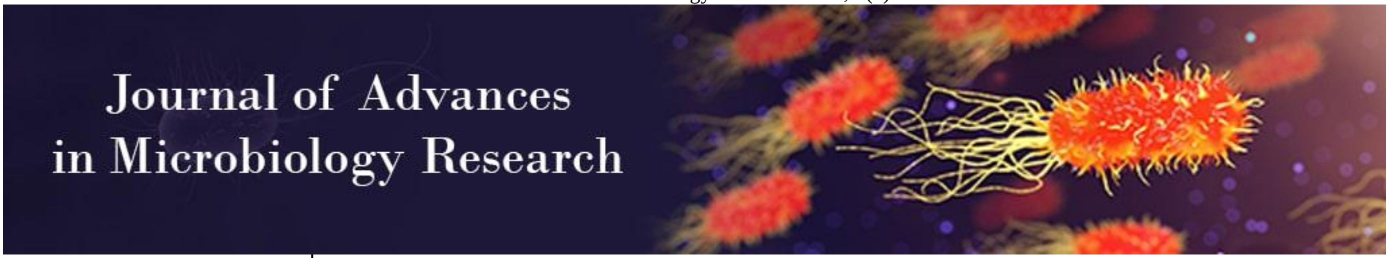


E-ISSN: 2709-944X
P-ISSN: 2709-9431
Impact Factor (RJIF): 6.2
JRM 2025; 6(2): 288-295

www.microbiojournal.com
Received: 02-07-2025
Accepted: 05-08-2025

All the authors details below the references

Correspondence
Edvande Xavier dos Santos Filho
A) Academic Institute of Health and Biological Sciences, State University of Goiás - UEG, Itumbiara, Goiás, Brazil
B) Centro Universitário de Goiatuba - UniCerrado, Goiatuba, Goiás, Brazil

Parasitological analysis of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) samples commercialized in open-air markets in the municipality of Itumbiara, Goiás, Brazil

Gabriela de Oliveira Silva, Júlia Mayumi Pereira Fuzinaga, Vinicius Eduardo Farias Silva, João Álefe Silva da Silva, Dorcas Fernandes dos Anjos Melo, Gustavo Caires Neves Magalhães, Eurípedes Ribeiro Bonifácio Júnior and Edvande Xavier dos Santos Filho

DOI: https://www.doi.org/10.22271/micro.2025.v6.i2d.264

Abstract
Parasitological contamination of vegetables sold in open-air markets poses a significant public health risk, especially in regions with poor sanitary practices. This study aimed to evaluate the presence of evolutionary forms of intestinal parasites in samples of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) sold in the municipality of Itumbiara, Goiás, Brazil, in June 2025. A total of 48 samples of raw vegetables were collected from three different markets and subjected to washing, spontaneous sedimentation (Lutz method), and centrifugation (Craig method), followed by microscopic analysis. The results indicated higher contamination in leafy vegetables, particularly lettuce (mean of up to 25.5 parasites per sample) and kale (mean of up to 11.75), followed by carrot and tomato. Cysts of *Giardia lamblia* and eggs of *Ascaris lumbricoides* were identified, in addition to occasional findings of *Entamoeba coli*, *Enterobius vermicularis*, and *Hymenolepis nana*. Markets with higher population flow and inadequate practices of exposure and handling exhibited the highest parasitic loads (P<0.05). It is concluded that vegetables displayed without proper hygienic and sanitary control facilitate the transmission of parasites, highlighting the necessity for health education initiatives, the use of protective packaging, and effective inspection to ensure the microbiological safety of foods sold in these environments.

Keywords: Vegetables, intestinal parasites, open-air markets, itumbiara, goiás, Brazil.

Introduction
The city, strategically located in southern Goiás, has intense agricultural and horticultural activity, making it essential to understand marketing patterns and potential sanitary risks in these environments [11].
Several studies have shown that the microbiological quality of vegetables sold in open-air markets varies significantly depending on the practices adopted by farmers, vendors, and consumers [12-14]. Research conducted in medium-sized cities similar to Itumbiara revealed alarming levels of thermotolerant coliforms in lettuce, kale, and mint sold in fairs, indicating failures in hygienic-sanitary control [15, 16]. Beyond microbiological contamination, the physicochemical quality and nutritional value of these products must also be considered, as they may be compromised by inadequate storage conditions and sun exposure during marketing. The loss of nutrients such as vitamin C and carotenoids is particularly significant under elevated temperatures and direct light exposure [17, 18].
Irrigation water is also a critical factor in evaluating the sanitary quality of vegetables. The presence of fecal coliforms in irrigation water has been reported in several producing regions, and its use without proper treatment directly contributes to vegetable contamination [19, 20]. Moreover, personal hygiene practices of handlers, the use of personal protective

equipment, and proper cleaning of stalls and utensils directly impact the microbial load of marketed foods [21, 22].

Brazilian sanitary legislation has advanced in establishing rigorous criteria to ensure the microbiological safety of foods offered to the population. Resolution RDC No. 331/2019 [23] and Normative Instruction No. 60/2019 [24] from ANVISA define specific microbiological standards for different food categories, including minimally processed vegetables, requiring compliance with limits for hygiene and pathogenicity indicator microorganisms. More recently, Normative Instruction No. 161, dated July 1, 2022 [25], complemented this regulatory framework by consolidating procedures for microbiological control and monitoring, expanding methodological standardization, and reinforcing the traceability of analytical results. The correlation among these regulations highlights the continuous effort of regulatory agencies to promote safer practices along the production and marketing chain, especially at critical points such as open-air markets and retail establishments, where exposure to contaminants is more frequent. Despite these regulations, studies show that many vendors are either unaware of such guidelines or lack technical training for their implementation, underscoring the importance of health education as a public health intervention tool [26, 27]. In this sense, the implementation of Good Agricultural Practices (GAP) and Good Handling Practices (GHP) has proven effective in reducing vegetable contamination, as shown by research reporting a significant decrease in coliform levels following training with producers [28, 29].

