



Gastrointestinal Parasite Contamination of Ready-to-Eat Vegetables Sold in Selected Markets in Ashanti Region, Ghana

Bright Darko Amoah ^{a*}, Emmanuel Effah-Yeboah ^b,
Christopher Mfum Owusu-Asenso ^a, Evans Aduhene ^a,
Albert Mensah ^c, Gabriel Bright Dzotefe ^{d,e},
Bright Churchill Obeng ^a, Christopher Yaw Dumev ^a,
Grace Danquah Arhin ^a, Clement Asante ^a and Lydia Darko ^f

^a Department of Medical Microbiology, University of Ghana Medical School, Accra, Ghana.

^b Department of Integrated Sciences, Akenten Appiah Menka university, Ghana.

^c Holy Child Catholic Hospital, Takoradi, Ghana.

^d Department of Medical Laboratory Technology, Accra Technical University, Ghana.

^e Department of Medical Laboratory Science, University for Development Studies, Ghana.

^f Department of Public Health, Akenten Appiah Menka University, Ghana.

Authors' contributions

This work was carried out in collaboration among all authors. Authors BDA, EE-Y and CMO-A did the designed the study. Authors BDA, AM, GBD, BCD, CYD, EA-H did the participated in data collection, laboratory and statistical analyses of the data. Authors BDA, CYD, GDA and LD did the drafted the manuscript. All authors read and approved the final manuscript.

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*Corresponding author: E-mail: amoahbright309@gmail.com;

ABSTRACT

Introduction: Intestinal parasite infections pose a significant public health concern in many developing countries, including Ghana. Inadequate sanitation and poor hygiene practices contribute to the transmission of these parasites, with contaminated food being a common route of infection. This research article investigates the prevalence of gastrointestinal parasite infections in ready-to-eat vegetables sold in selected markets in Ashanti region, Ghana.

Methods: A cross-sectional study was conducted, and vegetable samples were collected from various vendors in the markets. The samples were examined for the presence of intestinal parasites using standard laboratory techniques. The findings of this study shed light on the potential risks associated with consuming contaminated vegetables and highlight the importance of food safety measures in reducing the burden of intestinal parasite infections in the region.

Results: 22.7% (68/300) of the sampled vegetables were contaminated with intestinal parasites. The common intestinal parasites were *Entamoeba histolytica* (9.7%, 29/300), followed by both *Ascaris lumbricoides* and *Giardia lamblia* at 4.3% (13/300) and *Ancylostoma duodenale* at 3.0% (9/300). The prevalence of *Enterobium vermicularis* infections was 1.7% (5/300). However, *Trichuris trichiura* and *Strongyloides stercoralis* infections was 0.7% (2/300). The least common intestinal parasites were *Isospora belli* and *Taenia sp.* (0.3%, 1/300). *Entamoeba histolytica* was the only parasite detected in all vegetable type while *Ascaris lumbricoides* was detected in all vegetable types except cucumber.

Conclusion: our study highlights the need for heightened awareness, improved food safety practices, and tailored interventions to address the risks associated with the consumption of fresh vegetables.

Keywords: Gastrointestinal parasite; vegetables; consumption; contamination.

1. INTRODUCTION

Intestinal parasitic infections represent a significant global health problem, particularly in low and middle-income countries [1]. These infections are often associated with poor sanitation, limited access to clean water, and inadequate hygiene practices [2]. Ghana, like many other countries in sub-Saharan Africa, faces challenges in controlling and preventing intestinal parasite infections due to various socio-economic factors [3].

