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Updates**PARASITIC CONTAMINATION OF LEAFY VEGETABLES IN JOS AND LAFIA****Adamu, A. I^{1*}, Muhammad, M. B², Pam, V. A³**

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Detailed author information and related declarations are provided in the final section of this article.Article Publication Details**

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ABSTRACT

A good source of vitamins is leafy vegetables. However, contamination during cultivation, handling, transportation, and marketing can expose consumers to parasitic infections. This study assessed the occurrence and distribution of parasitic contaminants on commonly consumed leafy vegetables obtained from farms and markets in Jos, Plateau State and Lafia, Nasarawa State, Nigeria, between June and July 2024. Four commonly consumed leafy vegetables which constitute 6 samples each of cabbage, lettuce, spinach and spring onion were collected on sampling days from the farms and markets and transported to the Laboratory for identification and parasitological analysis. Overall, 46.88% of the vegetables examined were contaminated with at least one parasite. Hookworm larvae were the most frequently detected (37.78%) while Cyst of *Entamoeba histolytica*, *Fasciola hepatica*, Ova of *S. stercoralis* and Cyst of *Entamoeba coli* recorded the least prevalence parasites with 1(2.22%) each. Vegetables sampled in Jos recorded higher parasitic contamination (57.78%) than Lafia which recorded (42.22%). Although this difference was not statistically significant ($\chi^2 = 0.008$, $p = 0.929$). In Lafia, spinach had higher detection of parasites 4(21.05%) in market while in the farm cabbage shows more parasites prevalence of 3(15.79%). Lettuce sampled in the market in Jos recorded higher level of contamination with 7(26.92%) while in the farm cabbage recorded more contaminants with 4(15.38%). The least observed contamination was in Spring onion with 1(3.85%). The frequent consumption of these leafy vegetables in raw or lightly cooked forms increases the risk of parasitic infections. Improved hygiene practices and Continuous public health education on proper washing and handling is therefore strongly recommended.

Keywords: Leafy vegetables, Prevalence, Lafia, Jos, Farms, Markets**INTRODUCTION**

A good source of vitamins is leafy vegetables. They play a significant role in every family's diet and are necessary for optimal health. Vegetables are annual or perennial horticulture crops that include specific parts (roots, stalks, flowers, fruits, leaves, etc.) that can be eaten raw or cooked, in whole or in part, and are essential to a healthy lifestyle (Welbaum *et al.*, 2015). This is because, by offering vital nutrients, vitamins, protein, and fiber, veggies aid in defending the body against a variety of illnesses. Regular intake of vegetables has been associated with reduced risks of chronic conditions such as cardiovascular diseases, diabetics, strokes, obesity, and certain cancers. Global health agencies recommend adequate daily consumption of vegetables to prevent micronutrient deficiencies and promote healthy living (Pem & Jeewon, 2015; Bashir *et al.*, 2020; Dorothy *et al.*, 2024). Despite their benefits, vegetables may serve as vehicles for the transmission of intestinal parasites when contaminated during cultivation, harvesting, transportation, or marketing (FAO, 2010). Poor agricultural practices, including the use of untreated wastewater for irrigation and the application of improperly treated animal or human manure, contribute substantially to the contamination of vegetables in many developing regions (Anthony *et al.*, 2018; Alemu *et al.*, 2020). In addition, unhygienic handling and storage practices at farm and market levels increase the likelihood of exposure to parasitic stages such as ova, cysts, and larvae. The consumption of raw or poorly washed vegetables has been identified as an important pathway for human exposure to intestinal parasites, especially in regions with inadequate sanitation infrastructure. (Tefera *et al.*, 2014).