The literature also shows that consumers who purchase vegetables from open-air markets often fail to properly sanitize them at home, which increases the risk of ingesting pathogenic microorganisms. The use of sodium hypochlorite-based sanitizers, when correctly diluted, is recommended to mitigate this risk [30]. Therefore, microbiological analysis of vegetables becomes an essential tool not only to ensure food safety but also to support public policies and health education strategies [31].

Itumbiara, due to its agricultural dynamism and regional relevance, represents a strategic area for investigating food safety in vegetable trade. Understanding the practices adopted in local open-air markets may contribute to more effective and targeted interventions [11]. Comparative studies with other cities can be valuable for outlining a regional overview of the microbiological quality of vegetables [18, 32]. Identifying common patterns and critical points enables the design of joint actions among health surveillance agencies, rural extension workers, and educational institutions [14, 33].

The incorporation of simple technologies, such as portable sinks in fairs, training in safe handling, and encouragement of product traceability, are feasible measures that can raise the quality standards of marketed foods [34].

The literature reveals that the microbiological safety of vegetables is a multifactorial issue, involving all steps from the field to the consumer's table. Thus, integrated actions among producers, vendors, government, and consumers are indispensable to ensure safer and more nutritious foods [6, 35].

In this context, the present study aims to conduct a parasitological analysis of samples of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) sold in open-air markets in the municipality of Itumbiara, Goiás, Brazil, in 2025, with the purpose of identifying parasitic contaminants and supporting corrective and educational evidence-based actions.

Methodology

Local Identification

Itumbiara is a municipality located in the southern region of the state of Goiás, on the border with Minas Gerais. In 2022, the resident population was 107,970 inhabitants, distributed over a territorial area of 2,447.014 km², resulting in a population density of approximately 44.12 inhabitants per km². The Municipal Human Development Index (MHDI) of Itumbiara, in the same year, was 0.752. The city has a school enrollment rate of 97.9% for children aged 6 to 14 years and an infant mortality rate of 11.94 deaths per thousand live births. The local economy is mainly driven by agriculture and livestock, with emphasis on soybean and corn production, in addition to a per capita Gross Domestic Product (GDP) of R$ 49,832.28 [11].

According to records from the Office of the Attorney General of the Municipality of Itumbiara, there are six open-air markets held weekly in the city. Among these, three regularly sell food products of animal and plant origin. Thus, to obtain a significant and random sampling per market, it was decided to collect plant samples from these three open-air markets, chosen due to their high circulation of people and expressive commercialization of products.

As reported by Municipal Law No. 04 of May 28, 1996; Decree No. 537 of 1996; Municipal Law No. 2,112 of December 23, 1997; Municipal Law No. 2,893 of December 11, 2003; and Municipal Law No. 4,832 of November 28, 2017, which regulate the functioning of open-air markets, the following markets are established in the municipality of Itumbiara, with their respective locations and schedules:

a) Capim de Ouro Market - Avenida Trindade, on Saturdays starting at 12 p.m. and ending on Sundays at 1 p.m.;
b) Vila Vitória Market - Praça, Rua Dois, corner of Rua Inhô Querino, on Wednesdays, from 6 a.m. to 1 p.m.;
c) Santa Inês Neighborhood Market - Rua João da Cruz, on Fridays, from 6 a.m. to 1 p.m.;
d) Bus Station Market - Rua Mendes Sá, on Thursdays, from 6 a.m. to 1 p.m.;
e) Handicraft Market - Praça Pedro Ludovico, on Saturdays and Sundays, from 5 p.m. to 10 p.m.;
f) Friends Market - Avenida Walter Barra, on Fridays, from 5 p.m. to 10 p.m.

The three markets selected for this study comprised a total of 20 stalls selling the vegetables analyzed, distributed as follows: Market 1 (Capim de Ouro Market) with 12 stalls; Market 2 (Friends Market) with 5 stalls; and Market 3 (Bus Station Market) with 3 stalls. All vegetables analyzed came from small farms located in the urban area and rural surroundings of Itumbiara.

Sample Acquisition

This is an observational, qualitative-quantitative, cross-sectional study. During June 2025, four stalls were randomly selected from each of the three previously chosen open-air markets. From each stall, one whole and fresh sample of lettuce (*Lactuca sativa* L.), one of kale (*Brassica oleracea* var. *viridis*), one of carrot (*Daucus carota* subsp.

sativus), and one of tomato (*Solanum lycopersicum* L.) were purchased, totaling 48 samples evaluated. A whole head was considered for lettuce samples, one bundle of leaves for kale, and individual units for carrot and tomato, regardless of weight or size (Figure 1).

Fig 1: Acquisition of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) samples sold at open-air markets in the municipality of Itumbiara, Goiás, Brazil.

All samples were purchased directly from the stall vendors, handled by researchers using new latex gloves, placed in clean low-density polyethylene (LDPE) bags, properly labeled (market name, stall number, date, and time), packed in a polystyrene container, and immediately transported to the Microbiology Laboratory of the State University of Goiás (UEG - Itumbiara Campus) for analysis.