Ready-to-eat vegetables play a crucial role in the diet of many Ghanaians as they are rich in essential nutrients [4]. However, their consumption may also pose health risks, especially when contaminated with intestinal parasites [2,5]. Vegetables can serve as a source of intestinal parasite infection when contaminated with parasite eggs, cysts, or larvae [6]. The contamination can occur at various stages of the vegetable production and supply chain, making it crucial to implement proper food safety measures to minimize the risk of infection [7]. The use of contaminated water for irrigation or the application of untreated sewage or animal manure as fertilizer can introduce parasite eggs or cysts into the soil, where they can contaminate the growing vegetables [8,9]. Improper hygiene

practices among agricultural workers during harvesting can transfer parasites from their hands to the vegetables [10]. Additionally, contaminated equipment or surfaces can contribute to cross-contamination [4,11]. If vegetables are not thoroughly washed before consumption, parasite eggs or cysts may remain on the surface and can be ingested, leading to infection [12].

Several types of parasites can contaminate vegetables and potentially cause intestinal infections [13]. Parasites such as *Giardia lamblia* and *Entamoeba histolytica* are examples of protozoa that can contaminate vegetables [14]. Ingesting the cysts of these parasites can lead to gastrointestinal infections. Parasitic worms like *Ascaris lumbricoides* (roundworm), hookworms, and *Trichuris trichiura* (whipworm) are examples of helminths that can contaminate vegetables [15]. Ingesting the eggs of these worms can lead to parasitic infections [16]. Depending on the parasite species and the amount ingested, individuals may experience a range of symptoms, from mild gastrointestinal discomfort to severe diseases [17]. Children, the elderly, pregnant women, and immunocompromised individuals are particularly vulnerable to the adverse effects of these infections [18]. In addition to gastrointestinal symptoms, intestinal

parasite infections can cause nutritional deficiencies, leading to malnutrition and its associated health consequences [15,19]. Chronic infections can lead to anaemia and impair growth and cognitive development in children, affecting their overall well-being and future potential [20]. This study aims to assess the prevalence of intestinal parasite contamination of ready-to-eat vegetables sold in selected markets in the Ashanti region, Ghana. By understanding the extent of contamination, appropriate public health interventions can be developed to mitigate the risks associated with consuming contaminated vegetables

2. MATERIALS AND METHODS

2.1 Study Area

This study was a cross-sectional study carried out in the Ashanti region of Ghana from December 2022 to March 2023. Structured questionnaires were administered to vendors and consumers to obtain demographic information and gather data on food handling practices and hygiene behaviours. The study was conducted at three markets: Kejetia Market, Ejura Market and Ejusu Market. Kejetia market (6.6666° N,

1.6163° W) is one of the largest and busiest markets in Ghana, located in Kumasi, the capital city of the Ashanti Region of Ghana. The market serves as a significant trading hub, attracting traders from various regions and neighboring countries. Kejetia Market offers a wide range of goods, including fresh produce, clothing, textiles, crafts and household items. Kejetia Market plays a crucial role in the local economy and cultural life of Kumasi [21]. Ejura Market (7.3856° N 1.3562° W) is a bustling trading center located in the town of Ejura, which is also situated in the Ashanti Region of Ghana. This market serves as a vital commercial hub for the local community and surrounding areas. Ejura Market is well-known for its agricultural produce, including fresh fruits, vegetables, grains, and livestock, making it an essential economic and social center in the town of Ejura [22]. Ejusu Market (6.5388° N, 0.2601° W) is another significant trading center in the Ashanti Region, located in the town of Ejusu. Although smaller in size compared to Kejetia Market, it plays a crucial role in meeting the daily needs of the local community. Ejusu Market predominantly offers fresh produce, including fruits, vegetables, and grains, sourced from local farmers [23].



Fig. 1. Map of the study area [47]

2.2 Sample Collection

For this study, a total of 300 vegetables were collected including green pepper (*Capsicum* sp.), cucumber (*Cucumis sativus*), lettuce (*Lactuca sativa*), carrot (*Daucus carota*), green onions (*Allium* sp.), tomatoes (*Lycopersicon esculentum*), and cabbage (*Brassica oleracea*). The selection of these vegetables was based on their availability and the common methods of consumption, either raw or lightly cooked. Each week, 18 to 19 of these fresh vegetables and fruits were purchased in the smallest retail numbers, from various retail vendors operating in the three different markets.

