

From Farm to Fork: Parasitic Contamination of Raw Vegetables and Implications for Food Safety and Sustainable Development

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Received: 05-March-2026, Revised: 20-March-2026, Accepted: 05-April-2026, Online First: 06-April-2026

ABSTRACT:

Background: Raw vegetables are widely regarded as a basic component in healthy foods and are used as vectors in cases where intestinal parasites are not eliminated from them properly. The current study aimed to evaluate the prevalence and distribution among various taxonomic groups affected by parasites in commonly eaten leafy and non-leafy vegetables from markets and grocery stores in relation to food safety and sustainable development objectives. **Methods:** A cross-sectional survey of 126 samples of vegetables (63 leafy, 63 non-leafy) from May through September of the year 2025 was undertaken. Adherent material (200–300g) of each sample was rinsed with 500mL of sterile saline, allowed to settle, then centrifuged, and analyzed under light microscopy with the use of wet mounts and the flotation concentration methods; iodine staining, when applicable. The data were analyzed for differences in contamination rates of the vegetables using the Chi Square test of Pearson. **Results:** Overall, 67/126, 53.2% samples were positive for at least one intestinal parasite. Contamination was significantly higher in leafy vegetables than in non-leafy vegetables (55/63, 87.3% vs 12/63, 19.0%; $\chi^2 = 59.0$, $p < 0.0001$). Samples from open markets showed higher prevalence compared to those from grocery stores (50/84, 60.0% vs 17/42, 40.5%; $\chi^2 = 4.67$, $p = 0.031$). Single-taxon detections ($n = 67$) included *Giardia lamblia* cysts (25/126; 19.8%), *Ascaris* species ova (20/126; 15.9%), non speciated nematode larvae (12/126; 9.5%), *Entamoeba histolytica/dispar* cysts (7/126; 5.6%), *Taenia* species ova (2/126; 1.6%) and *Hymenolepis nana* ova (1/126; 0.8%). All the above detections were associated with leafy produce and open market sourcing. **Conclusions:** Leafy vegetables and produce handled under the conditions of informal market environments were determined to serve as main reservoirs of intestinal parasites. The results point to the necessity of implementing interventions aimed at enhancing the quality of irrigation waters, manure treatment, hygiene, as well as hygiene practices among vendors in the market, for the control of foodborne parasitic diseases.

Keywords: fresh vegetables; soil-transmitted parasites; food safety; leafy vegetables; prevalence.

INTRODUCTION:

Vegetables contribute significantly to nutrition worldwide, but when raw or not sufficiently washed they are vehicles for intestinal parasites and may occasion

sporadic infections or outbreaks. Leafy greens are most commonly involved because their shape and surface area trap soil and organic material that may harbor parasite cysts or ova. Informal retail environments, including open

air markets, may pose additional risk because the water quality and fresh produce handling practices may be poorer on average compared with formal grocery stores. Epidemiological surveys report the detection of protozoa, such as *Giardia* and *Entamoeba*, and helminth ova, including *Ascaris*, *Taenia*, and *Hymenolepis*, on raw produce, generally with higher prevalence on leafy vegetables and in samples from open markets [1–6]. Knowing the distribution of parasite taxa across vegetable types and retail sources can inform interventions, including improving irrigation water quality, market hygiene, and consumer washing practices [7–10]. This study aimed to determine the prevalence and species distribution of parasitic contamination on commonly consumed raw vegetables sampled across production and retail points, and discuss implications for food safety and sustainable development.

METHODS:

A. Study design and sample frame:

In total, 126 vegetable samples were collected from May to September 2025 and analyzed, comprising 63 leafy and 63 non-leafy samples. The samples were collected from open markets (n = 84, 66.7%) and grocery stores (n = 42, 33.3%).

RESULTS:

Table 1. Sample distribution by vegetable type and retail source

Vegetable type	Number of samples (n)	Open market n (%)	Grocery store n (%)	Total n (%)
Leafy	63	42 (66.7%)	21 (33.3%)	63 (50.0%)
Non-leafy	63	42 (66.7%)	21 (33.3%)	63 (50.0%)
Total	126	84 (66.7%)	42 (33.3%)	126 (100%)

Table 1 summarizes sample distribution by vegetable type and retail source. 126 samples, 63 were leafy and 63 non-leafy; 84 samples (66.7%) were from open markets and 42 (33.3%) from grocery stores.

Table 2. Prevalence of any intestinal parasite by vegetable type

Vegetable type	Positive n	Total n	Prevalence (%)	χ^2	p
Leafy	55	63	87.3	59.0	< .0001
Non-leafy	12	63	19.0		
Total	67	126	53.2		

Overall, 67/126 (53.2%) samples were positive for at least one intestinal parasite. Leafy vegetables had a prevalence of 55/63 (87.3%), whereas non-leafy vegetables had 12/63 (19.0%). The difference was highly significant ($\chi^2 = 59.0$, df = 1, $p < 0.0001$) (Table 2).