Laboratory Analyses

In the laboratory, any non-whole portions of the samples were discarded, and in a rectangular polypropylene tray (34.9 cm x 28.9 cm x 7.5 cm), each sample was immersed and individually washed with a 0.5% neutral detergent solution under light friction for one hour, aiming to remove dirt and possible microorganisms. This solution was prepared by mixing 10 mL of neutral detergent in two liters of distilled water.

Subsequently, the solution was collected, filtered through a sieve covered with gauze folded four times, and placed in a beaker for sedimentation for 24 hours, according to the Lutz method adapted for food [36]. This simple and low-cost spontaneous sedimentation technique is used for detecting parasitic forms, such as eggs, larvae, and cysts. After this period, an aliquot of approximately 0.05 mL of sediment was collected for direct examination, transferred to labeled slides, stained with one drop of Lugol's solution, covered with a coverslip, and analyzed in triplicate at 10x and 40x magnification using a binocular optical microscope, scanning the entire visual field.

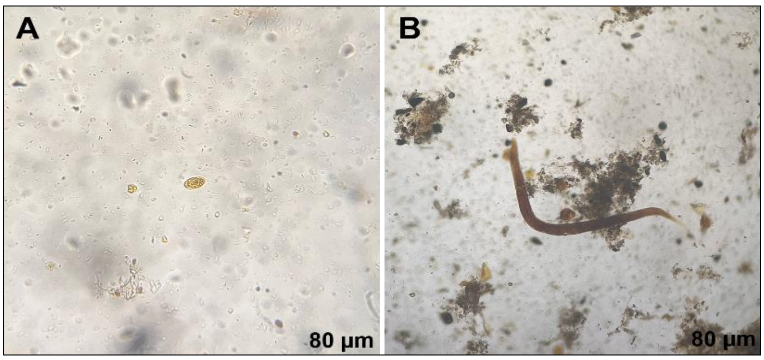
Additionally, to identify lighter helminth eggs, protozoan cysts, and oocysts that may not have sedimented, the remaining portion of the washing solution was centrifuged at 2,500 rpm for three minutes at room temperature. The supernatant was discarded, the sediment resuspended, and an aliquot was taken with the aid of a Pasteur pipette, stained with Lugol's solution, and analyzed under light microscopy at 10x and 40x magnification, according to the Craig method with adaptations for food samples [37]. The parasitic forms observed were identified based on their morphological characteristics, using specialized literature [38].

Statistical Analysis

Results were expressed as measures of central tendency, measures of dispersion, absolute and relative frequencies. Statistical analysis was performed using GraphPad Prism software version 5.01 for Windows. The chi-square test and Student's t-test were applied, considering statistical significance at $P<0.05$.

Results

This study evaluated the occurrence of parasitological contamination in 48 samples of raw vegetables - lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) - collected from three different open-air markets in the municipality of Itumbiara, Goiás, during June 2025 (Figure 2). The markets were selected based on population flow and commercial representativeness: Capim de Ouro Market (high turnover, about 700 weekly consumers), Friends Market (intermediate turnover, about 300 consumers), and Bus Station Market (low turnover, approximately 150 weekly consumers). In each market, four stalls were randomly selected, and from each stall, samples of the four types of vegetables were purchased, totaling 16 samples per market.