During the purchase, verbal interviews were conducted with the vendors to gather information about the sources of these vegetables and the type of water used for their cleaning. However, it's important to note that the vendors couldn't provide specific details regarding the sources or types of water used for irrigating the fields where these vegetables were grown. Some of the leafy vegetables originated from nearby hinterlands and villages, while others were sourced from different towns within the region. All the vegetables were prewash before being put up for sale. The vegetables were collected separately in sterile polythene bags in which they were transported to the laboratory at the department of medical microbiology, university of Ghana medical school.

2.3 Sample Processing and Parasitological Examination

Each vegetable sample was cut into pieces, ensuring that each sample weighed 200 grams [24]. These chopped samples were then individually washed in separate beakers containing 1 liter of physiological saline solution (0.9% NaCl). This washing process was carried out to detach any parasitic stages that might be present on the vegetables. After washing, the vegetable samples were removed from the saline solution. The remaining washing solution was allowed to settle for a duration of 8 hours to facilitate sedimentation. Subsequently, 15 milliliters of the sediment from each beaker were carefully collected and dispensed into a centrifuge tube. These tubes were then subjected to centrifugation at a speed of 3000 rotations per minute for a duration of five minutes, as described by Tefera and colleagues [24].

To further analyze the samples and detect any parasitic stages, the supernatant (the liquid

above the sediment) was carefully poured off. The sediment that remained in the tube was then gently agitated, placed onto a clean slide, and examined under a microscope, using both the 10x and 40x objective lenses. This examination was carried out following the principles outlined by the World Health Organization (WHO) in 1991 and 1994 [25,26].

2.4 Data Analysis

Descriptive statistics (frequencies and percentages) were used to determine the prevalence of parasitic contamination. Association between parasitic contamination and vegetables type was determined using chi square test and univariate logistic regression analysis. Statistical significance threshold was set at $p \leq 0.05$.

3. RESULTS

3.1 Socio-Demographic Characteristics of Participants and Vegetable Sampling

In the study, about 300 vegetable vendors and consumers were recruited as participants. Almost equal numbers were recruited from the Ejisu market (n=101), Kejetia (n=100), and Ejura markets (n=99) in Ghana's Ashanti Region. The majority of the participants were females (62.0%, n=186/300) ($\chi^2 = 17.280$, $df = 1$, $p < 0.001$). It was observed that most of the participant were those aged between ages 28 to 34 years (43.0%, n=129) ($\chi^2 = 58.987$, $df = 3$, $p < 0.001$) and the majority of participants had a formal education (69.3%, n=208) ($\chi^2 = 44.853$, $df = 1$, $p < 0.001$). Tomato (n= 58) and carrot (n= 50) were the most common vegetables in this study (Table 1).

3.2 Knowledge, Safety and Hygienic Practices among Participant sat Study Sites

Generally, most participants indicated they adequately washed their vegetables (83.3%, n=250) ($\chi^2 = 133.333$, $df = 1$, $p < 0.001$). However, a significant high proportion of these participants were from the Kejetia market (95.0%, 95/100) ($p < 0.001$) (Table 2). The commonest substances for washing vegetables were water with vinegar or salt (67.0%, n=201) ($\chi^2 = 168.140$, $df = 2$, $p < 0.001$). Most of these participants were from the Ejisu market (80.2%, 81/101) (Table 2). At home, most participants stored vegetables in a refrigerator (79.3%, n=238) ($\chi^2 = 103.253$, $df = 1$, $p < 0.001$). All participants from the Kejetia market commonly

refrigerated their vegetables at home (Table 2). Also, the majority of participants mentioned they were aware of IPI in vegetables (93.3%, n=280) ($\chi^2 = 225.333$, $df = 1$, $p < 0.001$), and most of these participants were from the Kejetia and Ejisu markets (Table 2).