In Nigeria, parasitic infections remain endemic in many communities, largely due to inadequate sanitation, unsafe water sources, and open defecation. Several studies across Africa and Asia have documented varying levels of parasitic contamination of vegetables sold in open markets, highlighting the public health relevance of this problem (Karshima, 2018). Report by Ibikounlé *et al.*, (2014) highlighted that high levels of contamination with harmful parasites in many poor nations have been attributed to the use of untreated sewage to irrigate vegetables. Helminths like *Hymenolepis nana*, *Toxocara canis*, *Ascaris lumbricoides*, *Ancylostoma duodenale*, and *Enterobius vermicularis*, for example, are known to be prevalent among Nigerians and are transmitted through the consumption of raw vegetables (WHO, 2018). In a study on parasite contamination of edible vegetables sold in Onitsha markets, Anambra State, Umeaneto *et al.* (2016) found that the prevalence rates for *Ascaris lumbricoides* and *Strongyloides stercoralis* were 57.1% and 7.1%, respectively. According to Said (2012), fresh vegetables have been linked to a rise in foodborne illness incidents.

Ascaris lumbricoides, *Cryptosporidium* species, *Entamoeba histolytica*, *Enterobius vermicularis*, *Fasciola* species, *Gardia intestinalis*, *Trichuris trichiura*, hookworm, *Hymenolepis*, *Taenia*, and *Toxocara* species are among the parasites that humans can contract by consuming contaminated, raw, or improperly cleaned vegetables (Gebremariam & Girmay, 2020). Epidemiology of human intestinal parasite has been traced to

the consumption of raw vegetables which play a major epidemiological significance in the transmission of food borne parasitic disease (Alemu *et al.*, 2020). Among the most prevalent illnesses on the planet, parasitic diseases are spread to people by water, soil, and vegetables (Kudah *et al.*, 2018; Agbalaka *et al.*, 2019; Seyyedeh *et al.*, 2021). Jos and Lafia are important agricultural and commercial centers in North-Central Nigeria where leafy vegetables are widely cultivated and traded. However, data on the level and types of parasitic contamination of vegetables in these locations remain limited. This study therefore assessed the prevalence and types of parasites contaminating selected leafy vegetables obtained from farms and markets in Jos and Lafia, with the aim of providing evidence to support public health interventions and improved food safety practices.

Materials and Methods

Study Area

The study was carried out in two major regions in two states which include Jos, Plateau state and Lafia, Nasarawa state. Plateau State, which occupies 26,899 square kilometers, is situated in the central belt of Nigeria. With Latitude 08°24'N and longitudes 008°32' and 010°38'E as its coordinates. There are an estimated three million people living in the state. Plateau State, located in north-central Nigeria, has Jos as its capital. Latitude 8° 24'N and Longitudes 8° 32' and 10° 38'E are the coordinates of Jos. Jos North has an area of around 291 km² and a population of 429,300, whereas Jos South has an area of about 510 km² with a population of 306,716, according to data from the official national census, which was conducted in 2006 (Zitta & Madaki, 2020). While Nasarawa state is situated in Nigeria's North Central Area. Lafia is located at 8°29'30"N, 8°31'0"E and has a geographical area of 2,737 km. The 2006 census observed that there were 330,712 inhabitants residing there. Lafia inhabitants work predominantly in the public sector, commerce, agriculture, arts and crafts. Lafia's residents also participate in a number of other kinds of business, but agriculture is still the main source of their income.

Sample Collection

For this study, four commonly consumed leafy vegetables some of which are often eaten raw were purchased at random from the markets and farms in Jos and Lafia. They included Cabbage (*Brassica oleracea*), Spring onion (*Allium sp*), African spinach (*Amaranthus cruentus*), and lettuce (*Lactuca sativa*). 96 vegetable samples, comprising 6 of each vegetable type (twenty four samples from farm and market for each study area), were selected. Samples collected were placed in sterile, labeled polythene bags and transported to the Parasitology Laboratory of the National Veterinary Research Institute (NVRI), Vom, for examination.