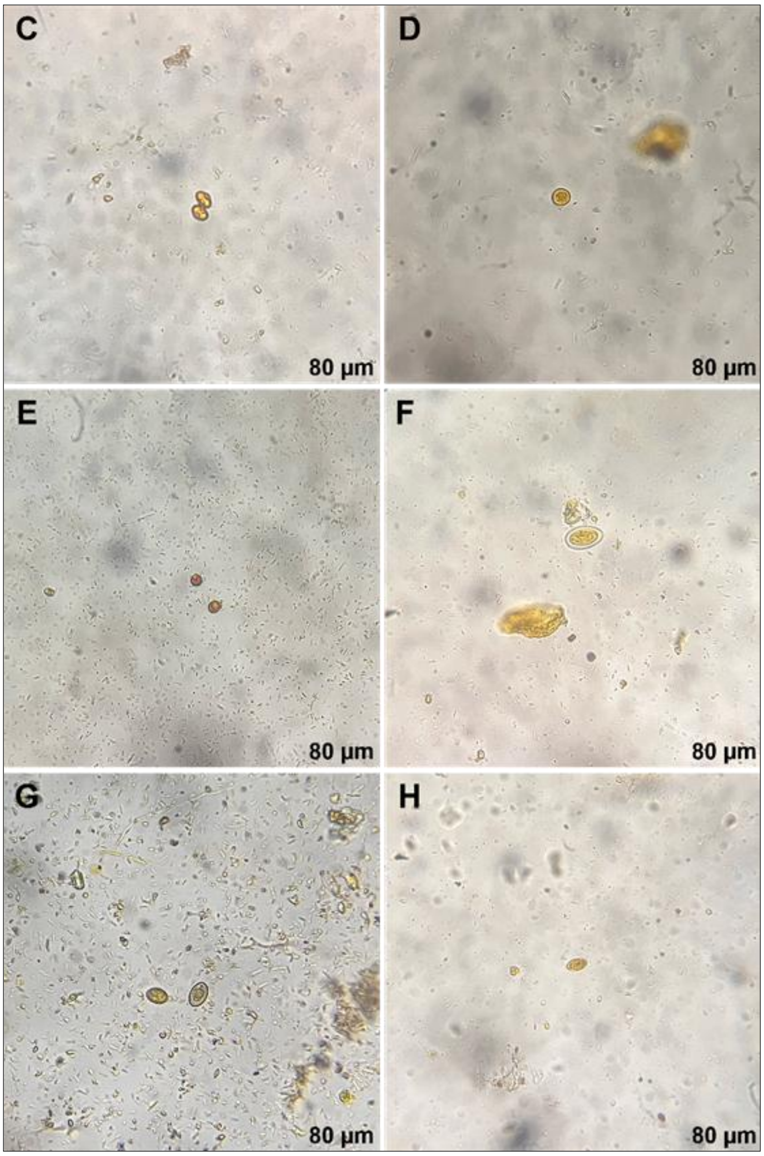


Fig 2: Parasitological structures identified in samples of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) sold at open-air markets in the municipality of Itumbiara, Goiás, Brazil. (A) Decorticated egg of *Ascaris lumbricoides*; (B) Larval form of *Ascaris lumbricoides*; (C) Cysts of *Giardia lamblia*; (D) Cyst of *Entamoeba coli*; (E) Egg of *Iodamoeba bütschlii*; (F) Egg of *Enterobius vermicularis*; (G) Simultaneous presence of a *Hymenolepis nana* egg and a *Giardia lamblia* cyst; (H) Larval stage of *Hymenolepis nana*. Optical microscopy, 80 µm.

At Capim de Ouro Market (Table 1), a wide diversity and intensity of parasitological contamination was observed, although the overall mean number of parasites per sample was lower than that of Friends Market ($P<0.05$). Lettuce was the vegetable with the highest parasite load in this market, with an average of 25.5 parasites per sample (± 21.48), ranging from 15 to 51, and a median of 20. Notably, Stall 3 recorded 51 *Giardia lamblia* cysts in a single lettuce sample, in addition to *Ascaris lumbricoides* eggs, *Enterobius vermicularis* eggs, and *Entamoeba coli* cysts. This was the only stall where the sales counter was also used for handling money and card machines directly on the food, which may have contributed to the high parasite load observed. Kale also showed significant contamination, with an average of 9.0 parasites per sample (± 3.91), ranging from 5 to 15, reinforcing the susceptibility of leafy vegetables. Carrots presented an average of 3.0 (± 2.16), ranging from 1 to 6, while tomatoes had an average of 1.5 (± 1.91), ranging from 0 to 4. Carrots and tomatoes were often sold in sealed plastic packaging, which may have limited their exposure to contaminants.

Table 1: Absolute parasite count in samples of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) sold at the Capim de Ouro market, Itumbiara, Goiás, Brazil.

Sample*	Parasites per vegetable at the Capim de Ouro Market			
	Lettuce	Kale	Carrot	Tomato
Stall 1	3 eggs of *Ascaris lumbricoides* 19 cysts of *Giardia lamblia* 1 cyst of *Entamoeba coli*	10 cysts of *Giardia lamblia* 5 eggs of *Ascaris lumbricoides*	0	3 eggs of *Ascaris lumbricoides*

Stall 2	21 cysts of *Giardia lamblia*	5 cysts of *Giardia lamblia*	1 ovo de *Ascaris lumbricoides*	2 eggs of *Ascaris lumbricoides*
Stall 3	51 cysts of *Giardia lamblia* 9 eggs of *Ascaris lumbricoides* 1 egg of *Lodamoeba bütschlii* 1 egg of *Enterobius vermiculares*	4 eggs of *Ascaris lumbricoides* 3 cysts of *Giardia lamblia*	0	0
Stall 4	15 cysts of *Giardia lamblia* 3 eggs of *Ascaris lumbricoides*	6 eggs of *Ascaris lumbricoides* 7 cysts of *Giardia lamblia*	2 eggs of *Ascaris lumbricoides*	0
*P<0.05 (t-test and chi-square test for all comparisons).				

At Friends Market (Table 2), the highest mean parasitological contamination among the three markets was recorded (P<0.05), with an overall mean of 13.75 parasites per sample (± 3.70). Lettuce remained the most contaminated vegetable, with an average of 18.75 (± 4.11), ranging from 14 to 25, with *Giardia lamblia* predominating in all samples analyzed. Kale presented a mean of 11.75 parasites (± 1.26), ranging from 10 to 13, showing consistent contamination across all stalls. Carrots had an average of 3.0 (± 2.94), with sporadic presence of *Ascaris lumbricoides* eggs. Tomatoes showed no parasitic forms, reinforcing the protective effect of the packaging used in their commercialization. The low data dispersion, especially for lettuce and kale, suggests a homogeneous contamination pattern in leafy vegetables.

Table 2: Absolute parasite count in samples of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) sold at the Friends Market, Itumbiara, Goiás, Brazil.

	Parasites per vegetable at the Friends Market			
Sample*	**Lettuce**	**Kale**	**Carrot**	Tomato
Stall 1	14 cysts of *Giardia lamblia*	9 eggs of *Ascaris lumbricoides* 4 cysts of *Giardia lamblia*	0	0
Stall 2	17 cysts of *Giardia lamblia* 1 egg of *Ascaris lumbricoides*	5 eggs of *Ascaris lumbricoides* 7 cysts of *Giardia lamblia*	0	0
Stall 3	25 cysts of *Giardia lamblia*	10 cysts of *Giardia lamblia*	1 egg of *Ascaris lumbricoides*	0
Stall 4	19 cysts of *Giardia lamblia*	6 cysts of *Giardia lamblia* 1 egg of *Ascaris lumbricoides*	2 eggs of *Ascaris lumbricoides*	0
*P<0.05 (t-test and chi-square test for all comparisons).				