3.3 Prevalence of Intestinal Parasite in Vegetables

Overall, 2.7% (68/300) of the sampled vegetables were contaminated with intestinal

parasites. Specifically, the most common IP was *Entamoeba histolytica* (9.7%, 29/300), followed by both *Ascaris lumbricoides* and *Giardia lamblia* 4.3% (13/300) and Hookworm 3.0% (9/300). The prevalence of *Enterobius vermicularis* infections was 1.7% (5/300). However, *Trichuris trichiura* and *Strongyloides stercoralis* infections was 0.7% (2/300). The least common IP were *Isospora belli* and *Taenia* sp. infections (0.3%, 1/300).

Table 1. Socio-demographic characteristics of participants and vegetable sampling

Total number of participants = 300			
Characteristics		Frequency (n)	Percent (%)
Sex			
	Male	114	38.0
	Female	186	62.0
	Total	300	100.0
Age Group			
	14-20	39	13.0
	21-27	71	23.7
	28-34	129	43.0
	>35	61	20.3
	Total	300	100.0
Level of education			
	Formal	208	69.3
	Informal	92	30.7
	Total	300	100.0
Study sites (market)			
	Ejura	99	33.0
	Kejetia	100	33.3
	Ejisu	101	33.7
	Total	300	100.0
Vegetable samples			
	Green pepper	37	12.3
	Cabbage	40	13.5
	Cucumber	43	14.3
	Spring onion	46	15.2
	Carrot	50	16.6
	Tomato	58	19.4
	Lettuce	26	8.6
	Total	300	100.0

n = frequency, % = percentage

Table 2. Knowledge, safety and hygienic practices among participants at study sites

Characteristic	Participants at study sites [markets] n (%)			
	Ejura	Kejetia	Ejisu	p-value
Adequate washing of vegetables				
Yes	62 (62.6)	95 (95.0)	93 (92.1)	< 0.001*
No	37 (37.4)	5 (5.0)	8 (7.9)	
Substance used to wash vegetables				
Running water	31 (31.3%)	38 (38.0)	8 (7.9)	< 0.001*
Water with vinegar or salt	68 (68.7)	52 (52.0)	81 (80.2)	

Characteristic	Participants at study sites [markets] n (%)			
	Ejura	Kejetia	Ejisu	p-value
Vegetable wash solutions	0 (0.0)	10 (10.0)	12 (11.9)	
Methods of storing vegetables at home				< 0.001*
Room temperature	24 (24.2)	0 (0.0)	38 (37.6)	
Refrigerator	75 (75.8)	100 (100.0)	63 (62.4)	
Awareness of IPI in vegetables				< 0.0001*
Yes	82 (82.8)	99 (99.0)	99 (98.0)	
No	17 (17.2)	1 (1.0)	2 (2.0)	

n = frequency, % = percentage, * = statistically significant at 0.05 with Chi-square test

Table 3. Specific intestinal parasitic infections as stratified by study sites

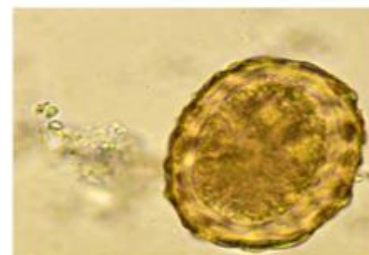
IP	Prevalence in Study sites [markets], n (%)		
	Ejura	Kejetia	Ejisu
<i>Entamoeba histolytica</i>	12 (41.4)	10 (34.5)	7 (24.1)
<i>Isospora belli</i>	0 (0.0)	1 (100.0)	0 (0.0)
<i>Giardia lamblia</i>	6 (46.2)	1 (7.7)	6 (46.2)
<i>Ascaris lumbricoides</i>	3 (23.1)	4 (30.8)	6 (46.2)
Hookworm	5 (55.6)	2 (22.2)	2 (22.2)
<i>Trichuris trichiura</i>	1 (50.0)	1 (50.0)	0 (0.0)
<i>Taenia</i> sp.	0 (0.0)	1 (100.0)	0 (0.0)
<i>Strongyloides stercoralis</i>	1 (50.0)	0 (0.0)	1 (50.0)
<i>Enterobius vermicularis</i>	2 (40.0)	2 (40.0)	1 (20.0)

n = frequency, % = percentage, IPI = intestinal parasitic infections, § = positive proportions within specific parasitic infection shown

