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Assessment of Parasitic Contaminations of Commonly Consumed Vegetables Sold in Two Markets in Jos South L.G.A, Plateau State

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Abstract:- Vegetables serves is a rich source of minerals and roughages that are essential for maintenance of good health and prevention of diseases but can as well serve as a source of parasitic pathogens to man. Intestinal parasites are known to cause significant morbidity and mortality worldwide particularly in underdeveloped countries such as Nigeria. The rate of consumption of raw and undercooked vegetable which can serve as a means of transmission of intestinal parasite to people is high especially in Jos. This study was to determine parasitic contamination of commonly consumed vegetables sold in two markets in Jos South LGA. A total of 260 samples of fresh vegetables; Tomato, Carrot, Lettuce, Cabbage and Spinach were purchased from vendors and examined for parasitic contamination using ordinary centrifugation method. Out of 260 samples examined, 215 (82.69%) were contaminated with at least one type of parasite. *Strongyloides stercoralis, Entamoeba coli, Entamoeba histolytica, Ascaris lumbricoides, Hookworm, Giardia lamblia, Taenia species, Enterobius vermicularis,* and *Mite* accounted for 72.02%, 13.10%, 6.15%, 3.97%, 3.77%, 0.40% and 0.20% respectively in this study. Lettuce, Spinach, Cabbage, Carrot and Tomatoes accounted for 28.13, 22.18%, 21.15%, 15.61%, and 12.94% respectively with overall parasitic prevalence of 82.69%. *Strongyloides stercoralis* is the most prevalent parasite seen while *Taenia specie, Enterobius vermicularis*, and *Mite* are the least parasites seen. Lettuce has the highest contamination rate of 137 (28.13%) followed by Spinach 108 (22.18%) while Tomatoes 63 (12.94%) had the least contamination. The findings of the study suggest that there is potential high risk of acquiring parasitic infection from consumption of raw and undercooked vegetables sold in Jos South LGA, Plateau State. There should be proper washing and cooking of these vegetables before consumption since they can serve as source of transmission of parasites to man when eaten raw or undercooked.

Keywords:- *Vegetables, Parasites, Ordinary Centrifugation Method, Two Markets, Jos South.*

I. INTRODUCTION

Vegetables are savory food source that improves appetite and supply consumer with fibers, protein, flavor, essential oils and flavonoid (Fagbenro, Mogaji, Oluwole, Adeniran, Alabi, Ekpo., 2016). They are highly beneficial for maintenance of health and prevention of diseases (Taha, Ayse, Onur, Funda., 2018). The presence of intestinal parasites on vegetables has been reported in several parts of Nigeria including Jos (Agbalaka, Ejinaka, Yakubu, Obeta, Jwanse, Dawet., 2019). Intestinal parasites can be transmitted

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via ingestion of contaminated foods such as vegetables or drinking of ontaminated water or direct eating with contaminated hands (Alemu, Nega, Alemu., 2020). In Nigeria, the transmission of intestinal parasitic infection through eating of contaminated vegetables has been considered to increase due to the regular use of untreated human or animal excretas as manure in cultivation by peasant farmers, which serves as a source of parasitic infestation to man (Agbalaka et al., 2019). The cultivation of vegetables for commercial and domestic purposes in Jos is mostly carried out by local farmers who depend on irrigation and or natural rainfall to water their farmland. Most farmers use untreated animal dung and human excreta as manure, which are known to contain various species of parasites that are of medical and veterinary importance. For the cultivation of these vegetables, the climate, vegetation and topography of the area have to be suitable.