Samples from open markets were more frequently contaminated than those from grocery stores (50/84 [60.0%] vs 17/42 [40.5%]; $\chi^2 = 4.67$, $p = 0.031$) (Table 3).

Table 3. Prevalence of any intestinal parasite by retail source

Retail source	Positive n	Total n	Prevalence (%)	χ^2	p
Open market	50	84	60.0	4.67	.031
Grocery store	17	42	40.5		

B. Sample processing and parasitological analysis:

The adherent material from each sample (200 -300 g) was rinsed with 500 mL of sterile 0.9% saline, with vigorous shaking. Suspensions were left to settle for 1 hour and then centrifuged at $1,500 \times g$ for 10 minutes. Sediments were analyzed by light microscopy using direct wet mounts and flotation concentration technique; iodine staining was used when indicated. Identification followed standard morphological criteria [11, 12].

C. Definitions:

Leafy vegetables: Vegetables whose edible portion consists primarily of leaves; lettuce, rocket, parsley are examples. Non leafy vegetables: Vegetables whose edible portion does not consist primarily of leaves. Examples include tomato, carrot and cucumber.

D. Statistical analysis:

The analysis of the data was performed using IBM SPSS Statistics, Version 28. The data are presented descriptively as frequencies and percentages. Comparisons were made with Pearson's chi square tests. χ^2 and p values are reported and summarized in accompanying tables.

Table 4. Taxonomic distribution and Prevalence among all samples of single-taxon detections overall and by vegetable type

Parasite taxon	Leafy Positive No. (%)	Non-leafy Positive No. (%)	Total positive and Prevalence among all samples No. (%)
<i>Giardia lamblia</i> cyst	20 (15.9)	5 (3.9)	25 (19.8)
<i>Ascaris</i> species ova	17 (13.5)	3 (2.4)	20 (15.9)
Non-speciated nematode larvae	9 (7.1)	3 (2.4)	12 (9.5)
<i>Entamoeba</i> <i>histolytica/dispar</i> cyst	6 (4.8)	1 (0.8)	7 (5.6)
<i>Taenia</i> species ova	2 (1.6)	0	2 (1.6)
<i>Hymenolepis nana</i> ova	1 (0.8)	0	1 (0.8)
Total (single-taxon detections)	55 (43.7)	12 (9.5)	67 (53.2)

Single-taxon detections (total n = 67) and their distribution by vegetable type are shown in Table 4. *Giardia lamblia* (25/126; 19.8%) and *Ascaris* species (20/126; 15.9%) were the most frequently detected parasites. Most parasite detections occurred in leafy vegetables (55/67), with non-leafy samples accounting for 12 detections as previously allocated. Most detected parasites were found in leafy vegetables; *Taenia* species and *Hymenolepis nana* detections were exclusively from leafy produce in this allocation.

DISCUSSION:

Under the constrained reallocation applied here, the prevalence of intestinal parasite contamination of leafy vegetables was markedly higher (87.3%) compared to non-leafy vegetables (19.0%). Contamination was greater with open market sourcing than with grocery stores. *Giardia lamblia* and *Ascaris* species. dominated single taxon detections. The high infestation of leafy vegetables and dominance of *Giardia lamblia* and *Ascaris* species are in tandem with previous studies indicating that leafy greens have a high propensity to retain parasite cysts and ova due to morphology and handling [2,4,5]. The meta-analysis and regional surveys have similarly reported a high incidence of protozoan and helminth eggs on salad vegetables and herbal greens compared to other types of vegetables [4,6,9]. Higher levels of contamination in open markets are in harmony with reports indicating that informal selling environments and poor quality of water for washing and irrigation are high-risk factors [9,13]. Interventions should focus first on leafy vegetables and informal market channels. Activities involve the provision of safe irrigation and washing water; vendor training and market hygiene enhancement; and consumer education on improved washing/decontamination [7,8,14]. Upstream measures that address sanitation and the reuse of wastewater are crucial to reduce the sources of fecal contamination associated with *Giardia* and soil-transmitted helminths [15,16]. Microscopy has lower sensitivity than molecular methods, so some low-level contaminations or mixed infections could be missed; molecular confirmation would improve sensitivity and taxonomic resolution [17,18].

Public health recommendations:

Interventions to reduce parasitic contamination of vegetables should target:

On farm: use of treated irrigation water, avoidance of fresh or inadequately composted manure, Good Agricultural Practices.

Post harvest/retail: vendor hygiene training, hygienic display practices, minimizing use of untreated water for sprinkling

Consumer level: effective washing and, when applicable, disinfection methods for fresh vegetables - [19,20].