3.4 Common Intestinal Parasite Identified



Entamoeba histolytica



Ascaris lumbricoides



Giardia lamblia



Hookworm

Plate 1. Common intestinal parasite identified [48]

3.5 Intestinal Parasite Infections Stratified by Study Sites

Generally, it was observed that IPI most commonly occurred in the Ejura market (36.8%, 25/68) and occurred the least at the Kejetia market (30.9%, 21/68). Specifically, *Entamoeba histolytica* infections occurred most at the Ejura market (41.4%, 12/29). *Isoospora belli* and *Taenia* sp. infections occurred only at the Kejetia market (n=1). *Giardia lamblia* infections occurred the most at both Ejura and Ejisu markets (46.2%, 6/13). While Ejisu market recorded the highest proportion of *Ascaris lumbricoides* infections (46.25, 6/13), the Ejura market recorded the highest proportion of hookworm infections in the sampled vegetables (55.6%, 5/9). *Trichuris trichiura* infections occurred only once at both the Ejura and Kejetia markets (n=1) with no occurrence at the Ejisu market [Table 3].

On another hand, *Strongyloides stercoralis* infections occurred once at both the Ejura and Ejisu markets (n=1) with no occurrence at the

Kejetia market. Finally, both Ejura and Kejetia markets had the highest proportions of *Enterobius vermicularis* infections (40.0%, 2/5) [Table 3].

3.6 Distribution of IPIS by Vegetable Type

It was observed that parasitic infections occurred in all vegetable types. Specifically, *Entamoeba histolytica* was the only parasite detected in most of vegetable type (Fig. 2); while *Ascaris lumbricoides* was detected in all vegetable types except cucumber (Fig. 2), hookworm was detected in all except spring onion (Fig. 2). Similarly, to *Giardia lamblia* (Fig. 2), *Enterobius vermicularis* was not detected in green pepper and carrot, however, it was also not detected in cabbage (Fig. 2). On the other hand, *Trichuris trichiura* was rather detected in carrot and green pepper only (Fig. 2). *Strongyloides stercoralis*, *Isoospora belli*, and *Taenia* sp., were detected in only one vegetable type (spring onion for *S. stercoralis* and tomato for both *I. belli* and *Taenia* sp.) [Fig. 2].