Vegetables are grown throughout the year in Jos Plateau state, depending on the rain during wet season and irrigation during dry season. Irrigation water is derived from two sources; river and mine ponds. These two sources may be highly polluted with animal and human excreta's (Damen, Banwat, Egah, Allanana., 2007). Consumers may not care to wash these contaminated vegetables or properly cook them before consumption. This oversight exposes them to high risk of acquiring parasitic infection. Studies conducted on various vegetables had shown that *Ascaris lumbricoides, Entamoeba histolytica, Entrobius vermicularis, Giardia lamblia, Hookworm, Taenia species, Trichuris trichuria, Hymenolepis spp,* can infect humans who consume contaminated vegetables without proper cooking, or proper washing before consumption (Alemu et al., 2020). The widespread habit of consuming contaminated raw or minimally cooked vegetables has increase the chances of hand-to-mouth transmission of these parasites (Fagbenro et al., 2016). Moreover vegetables such as carrot, tomatoes, lettuce, spinach and cabbage are frequently consumed raw or half-cooked to preserve the taste. These practice contribute to the ways these vegetables can serve as important vehicles for parasitic transmission in human (Abdullahi, H., 2021). Epidemiological studies indicated that the numbers of reported cases of food-borne illness due to consumption of raw vegetable has been increasing and continues to be a common and serious threat to public health in endemic areas for intestinal parasites (Seyyedeh, Mahmoodeza, Abbas, Amirhossein, Rahmat., 2021, Alemu et al., 2020).

Consumption of poorly prepared vegetables such as cabbage, tomatoes, carrot, spinach and lettuce is considered to be an important factor for human parasitic infections (Tsegahun, Deribew, Demissew, Tassew, Yosef, Berhanu., 2023, Alemu et al., 2020, Agbalaka et al., 2019). The Protozoa's (*Giardia lamblia, Entamoeba histolityca, Cryptosporidium spp, Cyclospora yetanenensis*) are the most common protozoa to cause intestinal infection (Andrew, Nobert, Joachim., 2019, Rashidul., 2007). Vegetables can become contaminated with parasitic pathogens through the process from planting to consumption. Use of human and animal feaces as natural fertilizer and untreated waste water for irrigation during cultivation phase is the main contributing factor before the harvesting phase (Alemu et al., 2020, Anthony, Isaac, Thor, Mathew, James., 2018). Most local farmers in developing countries use untreated human and animal waste as fertilizer and waste water for irrigation, contributing to increased transmission of intestinal parasites (Alemu et al., 2020, Anthony et al., 2018). Hygienic standards for storage, transmission and marketing conditions, catering and processing for consumption play an important role in the post-harvest stage (Tsegahun et al., 2023).

Vegetables are attractive when they are fresh. They can be cultivated in small gardens for family consumption or in a bigger farm and sold in different markets. Most of the fresh vegetables in Nigeria are sold directly as harvested from the farm, without preliminary washing, cleaning or processing. Vegetable contain essential nutrient and mineral for good health (Joanne & Beate., 2012). Vegetable sellers in most cases tend to wash their goods with untreated water from river and stream that may contain effective stage of a parasite and the vegetables in most cases are displayed openly to attract buyers and exposed in market places where they could get contaminated as well. Consumer may not care to wash these contaminated vegetables, or properly cook them before consumption. This negligence exposes them to higher risk of acquiring parasitic infection (Alemu et al., 2020, Tamirat, Abdissa, Zeleke, Teferi., 2014).

Vegetables can act as a potential source for the spreading of various infections and parasitic disease (Ahmed, Teshome, Tariku, Jiru, Abdusemed, Jafer., 2024, Dima, Marwan, Angel, Iman, Issmat, Sara, Fouad, Monzer., 2023, Khana, Rafiqb, Nawazc, Kabird, Farooqie, Rommanf, Parvezg, Alfarrajh, Noori, Ujjanj., 2022). Parasitic diseases can be considered among the most common diseases on earth, which are transmitted to humans through water, soil, and the vegetables (Seyyedeh et al., 2021,). Vegetables, especially salads are important route of transmission of intestinal parasites and have been shown to be an important source of food-borne outbreaks in developing countries (Fitsum & Teha., 2019). Consumption of unwashed, raw and un-hygienically prepared vegetables is considered a risk factor for man's parasitic infections. There has been increase in the number of reported cases of food borne-illness linked to fresh vegetables. Epidemiology of human intestinal parasite is traced to the consumption of raw vegetables which play a major epidemiological role in the transmission of parasitic food borne disease (Behnam, Asma, Behzad, Mahmood, Mohammad., 2021, Alemu et al., 2020). Many outbreaks of the protozoan infection in human have been linked to raw fruits and vegetables. Epidemiological studies have indicated that, in areas where parasitic disease are endemic in the population and where waste water is used to irrigate vegetables which are eaten raw, the consumption of waste water irrigated fruits and vegetables without proper washing might have led to parasitic infection (Agbalaka et al., 2019, Kudah, Simon, Frank., 2018). It is very necessary that vegetables should be cultivated, stored and distributed under safe hygienic methods in other to control parasitic contamination of vegetables. Whenever vegetables are bought they must be properly washed with clean and germ free water, and/or cooked before consumption to prevent