The Bus Station Market presented the lowest contamination indices among the evaluated markets (Table 3, P<0.05). Lettuce showed a mean of 2.0 parasites per sample (± 1.41), ranging from 1 to 3. Kale, although with a mean of 2.5 (± 0.58), stood out for its parasitic diversity, with identification of *Giardia lamblia* cysts, *Ascaris lumbricoides* eggs, and even one adult worm, in addition to two *Hymenolepis nana* eggs. Although isolated, these findings are concerning as they suggest failures in harvesting or pre-washing procedures. Carrots and tomatoes showed no parasitic identification in the samples. Restricting consumer handling of products and using sealed packaging for roots and fruits may have contributed to reduced contamination in this market.

Statistical analysis confirmed significant differences between vegetables within each market. Student's t-test revealed statistically significant differences in mean parasitological contamination between markets: Capim de Ouro vs. Friends (P = 0.031), Capim de Ouro vs. Bus Station (P = 0.024), and Friends vs. Bus Station (P = 0.004), with Friends Market showing the highest means. The chi-square test indicated a significant association between vegetable type and the presence of parasites (P = 0.0051), demonstrating a higher prevalence of *Giardia lamblia* in lettuce and *Ascaris lumbricoides* in kale and carrots, especially in markets with higher population flow.

Table 3. Absolute parasite count in samples of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) sold at the Bus Station Market, Itumbiara, Goiás, Brazil.

	Parasites per vegetable at the Bus Station Market			
Sample*	**Lettuce**	**Kale**	**Carrot**	**Tomato**
Stall 1	3 cysts of *Giardia lamblia*	3 cysts of *Giardia lamblia*	0	0
Stall 2	1 cyst of *Giardia lamblia*	1 cyst of *Giardia lamblia*	0	0
Stall 3	0	1 worm de *Ascaris lumbricoides* 1 egg of *Ascaris lumbricoides* 2 eggs of *Hymenolepis nana*	0	0
Stall 4	0	1 egg of *Ascaris lumbricoides*	0	0
*P<0.05 (t-test and chi-square test for all comparisons).				

Descriptive and inferential analyses converge on a consistent epidemiological pattern: leafy vegetables such as lettuce and kale showed greater susceptibility to contamination by protozoa and helminths, likely due to their irregular morphology, direct exposure on open stalls, and commercialization in bundles. In contrast, vegetables with protective skins or sold in packaging, such as carrots and tomatoes, showed lower contamination rates. Improper handling of vegetables by vendors and consumers, observed more frequently in busier markets, proved to be a considerable risk factor for parasite load (P<0.05). Stall 3 at Capim de Ouro Market, notably lacking basic hygiene practices, presented the highest parasite loads recorded, reinforcing the urgent need for educational and sanitary measures at fresh vegetable points of sale.

Discussion

The high parasitic load observed in lettuce and kale at the analyzed markets confirms well-documented patterns in the literature, according to which leafy vegetables exhibit a high prevalence of contamination in open-air and street markets [39-41]. In this study, the contamination means observed for lettuce at Capim de Ouro Market (25.5 parasites per sample) and Friends Market (18.75 per sample) reinforce this pattern, with predominance of *Giardia lamblia* cysts and *Ascaris lumbricoides* eggs. These findings are like those reported by Rodrigues *et al*. (2020) [41], who identified over 85% positivity in lettuce sold at open markets in Belém.

The method used for parasite detection - washing, sedimentation, and direct microscopy - is widely recognized in epidemiological studies, as demonstrated by Santos (2007) [42], who detected *Giardia*, *Ascaris*, and *Trichuris* contamination in vegetables in the Federal District, particularly those sold at open-air markets. Although the prevalence in that study was numerically lower than observed in the present research, the inclusion of collection sites with greater sanitary control (such as supermarkets and restaurants) may explain this discrepancy.

Statistical analyses supported the laboratory findings. The chi-square test indicated a significant association between vegetable type and parasite identified ($P = 0.0051$), with higher occurrence of *Giardia lamblia* in lettuce and *Ascaris lumbricoides* in kale and carrots. Student's t-test revealed statistically significant differences in mean parasitic contamination across markets, highlighting Friends Market as presenting the highest levels ($P<0.05$). These results are consistent with Pedroso *et al*. (2020) [40], who identified leafy vegetables as more prone to contamination due to their irregular morphology and larger surface area for particle adhesion.

In addition to favorable anatomy for dirt retention, lettuce and kale are often sold unpackaged and subjected to extensive handling by consumers, increasing contamination risk - as highlighted by Santarém *et al*. (2012) [43] and Ferreira (2014) [44]. This scenario was clearly illustrated at Stall 3 of Capim de Ouro Market, where direct handling of vegetables with money and card machines placed on the leaves resulted in the highest parasite loads detected, including *Giardia*, *Ascaris*, *Entamoeba coli*, and *Enterobius vermicularis*.

In contrast, carrots and tomatoes exhibited the lowest mean levels of parasitic contamination, especially when marketed in plastic packaging. This physical protection is consistent with findings by Santos *et al*. (2009) [39], who reported lower contamination prevalence in packaged vegetables. Proper packaging acts as a barrier against cross-contact and environmental exposure, contributing significantly to the microbiological safety of food.

The parasites identified in this study - *Giardia lamblia*, *Ascaris lumbricoides*, *Hymenolepis nana*, and, more rarely, an adult *Ascaris lumbricoides* worm - have already been widely reported in other regions of Brazil. Alves *et al*. (2006) [45], for instance, reported the presence of these species in vegetables sold in Florianópolis, with 100% positivity in some lettuce and watercress samples. In Campo Grande, Luz *et al*. (2021) [46] also identified multiple parasitic species in lettuce from open-air markets, with more than 83% of samples contaminated.