Laboratory Analysis

Each vegetable sample was soaked in 10% formal saline (150 ml) for about two hours, and then it was washed to dislodge parasitic stages from the vegetables. The washing solution was transferred into centrifuge tubes and centrifuged at 3000 rpm for five minutes (Idahosa, 2011). After centrifugation, the supernatant was carefully siphoned off without shaking the content of the tube and the remaining sediment was agitated gently by hand for redistributing the parasitic stages (Ebrahimzadeh *et al.*, 2013). Three slides were prepared to enhance the chances of parasite detection. A drop of the sediment was taken from the centrifuge tube to create a wet smear. It was then put on a clean slide and covered with a clean cover slip for microscopic inspection using 10x and 40x objective lenses. To observe eggs, cysts, and oocysts, iodine-stained smears were made by adding a little drop of Lugol's iodine solution before cover slipping to a slide that had been prepared identically for the unstained smear (El Said-Said, 2012; Gboeloh *et al.*, 2022). Morphological traits were used to identify the eggs/cysts.

Analysis of Data

Minitab Statistical Software version 2.1.2 was used to analyze the data, descriptive statistics (Percentages), and the chi square (X^2) test was applied to evaluate differences in contamination between locations, sources (farm versus market), and vegetable types. Statistical significance was set at $p < 0.05$.

Result

Result from the study of the different vegetables sampled were linked to six different parasites. This included *Entamoeba histolytica*, Hookworm, *Entamoeba coli*, *Strongyloides stercoralis*, mites, and *Fasciola hepatica*. The stages of parasites detected are Larva of Hookworm which recorded the highest prevalence of parasites with 17(37.78%) followed by mites with 11(24.44%), ova of hookworm 9(20.00%), Larva of *S. stercoralis* recorded 4(8.89%) while Cyst of *Entamoeba histolytica*, *Fasciola hepatica*, Ova of *S. stercoralis* and Cyst of *Entamoeba coli* recorded the least prevalent of parasites with 1(2.22%) each. Markets in Jos had the highest prevalence of parasites out of the two sites studied in both areas, based on the prevalence of parasites by location with 16(35.56) followed by markets in Lafia with 11(24.44) then farm in Jos which recorded 10(22.22) while farm in lafia recorded the least prevalence of parasites with 8(17.77). Although no significant differences ($\chi^2 = 0.008$, $df = 1$, $p\text{-value} = 0.929$) was observed in the parasites of the two study area.

Vegetables collected from Jos recorded a higher contamination rate (57.78%) compared with those from Lafia (42.22%), though statistical analysis did not indicate a significant difference between the two locations ($p > 0.05$). Cabbage and lettuce in Jos were more contaminated with parasite with the

prevalence of (20.00%) than Cabbage and Lettuce in Lafia which have the parasitic contamination of (15.56%) and (11.11%). Spring onion (4.44%) sampled in Jos were more contaminated with parasite than that of Lafia (2.22%). However spinach sampled in the two study area recorded the same rate of parasitic contamination with (13.33%) each. Larva of Hookworm recorded the highest prevalence in both the sample area (47.37%, 30.77%), followed by mites which were more prevalent in Jos (26.92%) than Lafia (21.05%). Ova of Hookworm were more prevalent in Jos 7(26.92%) than Lafia. Also Ova of *S. Stercoralis* were more prevalent in Jos (5.26%) than Lafia (3.48%). Cyst of *Entamoeba Histolytica*, *Fasciola hepatica* and Cyst of *Entamoeba coli* were only recorded in vegetables sampled in Jos with (3.84%), (3.34%) and (3.84%) prevalence each. While larva of *S. Stercoralis* 3(15.79) was only recorded in vegetables sampled in Lafia. No statistically significant association was observed between vegetable type and parasitic contamination ($p > 0.05$) in the study locations