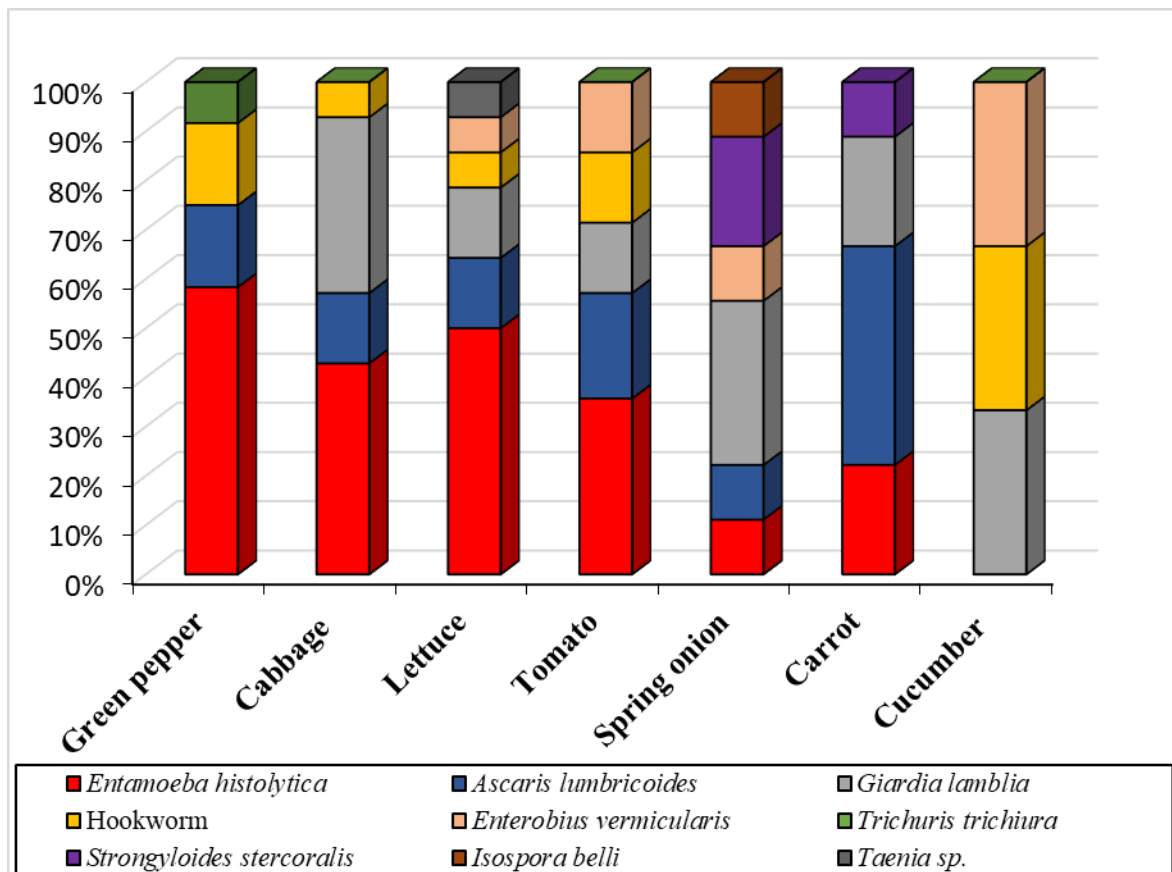


Fig. 2. Distribution of IPIs by vegetable type

4. DISCUSSION

The consumption of fresh vegetables is a vital component of a balanced diet, but growing concerns surround the potential transmission of parasites through contaminated produce [27]. In our research, we analyzed 300 vegetables and found that 22.7% of them were contaminated with intestinal parasites. To provide context, this percentage stands in contrast to a 31.7% contamination rate reported in a study conducted in Alexandria, Egypt [28]. Similarly, our findings deviate from higher prevalence rates reported in a study in Ghana, which documented an overall parasitic contamination rate of 36% [29], as well as a study in Nigeria, which also reported a 36% contamination rate [30]. This deviation could be attributed to geographical differences [30]. Nevertheless, our study aligns with the 29% prevalence reported in Ardabil city, Iran [31]. This is an encouraging finding, as proper vegetable washing is a fundamental step in reducing the risk of foodborne illnesses associated with contaminated produce [32].

The observed contamination rate carries significant implications for public health, indicating the potential health risks associated with the consumption of such vegetables [33]. The study reveals that the occurrence of IPI varies significantly across different markets. The Ejura market exhibited the highest prevalence of IPI at 36.8%, while the Kejetia market had the lowest prevalence at 30.9%. This variation suggests that environmental and local factors such as proper sanitation and personal hygiene may contribute to differences in contamination rates [34].

An alarming discovery from our research is the presence of *Entamoeba histolytica* infections in approximately 9.7% of the sampled vegetables. This parasite was found across all types of vegetables, indicating widespread contamination. *Entamoeba histolytica* is a protozoan parasite known to cause amoebiasis, a gastrointestinal disease associated with a range of symptoms, including diarrhea, stomach pain, and fever [35]. The nearly 10% contamination rate suggests a relatively high prevalence of this parasite in the food supply, posing a considerable public health concern. Contaminated vegetables can be a source of amoebiasis, a severe illness. Identifying the source of infection is crucial in preventing transmission [36].