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parasitic infections (Yahaya, Bishop, Umar, Enoch, Markus., 2023).

The justification of this study is based on the fact that intestinal parasites are known to cause significant morbidity and mortality worldwide, particularly in developing countries such as Nigeria. The rate of consumption of raw or undercooked vegetables in order to preserve, which serves as one of the ways parasites can be transmitted to man worldwide is high, especially in Jos. This study is to assess the parasites associated with vegetables sold in Jos south, Plateau state, Nigeria. There is increase in the consumption of vegetables due to general awareness of the health benefits. Knowledge gained from this study will guide healthcare workers on proper education of peoples on the need to properly wash/cook their vegetables before consumption.

The aim of this study is to assess the parasitic contamination of commonly consumed vegetables sold in two markets (Bukuru and Vom market) located in Jos south local government area, Plateau state Nigeria with the following objectives:

- To find out the most commonly found parasites in the vegetables sold in Jos South.
- To find out the vegetables with the most probable parasitic contamination in Jos South.

II. METHOD

A. Study Area

The study was conducted in two markets (Bukuru and Vom market) located in Jos south local government area, Plateau state Nigeria.

B. Sample Size

Sample size was calculated using the prevalence formula:

$$n = \frac{Z2\ P(1-P)}{d2}$$

Where:
n = sample size
Z = level of confidence at 95% (1.96)
p = local prevalence 21.6 (0.216)
1-P = 1-0.216
d = precision at (5%) = (0.05)

$$n = \frac{1.962 \times 0.216(1-0.216)}{0.052}$$

$$n = \frac{3.8416 \times 0.216(0.784)}{0.0025}$$

$$n = \frac{0.6505519104}{0.0025}$$

n=260.22
n= 260 samples

A total of 260 fresh vegetables was collected; 50 carrots, 50 cabbage, 50 tomatoes, 55 spinach and 55 lettuce and was bought from different tables/wheel barrow and floor within Bukuru and Vom market.

C. Specimen Collection

Specimen were bought early in the morning around 8am-9am from different spots (on tables/wheel barrow and floor) packaged separately into a polythene bags, labeled and transported to Parasitology department of FCVMLT VOM for laboratory analysis.

D. Specimen Analysis

Samples were analyzed by Ordinary Centrifugation Method using Normal Saline and Lugol's Iodine.

- With Normal Saline: The samples were washed with 20ml of normal saline , The sediment was centrifuged at 3000rpm for 5minutes, The supernatant was decanted, The deposit was transferred unto a clean grease free slide and cover with cover slip avoiding air bubbles and over floating, The slide was examined with x10 objective lens and confirm with x40 objective lens microscopically.
- With Lugol's Iodine: The samples were washed with 20ml of normal saline, The sediment was centrifuged at 3000rpm for 5minutes, The supernatant was decanted, The deposit was transferred unto a clean grease free slide, A drop of Lugol's iodine was added, It was covered with cover slip avoiding air bubbles and over floating, The slide was examined with x10 objective lens and confirm with x40 objective lens microscopically.

III. RESULTS

Out of 260 samples of vegetables examined for parasitic contamination, 135 of the samples were from Bukuru market while 125 samples were from Vom market. One hundred and two 102 (75.56%) samples were positive for parasitic contamination while 33 (24.44%) samples were negative for parasitic contamination on samples bought from Bukuru market. In Vom market, 113 (90.4%) samples were positive for parasitic contamination while 12 (9.6%) samples were negative for parasitic contamination.