The structure and organization of the mark*et al*so appeared to influence parasite load. The Bus Station Market, with lower population flow and more controlled commercialization practices, presented the lowest contamination indices, a result consistent with Santarém *et al*. (2012) [43]. According to the authors, environmental exposure, dust presence, type of coverage, and handling methods are determining factors in the contamination of fresh vegetables.

In this study, a statistically significant correlation was observed between market population flow, vegetable type, and parasite load ($P<0.05$). This direct relationship had already been proposed by Ferreira (2014) [44], who associated contamination risk with the intensity of handling and environmental exposure. The wide range of minimum and maximum values, particularly in busier markets, highlights variability among stalls, indicating the influence of individual hygiene and storage practices. This observation is supported by Luz *et al*. (2021) [46], who reported significant differences among stalls within the same market, even under similar environmental conditions.

Such evidence reiterates the urgency of educational initiatives targeting both vendors and consumers. According to Santos *et al*. (2009) [39], providing simple guidance on vegetable washing, storage, and exposure can substantially reduce contamination levels. The household use of sodium hypochlorite, for example, has proven effective in reducing infective forms such as cysts and eggs, as noted by Rodrigues *et al*. (2020) [41].

Moreover, public policies aimed at market sanitary surveillance and vendor technical training are essential. The creation of certification seals for stalls that adopt good handling practices, as suggested by Ambrozim *et al*. (2015) [47], may encourage continuous improvements in the sanitary quality of products offered. Finally, the use of robust statistical analyses in this study - including Student's t-test and the chi-square test - strengthened the results. Occasional discrepancies between tests in some comparisons reflect the natural variability of the data and reinforce the need for multifactorial approaches to understand the complexity of parasitic contamination in fresh foods.

Conclusion

This study demonstrated that vegetables sold at open-air markets in Itumbiara, particularly lettuce and kale, are highly vulnerable to contamination by intestinal parasites, in contrast to carrots and tomatoes, which showed lower contamination levels when properly packaged. Structural, sanitary, and behavioral factors of the markets were identified as key determinants of parasite load, with statistically significant differences between locations and vegetable types. These findings highlight the urgent need for integrated measures involving sanitary surveillance, vendor training, and consumer education campaigns focused on proper food hygiene, to ensure the microbiological safety of fresh produce and safeguard the right to safe and healthy food.

Acknowledgement

Authors acknowledge UEG - UnU Itumbiara for material support.

Declaration of interest statement

Authors state no conflict of interest.