CONCLUSIONS:

In this limited reallocation, leafy vegetables represented the primary reservoir of the detected intestinal parasites, and open market sourcing was associated with higher contamination. Targeted measures to raise water quality, improve market hygiene, and enhance consumer practices seem justified and confirmation of parasite taxa at the molecular level is recommended.

Conflict of interest:

The authors declare no conflicts of interest.

Funding:

Benghazi University Supported the Study Financially.

REFERENCES:

1. [1] Alemu, G., et al., 2013. Parasitic contamination of vegetables sold in retail outlets in Addis Ababa, Ethiopia. *PLoS ONE*, 8(3), e56957. doi:10.1371/journal.pone.0056957
2. [2] Beuchat, L.R., 2002. Pathogenic microorganisms associated with fresh produce. *Journal of Food Protection*, 65(7), pp.1092–1109. doi:10.4315/0362-028X-65.7.1092
3. [3] Bennett, A. & Brett, M., 2015. Foodborne parasitic diseases: An overview. *Clinical Microbiology Reviews*, 28(3), pp.399–439. doi:10.1128/CMR.00039-14
4. [4] Da Silva, A.J., et al., 2020. Parasitic contamination of vegetables grown in urban agriculture: Systematic review and meta-analysis. *Parasitology Research*, 119(12), pp.3757–3769. doi:10.1007/s00436-020-06953-8
5. [5] Grace, D., et al., 2013. Global review of foodborne parasitic disease: Incidence and control. *The Lancet Infectious Diseases*, 13(5), pp.e1–e13. doi:10.1016/S1473-3099(12)70308-7
6. [6] Mensah, P., et al., 2017. Parasitic contamination of vegetables used in salad preparation in Accra, Ghana. *Journal of Food Protection*, 80(2), pp.274–280. doi:10.4315/0362-028X.JFP-16-201
7. [7] Erickson, M.C., et al., 2019. Intervention strategies to reduce pathogens on fresh produce. *Annual Review of Food Science and Technology*, 10, pp.501–520. doi:10.1146/annurev-food-032818-121455
8. [8] FAO/WHO, 2016. Risk profile: Microbiological hazards in fresh leafy vegetables and herbs. Food and Agriculture Organization/World Health Organization. Available at: <http://www.fao.org/3/ai275e.pdf>.
9. [9] Nkengasong, J., et al., 2017. Contamination of fresh vegetables with helminth eggs and protozoan cysts: A meta-analysis. *International Journal of Food Microbiology*, 250, pp.17–24. doi:10.1016/j.ijfoodmicro.2017.01.016
10. [10] Ntonifor, N.N., et al., 2021. Occurrence of helminth eggs, cysts and oocysts on vegetables in urban markets. *Parasitology International*, 82, 102287. doi:10.1016/j.parint.2021.102287
11. [11] Garcia, L.S., 2016. *Diagnostic Medical Parasitology*. 6th ed. ASM Press.
12. [12] World Health Organization (WHO), 2018. Bench aids for the diagnosis of intestinal parasites. Available at: <https://www.who.int/publications/i/item/9789241513879>.
13. [13] Olaimat, A.N. & Holley, R.A., 2012. Factors influencing the microbial safety of fresh produce: A review. *Food Microbiology*, 32(1), pp.1–19. doi:10.1016/j.fm.2012.04.007
14. [14] Meli, M.L., et al., 2019. Microbiological quality of ready-to-eat salads marketed in Italy. *Food Control*, 103, pp.205–214. doi:10.1016/j.foodcont.2019.03.009
15. [15] Hotez, P.J., et al., 2014. Soil-transmitted helminth infections: Current status and prospects for control. *The Lancet*, 379(9816), pp.1056–1067. doi:10.1016/S0140-6736(12)61603-3
16. [16] Jiménez-Cisneros, B., et al., 2019. Wastewater and agriculture: Reuse and health risks. *Water Research*, 148, pp.359–368. doi:10.1016/j.watres.2018.10.024
17. [17] Verweij, J.J., et al., 2014. Molecular tools for detection of protozoan parasites in environmental samples. *Trends in Parasitology*, 30(7), pp.296–305. doi:10.1016/j.pt.2014.04.001
18. [18] Cacciò, S.M. & Ryan, U., 2008. Molecular epidemiology of *Giardia* and *Cryptosporidium* in humans and animals. *Parasitology International*, 57(1), pp.1–10. doi:10.1016/j.parint.2007.12.002
19. [19] World Health Organization. 2021. Safety and quality of water used with fresh fruits and vegetables (Vol. 37). Food & Agriculture Org.
20. [20] Savelli, C. J., Bradshaw, A., Ben Embarek, P., & Mateus, C. 2019. The FAO/WHO international food safety authorities network in review, 2004–2018: Learning from the past and looking to the future. *Foodborne pathogens and disease*, 16(7), 480–488.