.966	2	0.617
	Primary	69	24 (34.78)			
	SSCE	25	10 (40.00)			
Marital Status	Single	30	8 (26.67)	1.431	1	0.232
	Married	130	47 (36.15)			
Frequent Sanitation of the Market	Daily	101	33 (32.67)	1.322	2	0.516
	Rarely	19	8 (42.11)			
	Weekly	40	14 (35.00)			
Means of Display	Bucket	19	4 (21.05)	14.18	3	0.003
	Floor	10	5 (50.00)			
	Table	68	28 (41.18)			
	Wheelbarrow	63	18 (28.57)			
Washed before Display	Yes	59	20 (33.90)	0.008	1	0.928
	No	101	35 (34.65)			
Source of Vegetables/Fruits	Farm	120	46 (38.33)	4.119	1	0.042

	Local scale vendors	40	9 (22.50)			
Means of transportation	By humans	74	27 (36.49)	3.221	2	0.200
	By cart	29	7 (24.14)			
	By car	57	21 (36.84)			
Awareness of Transmission through Fecal Oral Route	Yes	67	30 (44.78)	0.679	1	0.410
	No	67	25 (37.31)			

6. Discussion

The present study investigated the parasitic contamination status and contributing factors of fruits and vegetables at tomato and modern markets in Lafia metropolis. Our findings revealed a high prevalence of parasitic infestation (34.38%) among the sampled fruits and vegetables, which is consistent with recent studies.

Similar studies have reported comparable contamination rates: 39.1% in Ethiopia [4], 32.1% in Brazil [12], 39% in Egypt [13]. Additionally, studies in Southern Thailand and Barkir City, Northwest Ethiopia, reported prevalence rates of 35.1% and 39.1%, respectively [4,7]. Recent research emphasizes the importance of proper handling and storage practices to reduce parasitic contamination. For instance, Alemu, et al. [4] found that improper handling and storage practices were associated with high contamination levels among fruits and vegetables in Ethiopia. Similarly, Khillare, et al. [14] reported that proper washing and storage practices reduced parasitic contamination among vegetables in India.

The high contamination rate among water leaf (50%) and spinach (35%) in this study is also consistent with recent findings. A study in Tanzania found a high contamination rate among leafy vegetables, including spinach and water leaf [15].

However, the present finding of 34.38%prevalence islower than what was reported in Brazil (50.9%) and Yemen (100%) as reported by Alemu, et al. [4]. The difference could be attributed to variations in sample types, collected, processing and laboratory methods, and inadequate washing practice. Other contributing factors may include the time of sample collection, geographical distribution of parasites, and the sanitary and socioeconomic status of the community [4].

The present study found hookworms species to be the most frequently encountered parasitesand accounting for 32.3% prevalence. This finding is similar to previous research in Oyo State, Nigeria, where hookworms were also the predominant parasite [16]. Poor sanitary practices, such as indiscriminate defecation and using human and animal feces as fertilizer, may contribute to this high prevalence [4]. In contrast, *A. lumbricoides and T. trichiura* were among the least detected parasites in this study, contradicting finding from Nigeria (56.31%) and Egypt (20.3%,) [4]. The discrepancy may be due to improvements in water, sanitation, and hygiene (WASH) programs and health education initiatives that have led to a reduction in open defecation and improved sanitation practices in the study area [7,17].

Larva of *Strongyloides spp* (6.25%) and cysts of *E. histolytica* (6.88%) were also detected. The prevalence of *E. histolytica* cysts was lower than reports from Sudan (42.9%) and Dessie (24%), town but higher than results from Arba Minch (8.4%) [4]. Geographical distribution differences and long survival periods of cysts under cool and moist conditions may explain these variations [18]. Cysts of *G. lamblia* (1.88%) was also detected, with a lower prevalence than previous studies in Asmara state of Eretria (36.4%), Khartoum state of Sudan (22.9%), and higher than the results of Dessie town (1.33%) [19]. The variation in prevalence may be due to the long survival periods of cysts under cool and moist conditions and geographical distribution differences [18].

The prevalence of parasitic contamination in fruits and vegetables sampled in markets in Lafia did not differ statistically ($P > 0.05$), although the tomato market had a higher infection rate (33%) than the modern market (28%). This may be due to variation handling practicesuch washing, displaying them on tables or buckets, and frequent sanitation of the market [4].

Contamination of vegetables and fruits can occur during harvesting, post-harvest treatment, storage, and transportation, due to the absence of clean facilities, dirty storage areas, and contact with contaminated soil or irrigation water [20]. In this study, water leaf was the most frequently contaminated item (50%), while garden egg (20%) and orange (20%) were the least contaminated. Vegetables are more prone to contamination than fruits due to their uneven surfaces, which enable parasites to attach more easily and resist washing [21]. Vendors often do not thoroughly wash vegetables before display, and the edible parts of vegetables grow closer to the soil, making them more susceptible to contamination [4]. Factors associated with parasitic contamination of fruits and vegetables revealed that unwashed fruits and vegetables had a higher prevalence of contamination compared to those washed before display. This finding is consistent with a study conducted in Dire Dawa [22], which suggests that washing before display can remove parasites. However, this finding contradicts previous reports by Aziz, et al. [23], who noted that the cleanliness of the water used for washing and the washing process itself may lead to discrepancies. Moreover, fruits and vegetables displayed on the floor were more likely to be contaminated than those displayed on tables and buckets, likely due to contact with soil [4]. Additionally, fruits and vegetables supplied directly by farmers to vendors were more contaminated with parasites compared to those supplied by local scale vendors. This may be because local scale vendors receive fruits and vegetables on the farmland, pack and transport them to the market using their vehicles, and store them properly, whereas small-scale vendors who receive vegetables directly from farmers transport them either on animal backs or via human labor, leaving them exposed to contamination [24]. Recent, studies have highlighted the importance of knowledge, attitudes, and practices in preventing parasitic contamination of fruits and vegetables. For instance, a study in Nigeria found that vendors who had knowledge of parasitic contamination were more likely to practice proper handling and storage [25]. Another study in Port Harcourt found that attitudes towards hygiene practices were associated with reduced parasitic contamination among vendors [26].

The significant difference in practices among vendors who displayed produce on tables compared to other display methods is consistent with recent findings. A study in Ethiopia found that improper display practices were associated with high levels of parasitic contamination [27].

The significant difference in practices among vendors who sourced produce from farms compared to local scale vendors is also consistent with recent findings. A study also found that produce sourced from farms was more likely to be contaminated with parasites compared to produce sourced from local markets [2].

7. Conclusion

In conclusion, this study revealed a high prevalence of parasitic contamination in commonly consumed fruits and vegetables sold in two selected markets within Lafia Local Government Area of Nasarawa State. The contamination rates observed in this study pose a significant public health risk to consumers, particularly in the absence of proper washing and handling practices. The findings of this study highlight the need for improved hygiene practices among fruit and vegetable vendors, as well as increased awareness and education among consumers about the importance of proper fruit and vegetable handling and washing. Additionally, regular monitoring and regulation of markets by relevant authorities are crucial in preventing the sale of contaminated fruits and vegetables. Overall, this study emphasizes the importance of ensuring the safety and quality of fruits and vegetables in order to protect public health.

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