In our study, *Ascaris lumbricoides* and *Giardia lamblia* infections were found in approximately

4.3% of the sampled vegetables, further raising concerns. It is noteworthy that *Ascaris lumbricoides* was not detected in cucumber, suggesting a potentially lower risk of contamination for this vegetable. Similarly, *Giardia lamblia* was absent from spring onions, green peppers, and carrots. These parasitic infections carry substantial public health risks, as their ingestion through contaminated food, including the sampled vegetables, can lead to various health issues [6,37]. The presence of *Ascaris lumbricoides* in contaminated vegetables implies fecal contamination, likely during cultivation and handling [14, 38]. Once ingested, these worms can cause intestinal obstruction, a serious condition with severe symptoms. The presence of *Giardia* in vegetables suggests that water used in irrigation or washing may be contaminated [39]. Consumption of *Giardia*-contaminated vegetables can lead to giardiasis, characterized by gastrointestinal symptoms, particularly diarrhea. This discovery highlights the potential for cross-contamination during food processing or handling [40].

The presence of Hookworm infections in 3.0% of the sampled vegetables is another disconcerting finding in our research. Except for spring onions, hookworm was found in all types of vegetables, showing a widespread contamination risk. The presence of hookworm in multiple types of vegetables amplifies the potential health hazards for consumers. While susceptibility to contamination may vary among different vegetables, the presence of hookworm in any produce raises concerns due to the associated health risks [41].

In the study, *Enterobius vermicularis* was detected in 1.7% of the vegetables, indicating a moderate prevalence. This parasite was notably absent in green peppers and carrots, as well as cabbage. This absence suggests that the distribution of parasites in vegetables is not uniform, possibly owing to differences in surface texture and other factors. *Trichuris trichiura* and *Strongyloides stercoralis* were less common, each accounting for 0.7% of the contamination. *Trichuris trichiura* was confined to carrots and green peppers, while *Strongyloides stercoralis* was found in spring onions, indicating more limited distribution. Finally, *Isospora belli* and *Taenia sp.* infections were the least common IPI, each detected in only 0.3% of the sampled vegetables. These parasites were identified in only one specific type of vegetable (tomato), suggesting a localized risk associated with them [42].

The data shows that the types of parasites varied among the markets. For instance, the Ejura market had the highest proportion of hookworm infections, while the Ejisu market recorded the highest proportion of *Ascaris lumbricoides* infections. This variability suggests that specific environmental and agricultural practices in each region may influence the types of parasites present in vegetables [43]. A substantial majority of the participants (83.3%) reported that they adequately washed their vegetables before consumption. It's notable that a significantly higher proportion of participants from the Kejetia market (95.0%) reported adequately washing their vegetables. This is an encouraging finding, as proper vegetable washing is a fundamental step in reducing the risk of foodborne illnesses associated with contaminated produce [33, 44]. While a slightly lower percentage of participants (77.3%) mentioned they adequately washed their hands, it is still a considerable majority. Hand hygiene is essential in preventing the transfer of pathogens from hands to food, and the reported rates are generally positive [45]. Participants from the Ejisu market (86.1%) had the highest proportion of individuals who reported proper handwashing practices. The variation across different market areas may be attributed to differences in public health initiatives or local education programs. The majority of participants (79.3%) reported storing vegetables in a refrigerator. Proper storage is crucial for maintaining the freshness and safety of vegetables, reducing the risk of contamination or spoilage [46]. A significant proportion of participants (93.3%) indicated awareness of intestinal parasites in vegetables. This awareness is crucial in promoting informed consumer choices and practices.

5. CONCLUSION

In conclusion, our study highlights the need for heightened awareness, improved food safety practices, and tailored interventions to address the risks associated with the consumption of fresh vegetables contaminated with intestinal parasites. Public health initiatives and education programs should continue to emphasize the importance of safe food handling and proper hygiene to reduce the risk of foodborne illnesses and safeguard public health.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was approved by Ethical and Protocol Review Committee (EPRC) of the

College of Health Sciences, University of Ghana (protocol identification number CHS-Et/M.8-PS.3/2021-2022). The study objectives were carefully explained in English and the local language to the participants before they were recruited into the study.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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