Combining the two markets (Bukuru and Vom), 215 (82.98%) samples were positive for parasitic contamination while 48 (17.02%) were negative for parasitic contamination. Among the parasites isolated from the samples examined are *S. stercoralis, A. lumbriciodes, Giardia lamblia, Taenia specie, Mite, E. histolytica, E. coli, E. vermicularis*, and *hookworm*. The vegetables examined are tomatoes, spinach, cabbage, carrot and lettuce.

Table 1 indicates different number of vegetables bought from floor and table/wheel barrow in Bukuru and Vom market. A total of 25 samples each were analyzed for tomatoes, carrot and cabbage while 35 samples were analyzed for spinach and lettuce from samples bought in Bukuru market. In Vom market, 25 samples each were bought and analyzed across all vegetables.

Table 2 indicates the number of positive and negative samples from different vegetables bought at Bukuru and Vom market. At Bukuru market, a total of 70 samples were purchased from the floor while 65 samples were purchased from tables/wheelbarrow. On the 70 samples from the floor,

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55 (78.57%) were positive for parasites while 15 (21.43%) were negatives for parasites. 47 (72.32%) samples out of 65 samples purchased from tables/wheelbarrow were positive for parasitic contamination while 18 (27.70%) were negative for parasitic contamination. A total of 65 samples were purchased from the floor at Vom market while 60 samples were purchased from tables/wheelbarrow. 64 (98.46%) were positive while 1 (1.54%) samples were negative for parasitic contamination in samples purchased from floor. For samples purchased from tables/wheelbarrow 49 (81.67) were positive for parasites while 11(18.34) were negative for parasites.

Table 3 indicates the total number for different parasites seen in different vegetables bought at Bukuru market. Carrots had the highest number seven (7) of different parasitic specie contamination while spinach had the lowest number three (3) of different parasitic specie contamination, none of the vegetables analyzed were free from parasitic contamination.

Table 4 indicates total number of different parasitic specie seen in different vegetables bought from Vom market. Cabbage had the highest number six (6)of different parasitic specie contamination while lettuce had the lowest number four (4)of different parasitic specie contamination. None of the vegetables analyzed were free from parasitic contamination.

Table 5 indicates the total number of parasites seen and their percentage contribution to the overall parasites seen in different vegetables bought from Bukuru and Vom markets. Nine parasitic species were isolated from the samples analyzed. *S. stercoralis* was the highest in number 363 (72.02%) seen across all vegetables while mite 1(0.20%), *Taenia specie* 1 (0.20%), and *Enterobius vermicularis* 1(0.20%) were the least parasites seen across all vegetables.

Table 6 indicates the total number of parasites seen in different vegetables bought at Bukuru and Vom market. Lettuce had the highest number of parasitic contamination followed by spinach, cabbage and carrot while tomatoes had the least number of parasites seen. Lettuce 137(28.13%), spinach 108 (22.18%), cabbage 103 (21.15%), carrot 76 (15.61%), and tomatoes 63 (12.94%).

Table 7 indicates the total number of positive and negative samples displayed in floor and tables wheelbarrow in Bukuru and Vom market. In Bukuru market, 72 samples were purchased from the floor which have 55 (76.39%) positive and 17 (23.61%) negative for parasites. 53 (81.54%) out of 65 samples purchased from tables/wheelbarrow were positive while 12 (18.46%) were negative for parasites in Vom market, 64 (98.46%) out of 65 samples purchased from the floor were positive while 1(1.54%) is negative for parasites. For samples purchased from tables/wheelbarrow, 49 (81.67%) were positive for parasites while 11 (18.33%) were negative.

Table 1: Different Number of Vegetables Bought from Floor and Tables/Wheel Barrow in Bukuru and Vom Market.