Table 1: Overall parasite prevalence on vegetables in the two study area

PARASITES	LAFIA		JOS		Total (n=96)	
	Market (%)	Farm (%)	Market (%)	Farm (%)	Market (%)	Farm (%)
<i>Cyst of Entamoeba Histolytica</i>	0(0.00)	0(0.00)	0(0.00)	1(10.00)	1(2.22%)	1(2.22%)
<i>Cyst of Entamoeba coli</i>	0(0.00)	0(0.00)	1(6.25)	0(0.00)	1(2.22%)	1(2.22%)
<i>Fasciola hepatica</i>	0(0.00)	0(0.00)	0(0.00)	1(10.00)	1(2.22%)	1(2.22%)
Ova of <i>S. stercoralis</i>	1(9.09)	0(0.00)	0(0.00)	0(0.00)	1(2.22%)	1(2.22%)
Larva of <i>S. stercoralis</i>	0(0.00)	3(37.50)	1(6.25)	0(0.00)	4(8.89%)	4(8.89%)
Ova of Hookworm	2(18.18)	0(0.00)	4(25.00)	3(30.00)	9(20.00%)	9(20.00%)
Mite	4(36.36)	0(0.00)	6(37.50)	1(10.00)	11(24.44%)	11(24.44%)
Larva of Hookworm	4(36.36)	5(62.5)	4(25.00)	4(40.00)	17(37.78%)	17(37.78%)
Total	11(24.44)	8(17.77)	16(35.56)	10(22.22)	45(46.88%)	45(46.88%)

No significant differences ($\chi^2 = 0.008$, $df = 1$, $p\text{-value} = 0.929$) was observed in the parasites of the two study area

Table 2: The prevalence of parasitic contamination on different vegetables in the two study areas

PARASITES PREVALENCE ON THE VEGETABLE BASED ON THE									

TWO LOCATIONS									
	Cyst of <i>Entamoeba Histolytica</i> (%)	Ova of Hookworm (%)	Larva of Hookworm (%)	<i>Fasciola hepatica</i> (%)	Mite (%)	Larva of <i>S. Stercoralis</i> (%)	Ova of <i>S. Stercoralis</i> (%)	Cyst of <i>Entamoeba coli</i> (%)	Total (n=96)
Locations									
Lafia									
Lettuce	0(0.00)	1(50.00)	4(44.44)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	5(11.11%)
Cabbage	0(0.00)	1(50.00)	2(22.22)	0(0.00)	0(0.00)	3(100)	1(100)	0(0.00)	7(15.56%)
Spring onion	0(0.00)	0(0.00)	0(0.00)	0(0.00)	1(25.00)	0(0.00)	0(0.00)	0(0.00)	1(2.22%)
Spinach	0(0.00)	0(0.00)	3(33.33)	0(0.00)	3(75.00)	0(0.00)	0(0.00)	0(0.00)	6(13.33%)
TOTAL	0(0.00)	2(10.53)	9(47.37)	0(0.00)	4(21.05)	3(15.79)	1(5.26)	0(0.00)	19(42.22)
Jos									
Lettuce	0(0.00)	2(28.57)	4(11.11)	0(0.00)	3(11.11)	0(0.00)	0(0.00)	0(0.00)	9(20.00%)
Cabbage	0(0.00)	2(14.29)	3(22.22)	1(11.11)	2(0.00)	0(0.00)	1(0.00)	0(0.00)	9(20.00%)
Spring onion	0(0.00)	2(14.29)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	0(0.00)	2(4.44%)
Spinach	1(100)	1(14.29)	1(11.11)	0(0.00)	2(0.00)	0(0.00)	0(0.00)	1(0.00)	6(13.33%)
TOTAL	1(3.84)	7(26.92)	8(30.77)	1(3.34)	7(26.92)	0(0.00)	1(3.48)	1(3.84)	26(57.78)

No significant differences ($\chi^2 = 0.670$, $df = 3$, $p\text{-value} = 0.880$) was observed between the vegetables sampled in the study locations