References

1. Suresh A, Shobna, Salaria M, Morya S, Khalid W, Afzal FA, Mukonzo Kasongo EL. Dietary fiber: an unmatched food component for sustainable health. Food and Agricultural Immunology. 2024;35(1):1-20.
2. Malta DC, Bernal RTI, Vieira Neto E, Curci KA, Pasinato MTDM, Lisbôa RM, Freitas MIF. Doenças Crônicas Não Transmissíveis e fatores de risco e proteção em adultos com ou sem plano de saúde. Ciência & Saúde Coletiva. 2020;25:2973-2983.
3. Liang J, Wen Y, Yin J, Wang H, Zhou Y, Huang Z, Feng X, Zhang Y, Deng L, Lu Y. Utilization of plant-based foods for effective prevention of chronic diseases: a longitudinal cohort study. NPJ Science of Food. 2024;8:113-125.
4. Silva D, Borges J. As feiras-livres da agricultura familiar em Arapiraca, Alagoas, Brasil. Raízes: Revista de Ciências Sociais e Econômicas. 2020;40(1):84-101.
5. Silva WPC, Silva MC, Ferreira LA, Estumano SB, Ribeiro RM, Costa NYM. Análise da contaminação microbiológica em amostras de cheiro-verde (*Petroselinum crispum*), alface (*Lactuca sativa*), couve (*Brassica oleracea*) e hortelã (*Mentha spicata*) comercializadas em feira livre, Belém-PA. Brazilian Journal of Health Review. 2021;4(2):8263-8269.
6. Silva DB, Siqueira CEAF, Santos JS. A importância da seguridade e qualidade microbiológica e parasitológica em hortaliças. Research, Society and Development. 2021;10(14):e109101421589-e109101421600.
7. Silva PMGD, Padilha FMQDH, Figueredo MB. Qualidade microbiológica de hortaliças comercializadas em diferentes restaurantes do tipo self-service na cidade do Recife-PE. Higiene Alimentar (Online). 2022;36(1):1-10.
8. Martins IA, Vieira AC, Machado JMS, Gregório EL, Amaral DA. Análise microbiológica de hortaliças e vegetais minimamente processados comercializados em grandes redes de supermercados de Belo Horizonte-MG. Brazilian Journal of Health Review. 2021;4(1):1172-1185.
9. Lacerda TS, Ferreira LC. Contaminação microbiológica de hortaliças produzidas em uma comunidade rural do município de Januária-MG. Research, Society and Development. 2022;11(6):e33211629081-e33211629095.
10. Espírito Santo AM, Almeida VO. Contaminação da alface em supermercados e feiras livres: uma revisão sistemática. Revista de Formação e Pesquisa em Saúde. 2023;5(2):1-15.
11. Instituto Brasileiro de Geografia e Estatística - IBGE. Itumbiara. Available at: https://cidades.ibge.gov.br/brasil/go/itumbiara/panorama.
12. Ferreira AB, Alvarenga SHF, São José JFB. Qualidade de frutas e hortaliças orgânicas comercializadas em feiras livres. Revista do Instituto Adolfo Lutz. 2015;74(4):410-419.
13. Rocha MM, Albuquerque Sousa MA, Sousa RDS, Arcanjo SRS, Parreira CR, Oliveira AMC. Qualidade microbiológica de hortaliças folhosas comercializadas em Picos-PI. Higienistas Alimentares Reúnem-se em Búzios. 2015;29(242-243):130-135.
14. Andrade RM, Marques LP, Souza RF. Avaliação da qualidade microbiológica do tomate (*Solanum lycopersicum*) e alface (*Lactuca sativa*) comercializados em feiras livres em uma cidade do interior da Bahia. Diálogos & Ciência. 2022;2(1):129-138.
15. Coutinho MGS, Ferreira CS, Neves AM, Alves FRL, Souza FFP, Fontenelle ROS. Avaliação microbiológica e parasitológica de alfaces (*Lactuca sativa L.*) comercializadas em feiras livres no município de Sobral-CE. Revista da Universidade Vale do Rio Verde. 2015;13(2):388-397.
16. Silva AC, Dias RBG. Desafios da agricultura familiar na produção e comercialização de hortaliças: gestão da qualidade na produção [trabalho de conclusão de curso]. Assis: Faculdade de Tecnologia de Assis; 2023.
17. Pereira EM, Leite DDF, Fidelis VDL, Porto RM, Oliveira MD, Magalhães WB. Caracterização físico-química de hortaliças tipo folha comercializadas no Brejo Paraibano. Revista Agropecuária Técnica. 2016;37(1):19-22.
18. Ferreira RP, Franco NDR. A importância das boas práticas de manipulação dos alimentos ao combate de doenças: revisão de literatura. Revista Interdisciplinar em Saúde. 2021;8:365-378.
19. Christovão DA, Iaria ST, Candeias JAN. Condições sanitárias das águas de irrigação de hortas do município de São Paulo. Revista de Saúde Pública. 1967;1(1):30-38.
20. Empresa Brasileira de Pesquisa Agropecuária - EMBRAPA. Qualidade e segurança sanitária da água para fins de irrigação. Brasília: Embrapa; 2018.
21. Batista PDS, Mancini CE, Barreto ES. Análise de coliformes totais e termotolerantes em água de irrigação de hortas no município de Sinop - MT, Brasil. Scientific Electronic Archives. 2015;8(1):1-6.
22. Gonçalves MT, Farias RS, Almeida CE. Bactérias indicadoras de poluição fecal em águas de irrigação de hortaliças em Natal, RN. Revista Brasileira de Agricultura. 2023;75(4):378-386.
23. Brasil. Agência Nacional de Vigilância Sanitária - ANVISA. Resolução RDC nº 331, de 23 de dezembro de 2019. Dispõe sobre os padrões microbiológicos para alimentos e sua aplicação. Diário Oficial da União. 2019;26 dez:1-25.
24. Brasil. Agência Nacional de Vigilância Sanitária - ANVISA. Instrução Normativa nº 60, de 23 de dezembro de 2019. Estabelece as listas de padrões microbiológicos para alimentos prontos para oferta ao consumidor. Diário Oficial da União. 2019;26 dez:1-20.
25. Brasil. Agência Nacional de Vigilância Sanitária - ANVISA. Instrução Normativa nº 161, de 1º de julho de 2022. Estabelece os padrões microbiológicos dos alimentos. Diário Oficial da União. 2022;6 jul;126:1-30.
26. Luz JRD, Câmara HCF, Lima DVP, Silva MHR, Costa EL, Zelenoy CKG. Avaliação da contaminação parasitária em alfaces (*Lactuca sativa*) comercializadas em feiras livres na região da Grande Natal, RN. Nutrivisa. 2014;1(2):16-19.
27. Cruz Matos J, Benvindo LRS, Silva TO, Carvalho LMF. Condições higiênico-sanitárias de feiras livres: uma revisão integrativa. Revista Eletrônica Gestão e Saúde. 2015;6(3):2884-2893.
28. Luengo RFA, Maldonade IR, Ginani VC, editors. Manuseio para processamento mínimo de hortaliças e frutas no Brasil. Brasília: Embrapa; 2021.
29. Oliveira da Silva MG, Cássia Serra Furtado R, Moura de Almeida R, Silva Mesquita Serfaty D, Teixeira Paes