Bukuru Market	**Tomatoes**	**15**	**10**	**25**
	Carrot	15	10	25
	Spinach	20	10	30
	Lettuce	10	20	30
	Cabbage	10	15	25
Vom market	Tomatoes	10	15	25
	Carrot	10	15	25
	Spinach	10	15	25
	Lettuce	20	5	25
	Cabbage	15	10	25
Total		135	125	260

Table 2: Number of Positive and Negative Samples from Different Vegetables bought from Bukuru and Vom Market Floor

BUKURU MARKET		**Table/wheelbarrow**			
		Positive (%)	**Negative (%)**	**Positive (%)**	**Negative (%)**
Vegetables	Cabbage	10 (18.18)	0(0.00)	12 (18.46)	3 (4.62)
	Carrot	12 (17.14)	3 (4.29)	7 (10.77)	3 (4.62)
	Lettuce	8 (14.55)	2 (2.86)	7 (10.77)	3 (4.62)
	Spinach	18 (25.71)	2 (2.86)	15 (23.08)	5 (7.69)
	Tomatoes	7 (10.00)	8 (11.43)	6 (9.23)	4 (6.15)
Total		55 (78.57)	15 (21.43)	47 (72.3)	18 (27.70)
VOM MARKET					
Vegetables	Cabbage	15 (23.08)	0(0.00)	10 (16.67)	0(0.00)
	Carrot	10 (15.38)	0(0.00)	8 (13.33)	7(11.67)
	Lettuce	20 (30.77)	0(0.00)	4 (6.67)	1(1.67)
	Spinach	9 (13.85)	1(1.54)	12 (20.00)	3(5.00)
	Tomatoes	10 (15.38)	0(0.00)	15 (25.00)	0(0.00)
Total		64 (98.46)	1 (1.54)	49 (81.67)	11 (18.34)

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Table 3: Total Number of Different Parasites Seen in Different Vegetables bought from Bukuru Market.

VEGETABLES	PARASITE SEEN	TOTAL (%)
Cabbage	Larva of *A. Lumbriciodes*	2 (4.55)
	Cyst of *E. coli*	5 (11.36)
	Cyst of *E. histolytica*	3 (6.82)
	Egg of *hookworm*	4 (9.09)
	Larva of *S. stercoralis*	30 (68.18)
		40 (100)
Carrot	Larva of *A. Lumbriciodes*	1 (2.38)
	Cyst of *E. coli*	3 (7.14)
	Cyst of *E. histolytica*	3 (7.14)
	Cyst of *E. vermicularis*	1 (2.38)
	Trophozoite of *G. lamblia*	1 (2.38)
	Egg of *hookworm*	1 (2.38)
	Larva of *S. stercoralis*	32 (76.19)
		42 (99.99)
Lettuce	Larva of *A. Lumbriciodes*	3 (4.17)
	Cyst of *E. coli*	8 (11.11)
	Cyst of *E. histolytica*	3 (4.17)
	Egg of *hookworm*	1 (1.39)
	Larva of *S. stercoralis*	57 (79.17)
		72 (100.01)
Spinach	Cyst of *E. coli*	15 (26.79)
	Cyst of *E. histolytica*	5 (8.93)
	Larva of *S. stercoralis*	36 (64.29)
		56 (100.01)
Tomatoes	Larva of *A. Lumbriciodes*	2 (13.33)
	Cyst of *E. histolytica*	3 (20.00)
	Egg of *hookworm*	3 (20.00)
	Larva of *S. stercoralis*	6 (40.00)
	Egg of *Taenia. Specie*	1 (6.67)
		15 (100)

Table 4: Total Number of Different Parasites Seen in Different Vegetables Bought from Vom Market.

Vegetables	Parasites seen	Total (%)
Cabbage	Larva of *A. Lumbriciodes*	8 (11.59)
	Cyst of *E. coli*	7 (10.14)
	Cyst of *E. histolytica*	4 (5.80)
	Trophozoite of *G. lamblia*	1 (1.45)
	Egg of *hookworm*	3 (4 35)
	Larva of *S. stercoralis*	46 (66.67)
		69 (100)
Carrot	Larva of *A. Lumbriciodes*	2 (5.88)
	Cyst of *E. coli*	3 (8.82)
	Cyst of *E. histolytica*	3 (8.82)
	Trophozoite of *G. lamblia*	1 (2.94)
	Larva of *S. stercoralis*	25 (73.53)
		34 (99.99)
Lettuce	Cyst of *E. coli*	9 (12.33)
	Cyst of *E. histolytica*	3 (4.11)
	Egg of *hookworm*	5 (6.85)
	Larva of *S. stercoralis*	56 (76.71)
		73 (100)
Spinach	Cyst of *E. coli*	7 (13.46)
	Cyst of *E. histolytica*	1 (1.92)
	Egg of hookworm	1 (1.92)
	Mite	1 (1.92)
	Egg of hookworm	42 (80.77)