DISCUSSION

The present study demonstrates that leafy vegetables sold in Jos and Lafia are commonly contaminated with parasitic organisms, posing potential risks to public health. A total of six parasites were identified with an overall contamination rate of 46.88% which indicates that nearly half of the vegetables examined carried at least one parasitic stage. The parasites include *Entamoeba histolytica*, Hookworm, *Entamoeba coli*, *Strongyloides stercoralis*, mites, and *Fasciola hepatica*. Similar studies have been carried out to evaluate the status of contamination of vegetables with medically important parasites by (Maikai *et al.*, 2012; Caradonna *et al.*, 2018; Karshima *et al.*, 2018; Li *et al.*, 2019). The result is consistent with findings reported from Egypt by (Hassana *et al.*, 2012), Nigeria (Simon-Oke *et al.*, 2014; Dorathy *et al.*, 2024) and Sudan (Mohamed *et al.*, 2016). But it is lower than the prevalence of (82.69%) reported by Ozor, Amarachi & Kinjir, (2024) in Jos and (57.33%) reported by Adegbe *et al.* (2020) in Abuja. The prevalence observed in this study is higher than the (37.5%) reported from Lafia by Abe *et al.*, (2016),

20% by Akyala *et al.* (2013) in Alhamis, Lafia, Nasarawa State; 21.6% reported by Agbalaka *et al.* (2019) and 36% of contamination on vegetables reported in Jos by Damen *et al.* (2007). The high prevalence found in the present study could be as a result of improper handling of the vegetables by farmers, transporters, and vegetable vendors who wash their produce with tainted water to keep it fresh and draw buyers, or it could be because the study was carried out during the early rainy season, when water bodies were washing human and animal waste into farmlands where vegetables were grown awaiting harvest. Differences in contamination levels observed across studies conducted in various regions may be attributed to variations in environmental conditions, agricultural practices, sanitation standards, and sampling seasons. The stages and species of parasites detected are Larva of Hookworm which recorded the highest prevalence of parasites with 17(37.78%) this is similar to the findings of Adegbe *et al.* (2020), Hamed *et al.* (2021) and Duedu *et al.* (2014) while it differ from the report of Abe *et al.* (2016) and Fagbenro *et al.* (2016) who reported *Ascaris lumbricoides* as the most dominant parasites on the vegetables in their study. Findings from this present study might be due to the fact that hookworm has a free living stage in the soil which can be easily transmitted to new host, in addition to its parasitic mode of life. The predominance of hookworm larvae observed in this study may also be linked to favorable environmental conditions that support larval survival in moist soils, particularly during the rainy season. Furthermore the use of organic manure and contaminated irrigation water may further facilitate the transfer of infective stages onto vegetable surfaces (Silver *et al.*, 2018). The second highest parasites recorded in these study are mites with 11(24.44%), ova of hookworm recorded 9(20.00%), Similar to other studies, we found the occurrence of Larva of *S. stercoralis* 4(8.89%), although lower than the result reported by Hotez *et al.* (2004) from Ethiopia. This observation might have been influenced by the dual life stages of the worm, with the free living stage reported to be abundant on soils (Tefera *et al.*, 2014; Mogaji *et al.*, 2017) while Cyst of *Entamoeba histolytica*, *Fasciola hepatica*, Ova of *S. stercoralis* and Cyst of *Entamoeba coli* recorded the least prevalent of parasites with 1(2.22%) each which concurs to the finding of Sia Su *et al.* (2012) were frequency of *Entamoeba coli* was 2.5% and *Entamoeba histolytica* was 0.6%. However, higher frequency of *Entamoeba coli* contamination were detected (19.04%) in South Western Saudi Arabia, and *Entamoeba histolytica* was 3.1% in the same study by Al-Binali *et al.*, (2006). Prevalence of parasites in relation to location shows that among the two locations sampled in both areas markets in Jos recorded the highest prevalence of parasites with 16(35.56) followed by markets in Lafia with 11(24.44) then farm in Jos which recorded 10(22.22) while farm in lafia recorded the least prevalence of parasites with 8(17.77) in both locations parasitic contaminations were more in markets in the study areas. The higher contamination levels recorded in market samples compared with farm samples highlight the contribution of post-harvest handling, transportation, and market hygiene to parasite transmission. Exposure of vegetables to flies, dust, contaminated water, and unsanitary surfaces during marketing may increase the likelihood of contamination (Oranusi *et al.*, 2012). No significant difference was observed between the parasites of the two study area.