F, Amoras Nascimento MT, Costa de Castro NJ. Educação ambiental, feiras livres e vigilância em saúde: aprendizagem a partir do Arco de Maguerez. Journal of Nursing UFPE. 2024;18(1):1-12.
30. Rossi EM, Guzela RR, Kochhann M, Menezes LK, Honorato JFB. Conhecimento dos consumidores e eficiência dos métodos de lavagem e desinfecção de alface (*Lactuca sativa*) comercializada em supermercados em uma cidade do sul do Brasil. Brazilian Journal of Food Technology. 2020;23:e2019245:1-10.
31. Santos JKT, Alves LCS. Pesquisa de parasitos intestinais em hortaliças: uma revisão integrativa [trabalho de conclusão de curso]. Goiânia: Pontifícia Universidade Católica de Goiás; 2024.
32. Oliveira AGD, Dantas JCBP, Santana PMSDS. Comparações das condições higiênico-sanitárias de hortifrútis de feiras livres dos municípios brasileiros: revisão de literatura. Revista Brasileira de Agricultura. 2021;72(3):455-463.
33. Vicente IV, Ikefuti CV, Souza BMS, Covizzi UDS. Avaliação preliminar da qualidade microbiológica de hortaliças na cidade de São José do Rio Preto/SP. Open Science Research I. 2022;1:584-599.
34. Golin A, Coden MAS, Rolim RI, Bertagnolli SMM, Margutti KMM, Basso C. Qualidade higiênico-sanitária e o perfil de feirantes e usuários das feiras-livres de Santa Maria - RS. Disciplinarum Scientia. Série: Ciências da Saúde. 2016;17(3):423-434.
35. Morgado KR, Silva MGR, Evaristo RAF, Souza RS, Vigoder HC. Segurança microbiológica de hortaliças orgânicas no Brasil. The Journal of Engineering and Exact Sciences. 2022;8(9):14888-14901.
36. Santos EL, Santos FJR, Lima JNP, Borba MNJ, Moreno JS, Rodrigues EP, Costa EN. Avaliação das condições higiênico-sanitárias nas feiras livres das cidades de Cachoeira e Muritiba - BA. Holos. 2021;1:1-16.
37. Moura LR, Santos T, Viegas AA. Pesquisa de parasitos em alface e couve provenientes de feiras da região central e suas mediações na cidade de Anápolis-GO. Revista Educação em Saúde. 2015;3(2):35-41.
38. Neves DP. Atlas de parasitologia humana. 4th ed. São Paulo: Atheneu; 2016.
39. Santos NM, Costa RA, Nascimento LO, Oliveira RM. Avaliação parasitológica de hortaliças comercializadas em supermercados e feiras livres no município de Salvador-BA. Revista de Ciências Médicas e Biológicas. 2009;8(2):146-152.
40. Pedroso RR, Martins RP, Sousa ML, Borges TF. Ocorrência de helmintos e protozoários em hortaliças folhosas comercializadas no Brasil. Brazilian Journal of Food Technology. 2020;23:e2020073:1-12.
41. Rodrigues AC, Moura MSB, Lima CG, Pinheiro FP, Nascimento MBF. Prevalence of contamination by intestinal parasites in vegetables (*Lactuca sativa L.* and *Coriandrum sativum L.*) sold in markets in Belém, northern Brazil. Journal of the Science of Food and Agriculture. 2020;100(7):2859-2865.
42. Santos AO. Investigação epidemio-parasitológica em hortaliças comercializadas em feiras livres, mercados e restaurantes do Distrito Federal [dissertação de mestrado]. Botucatu: Universidade Estadual Paulista; 2007.
43. Santarém RV, Ferraz FF, Garcia LB, Pereira DA. Avaliação parasitológica de alface comercializada em feiras livres do município de Maringá-PR. Revista do Instituto Adolfo Lutz. 2012;71(3):408-413.
44. Ferreira DF. Contaminação da alface em supermercados e feiras livres: uma revisão sistemática. Revista Food Technology. 2014;9(1):56-67.
45. Alves MA, Tavares-Dias M, Garcia JL. Contaminação de hortaliças por parasitas intestinais em Florianópolis, SC. Revista Brasileira de Epidemiologia. 2006;9(3):280-285.
46. Luz JMF, Souza AP, Marques MJ, Silva VL. Análise parasitológica em alface (*Lactuca sativa*) comercializada em feiras livres da cidade de Campo Grande, MS. Anais do Conigran. 2021;5:1-5.
47. Ambrozim FM, Oliveira MA, Ribeiro RA, Lima TS. Avaliação parasitológica de alfaces comercializadas na cidade de Dourados-MS. Anais do Congresso de Ciências da Saúde. 2015;2:19-26.

Authors Details

Gabriela de Oliveira Silva
Academic Institute of Health and Biological Sciences, State University of Goiás - UEG, Itumbiara, Goiás, Brazil

Júlia Mayumi Pereira Fuzinaga
Academic Institute of Health and Biological Sciences, State University of Goiás - UEG, Itumbiara, Goiás, Brazil

Vinicius Eduardo Farias Silva
Academic Institute of Health and Biological Sciences, State University of Goiás - UEG, Itumbiara, Goiás, Brazil

João Álefe Silva da Silva
Academic Institute of Health and Biological Sciences, State University of Goiás - UEG, Itumbiara, Goiás, Brazil

Dorcas Fernandes dos Anjos Melo
Centro Universitário de Goiatuba - UniCerrado, Goiatuba, Goiás, Brazil

Gustavo Caires Neves Magalhães
Centro Universitário de Goiatuba - UniCerrado, Goiatuba, Goiás, Brazil

Eurípedes Ribeiro Bonifácio Júnior
Centro Universitário de Goiatuba - UniCerrado, Goiatuba, Goiás, Brazil

Edvande Xavier dos Santos Filho
A) Academic Institute of Health and Biological Sciences, State University of Goiás - UEG, Itumbiara, Goiás, Brazil
B) Centro Universitário de Goiatuba - UniCerrado, Goiatuba, Goiás, Brazil

How to Cite This Article
Silva GO, Fuzinaga JMP, Silva VE, Silva da Silva JÁ, Melo DF dos A, Magalhães GCN, Bonifácio Júnior ER, Santos Filho EX dos. Parasitological analysis of lettuce (*Lactuca sativa* L.), kale (*Brassica oleracea* var. *viridis*), carrot (*Daucus carota* subsp. *sativus*), and tomato (*Solanum lycopersicum* L.) samples commercialized in open-air markets in the municipality of Itumbiara, Goiás, Brazil. Journal of Advances in Microbiology Research. 2025;6(2):288-295.