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		52 (99.99)
Tomatoes	Larva of *A. Lumbriciodes*	2 (5.88)
	Cyst of *E. coli*	9 (18.75)
	Cyst of E. *histolytica*	3 (8.82)
	Egg of *hookworm*	1 (2.08)
	Larva of *S. stercoralis*	33 (68.75)
	Total	48 (100)

Table 5: Total Number of all the Parasites Seen in all the Vegetables

Parasites	**Numbers Seen Percentage (%)**
Larva of A. *Lumbriciodes*	20 (3.97)
Cyst of *E. coli*	66 (13.10)
Cyst of *E. histolytica*	31 (6.15)
Cyst of *E. vermicularis*	1 (0.20)
Trophozoite of G. *lamblia*	2 (0.40)
Egg of *hookworm*	19(3.77)
Mite	1 (0.02)
Larva of S. *stercoralis*	363 (72.02)
Egg of *Taenia spp*	1 (0.20)
Total	504 (100.01)

Table 6: Total Number of Parasites Seen in Different Vegetables Bought from Bukuru and Vom Market

Vegetables	**Total parasites seen (%)**
Cabbage	103 (21.15)
Carrot	76 (15.61)
Lettuce	137 (28.13)
Spinach	108 (22.18)
Tomatoes	63 (12.94)
Total	487(100.01)

Table 7: Total Number of Positive and Negative Samples in both Bukuru and Vom Market Displayed in Floor and Table/Wheelbarrow

Bukuru Market		
	Positive (%)	**Negative (%)**
Floor	55 (78.57)	15 (21.43)
Table	47 (72.31)	18 (27.50)
	Vom market	
Floor	64 (98.46)	1 (1.54)
Table	49 (81.67)	11 (18.33)
TOTAL	Bukuru 102	33
	Vom 113	12

KEY:
A. lumbricoides: Ascaris lumbricoides
E. coli: Entamoeba coli
E. histolytica: Entamoeba histolytica
E. vermicularis: Entamoeba vermicularis
G. lamblia: Gairdia lamblia
S. stercoralis: Strongyliodes stercoralis
T. spp: Taenia specie

IV. DISCUSSION

The presence of parasites on vegetables is a threat of public health significance, most importantly to the numerous effort and resources passed towards combating food borne diseases. Vegetables act as mode of transmission of pathogenic parasite (helminthes and protozoa) that are primarily transmitted through consumption of raw and undercooked vegetables. Contamination of these vegetables could be from different sources, such as the pre harvest period, during harvesting, post-harvest period, storage and during preparation for consumption. Intestinal parasites are widely prevalent in developing countries like Nigeria and especially here in Jos which could probably be due to improper hygiene, poor sanitation and environmental factors. Continued use of untreated waste water and human excreta as fertilizer for production of vegetables is a major contributing factors of parasitic contamination that causes numerous food borne disease outbreaks (Victoria et al., 2019).