Vegetables sampled in Jos recorded higher parasitic contamination with (57.78%) than Lafia which recorded (42.22%). Given Jos's status as the center of vegetable production and the fact that many other urban and suburban settlements in North-Central Nigeria, including Abuja, the country's capital, rely heavily on it for their vegetable supplies, the results of this study are even more important. The discrepancies observed in the results could be caused by variations in how these vegetables are transported from the farms to the marketplace, as well as by unsanitary conditions and local weather, because Jos in Plateau State receives more rainfall than Lafia Local Government. In Jos, Lafia, and other

parts of Nigeria, cabbage and lettuce are usually eaten raw or partially cooked. Therefore, proper handling and washing are necessary before consumption to prevent disease transmission. The parasite contamination of cabbage and lettuce in Jos was higher than that of Lafia. Although spring onions had the lowest rates of parasite contamination among the leafy vegetable samples taken from the two locations during this investigation, samples of spring onions from Jos were more infested with parasites (4.44%) than those from Lafia (2.22%). According to reports, spring onions are rich in volatile sulfur-containing compounds and can either prevent or treat a number of helminth and parasitic protozoal disorders (Gîtin et al., 2014; Cheraghipour et al., 2019). Thus, more research on the health advantages of spring onions, particularly with regard to intestinal parasites, ought to be taken into account. The result is in contrast to some earlier research on vegetable parasite contamination, which found that spring onions had the highest parasite prevalence (Al Binali et al., 2006; Nyirenda et al., 2021). The variations may be attributed to the environmental and human elements that are prevalent in the various research areas and are related to its processing, transportation, and production. However, the rate of parasite contamination in spinach samples from the two study areas was the same, at 13.33% each. Larva of Hookworm recorded the highest prevalence in both the sample area (47.37%, 30.77%), followed by mites which were more prevalent in Jos (26.92%) than Lafia (21.05%). Ova of Hookworm were more prevalent in Jos 7(26.92%) than Lafia. Also Ova of *S. Stercoralis* were more prevalent in Jos (5.26%) than Lafia (3.48%). Cyst of *Entamoeba Histolytica*, *Fasciola hepatica* and Cyst of *Entamoeba coli* were only recorded in vegetables sampled in Jos with (3.84%), (3.34%) and (3.84%) prevalence each. While larva of *S. Stercoralis* 3(15.79) was only recorded in vegetables sampled in Lafia. Although no significant difference was observed between the vegetables sampled in the study locations. The absence of statistically significant differences between locations and vegetable types suggests that parasitic contamination is a widespread problem affecting multiple points along the farm-to-market chain.

CONCLUSION

This study confirms that leafy vegetables sold in Jos and Lafia are frequently contaminated with parasites of public health importance. As the study revealed contaminations with parasites such as *Entamoeba histolytica*, Hookworm, *Entamoeba coli*, *Strongyloides stercoralis*, mites, and *Fasciola hepatica*. With an overall prevalence of 46.88% from the two locations sampled. Vegetables sampled in Jos recorded higher parasitic contamination with (57.78%) than Lafia which recorded (42.22%). Cabbage and lettuce which showed high prevalence of parasitic contamination than the other vegetables observed in the study where more contaminated in Jos with parasite than Cabbage and Lettuce in Lafia. Market samples exhibited higher contamination levels than farm samples, emphasizing the need for improved hygiene during transportation, storage, and marketing. Given that many leafy vegetables are consumed raw or lightly cooked, consumers are at risk of acquiring parasitic infections if proper washing and food safety practices are not observed. Public health education targeting farmers, vendors, food handlers, and consumers should be strengthened. The use of clean water for irrigation and washing, improved sanitation around farms and markets, and thorough washing and adequate cooking of vegetables before consumption are recommended to reduce the burden of foodborne parasitic infections.

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The author(s) declare that it is not applicable.

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Competing interests

The author(s) declare that they have no competing interests.

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