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Out of 260 samples examined, 215(82.69%) were positive for parasites while 45(17.31%) were negative for parasite contamination. The high level of vegetable contamination observed in this study differ from result obtained by (Agbalaka *et al*,. 2019) who recorded 21.6% of intestinal parasite on green vegetables, 57.5% of parasitic contamination on vegetables was observed in Ghana (Kudah *et al.,* 2018), 36% of contamination on vegetables was observed in another study in Jos (Damen., 2007). High rate of contamination of green vegetables was detected in Tripoli, Libya where the study detected 58% for intestinal parasites as reported by (Abougraina *et al*., 2010). Examination of vegetables in Kenya in 2008 revealed a higher contamination of 65.5% as reported by (Nyarango *et al*., 2008). A study done in Khorramabad Iran by (Ezatpour *et al.,* 2013) reported a contamination rate of 79% while a lower rate of contamination was observed in Riyadh Saudi Arabia which recorded 16.2% (Al-megrm., 2010) and in Turkey 6.3% (Adanir & Tasci., 2013). The high prevalence recorded in this sturdy may be due to the fact that the study was conducted during rainy season where water body was washing human and animal excreta into farmlands where vegetables were cultivated awaiting harvest or may be due to the improper handling of the vegetables by farmers or transporters and vegetable sellers who use contaminated water to wash their vegetables in order to keep it fresh to attract buyers. However several other factors may contribute to differences observed in the contamination rate which may include geographical location, types and number of samples examined, method used for parasite examination of samples, types of water used for irrigation, post-harvest handling methods of the vegetables which are different from region to region and from one country to another. The variation in parasites observed may be due to geographical location of the study area or hygienic practices across the studied locations. Despite the variation in isolated parasites, larva of *Strongyloides stercoralis* (72.02%) was common to all the vegetables in this studies which agrees with the study done by Agbalaka *et al*., 2019. This could be due to the parasite having a parasitic and free living state and does not require an intermediate host for its contamination of vegetables. *Mite* (0.20%), *Taenia species* (0.20%), *Enterobius vemicularis* (0.20%) were the least numbers of parasites isolated across all the vegetables in this studies which differs from previous studies done by Agbalaka *et al.,* who found *Trichuris trichuria* as the least parasitic contamination across the vegetables they studied, and the work of Yahaya *et al*., 2023 who found cyst of *Entamoeba histolytica* as the least occurring parasite in their study. *Entamoeba coli* (13.10%) was the second most prevalent parasite in vegetables studied which is an indicative of fecal contamination from human and/or animal origin. As in many tropical climates, intestinal parasites are widely distributed not only due to favorable climatic conditions that support their survival and transmission of the parasites but also due to poor sanitary conditions that facilitate fecal contamination of water bodies, soil and farm produce especially vegetables. The highest contamination was detected in lettuce (28.13%) followed by spinach and cabbage, this may be due to the strong adhesion of the vegetables thereby successfully evading the effect of prior washing by vendors in the market.

Vegetable with the highest parasitic contamination from this study was lettuce (28.13%), spinach (22.18%), cabbage (21.15%), carrots (15.61%), and tomatoes (12.94%). This study is in variance with the work of Dawet *et al*., 2019 and Damen *et al*., 2007 who reported cabbage (66.67%) for Dawet *et al* and (64%) for Damen et al, as their vegetables with the highest parasitic contamination. The report of this work found tomatoes to be the least contaminated with parasite (12.94%) which is consistent with the work of Bekele & Shumbej 2019 who found tomatoes to be the least contaminated with parasites (24.4%) and Damen *et al.*, 2007 who also recorded tomatoes (20%) to be the least contaminated vegetables with parasites. The high prevalence of lettuce contamination (28.13%) in this study is in consonance with the work of Eraky *et al.*, 2014 who also recorded that lettuce was the highest contaminated vegetables (45.5%) in Bengha Egypt. On the two location studied, vegetables displayed on the floor had a high rate of parasitic contamination when compared to those displayed on tables/wheel barrow. Vegetables studied from Bukuru had a (78.57%) parasitic contamination for samples displayed on the floor when compared with (72.31%) of contamination for vegetables displayed on table/wheel barrow, also vegetables studied from Vom market had a (98.46%) of parasitic contamination for samples displayed on the floor while those displayed on tables/wheel barrow had (81.67%) contamination of parasites. This might be due to exposure to dust and other sand particles which may be a source of parasitic infections.

The results obtained from this study showed that the most commonly found parasites in the vegetable sold in two markets of Jos South L.G.A is *Strongyloides stercoralis* (72.02%), followed by *Entamoeba coli* (13.10%), *Entamoeba histolytica* (6.15%), *Ascaris lumbricoides* (3.97%), *Hookworm* (3.77%), *Gardia lamblia*, (0.40%), *Mite* (0.20%), *Taenia specie* (0.20%), *Enterobius vermicularis* (0.20%). The high rate of *Strongyloides stercoralis* contamination of vegetables agrees with the work of Kudah *et al*., 2018 who reported that the commonest parasites in their study was *S. stercoralis* (36.4%). The high prevalence of *S. stercoralis, E. coli, E. histolytica, A. lumbricoides* and other protozoa is an indication that soil/farmland were contaminated with fecal contamination. Also, water bodies that irrigate the farms is equally contaminated with human and animal excreta. Also, some of the farmland where the vegetables are cultivated and sold was located in rural/semi urban area as in the case of Vom market. Another factor that may play a role in the higher level of parasites found may be the use of contaminated water for irrigating vegetables on the farmland which could be potential source of contamination with these parasites. The contamination rate of Bukuru differed from Vom market; this might be associated with the unhygienic practice of the sellers and market conditions. Vegetables displayed on the floor had higher rate of contamination and this finding is in consistent with the findings of other researchers from different areas.

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The occurrence of high parasitic contamination highlights the role of vegetables in the transmission of parasitic diseases. This finding is consistent with similar report of Gupta *et al*., 2009 in India, Istifanus & Panda 2018 in Bauchi. This may be due to the epidemiological factors that make the spread of parasites high, especially in high population density, poor housing and poor sanitary condition of the studied area. The use of human and animal excreta as fertilizer in farms is another probable way of parasitic contamination of vegetables. It had been reported by Damen *et al*., 2007 that the use of untreated waste water and raw human feces as fertilizer is predominantly high in Jos. No significance relationship was found between different parasitic contamination and vegetable types but the contamination rate of spinach, lettuce and cabbage than other vegetables may be due to their foliage which offers great surface area for parasitic contamination either in farmland, during transport to the market, and open display on the floor in the market as equally reported by other researchers Dawet *et al*., 2019., Damen *et al.,* 2007 & Eraky *et al.,* 2014.

V. CONCLUSION

This study shows that the contaminated vegetables consumed in Jos south metropolis can be a major source of parasitic infection and may have serious public health implication. This shows the important role of consumption of raw and undercooked vegetables can play in the transmission of intestinal parasite in a new host and the need to improve the sanitary conditions in the two areas where our vegetables were collected from. The present study reveal that *S. stercoralis, E. coli, E. histolytica* and *A. lumbricoides* are the most prevalent parasites found on vegetables in Jos south L.G.A since the two market where our vegetable are purchased are the major market in this metropolis, and this can cause parasitic infection of different magnitude in Jos south metropolis. These findings raised concern of public health being at higher risk of infection with Strongyloidiasis, Amoebiasis, Ascariasis and others. Humans are at risk of getting infected from contaminated fresh vegetables eaten on daily basis. No vegetables that are bought from the two markets should be considered safe for direct raw consumption without proper washing, cooking of the vegetables. Proper sanitation and good personal hygiene should be performed to avoid transmission of intestinal parasites, and safe disposal of human and animal excreta which play a role in the epidemiology and control of these intestinal parasites.

RECOMMENDATION

Prevention of contamination is the most effective way of reducing food-borne parasitic infection. A comprehensive health education should be given to farmers, vendors and consumers on the risk associated with consumption of contaminated vegetables. Farmers should be motivated to use only digested human excreta as manure to grow their vegetables. Consumers should be enlightened/and educated on the need for proper washing of vegetables with saline water and proper washing, cooking before consumption. Media programs can be used to inform the studied area of the need about good sanitation, and personal hygiene and potential health risk of raw vegetables to prevent transmission of food-borne diseases. The vendors of these vegetables should avoid the contact of the vegetables with soil while on display since vegetables purchased from the floor had higher parasitic contamination than vegetable purchased from tables/wheel barrow. Further studies should be done by other researchers using higher number of samples in other to confirm/validate the higher prevalence reported in this study. Government/market authorities should make provisions for safe water, for washing of vegetables since water is being used by vendors to keep their vegetables fresh to attract buyers and contaminated water is one way of contaminating vegetables with different parasitic species.

- Conflict of Interests: The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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