

**EVALUATION OF PARASITIC CONTAMINATION OF SOME RAW VEGETABLE
IN KASUWAN DAJI MARKET, SOKOTO STATE**

A PROJECT REPORT

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CERTIFICATION

This is to certify that this project titled “Evaluation of Parasitic Contamination of Some Raw Vegetable In Kasuwan Daji Market, Sokoto State” was carried out by Mary Hillary Eneh with admission number 2010302082, a student of the Department of Biological Sciences, Usmanu Danfodiyo University, Sokoto, in partial fulfillment of the requirements for the award of the degree of Bachelor of Science (B.Sc.) in Biology.

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DEDICATION

This Research Project is dedicated to God almighty, My Beloved Parents, Mr. Hillary Odeh, Mrs Hajara Hillary, and to the loving memory of my dear sister Peace Ephraim. And to a good friend of mine Friday Idoko Godwin

ACKNOWLEDGEMENT

I give all glory, honour, and praise to God Almighty, whose unending grace, wisdom, and strength have guided me throughout the course of this research. His divine favour has been my source of courage and perseverance from the beginning to the completion of this work.

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ABSTRACT

Vegetables are essential compound of human diet, providing vital nutrient and health benefits, poor agricultural practices and unhygienic handling exposed vegetable to various parasitic contamination. This study investigate parasitic contamination of vegetables sold at Kasuwan Daji Market, Sokoto. A cross-sectional sampling of commonly consumed vegetables was conducted, and samples were examined for the presence of parasites by parasitological techniques. The results revealed notable levels of contamination, with Lettuce showing the highest prevalence of 18(100%), followed by Spinach 16(88.8%) and Cabbage 13(72.2%). Identified parasites included *Ascaris lumbricoides* 20(28.2%), *Giardia lamblia* 11(15.4%) *Entamoeba histolytica* 10(14.0%), *Trichuris trichura* 9(12.7%), *Cryptosporidium* 8(11.3%), *Ancylostoma duodenale* 7(9.9%), *Strongyloides stercoralis* 6(8.5%), indicating the presence of both protozoa and helminths. The result based on the vegetable hygiene by the vendors showed that 33.3% of vendors placed their vegetable on bench while 66.7% placed their vegetable on bare land. Also 79.6% do no wash vegetables before sale and only 20.4% do wash vegetables before sale. The findings identified that poor hygiene practices, inadequate washing, and exposure to contaminated water or soil contribute to the contamination burden. The study underscores the need for improved vegetable handling practices and increased public health awareness to reduce the risk of foodborne infections.

CHAPTER ONE

1.0

INTRODUCTION

1.1 Background of study

Vegetables are essential component of the human diet, providing vital nutrients and health benefits. In many parts of the world, including Nigeria vegetables form an important part of the daily food intake of the population. However despite their nutritional value, can sometimes serve as a vehicle for transmission of harmful microorganisms, which may cause significant health challenge (Abera, 2024).

Parasitic contamination of vegetables refers to the presence of harmful parasite, such as protozoa, helminths and nematodes on within vegetables, which can be ingested when consumed raw or poorly washed. These parasites can result in significant health problems to humans especially in regions with limited access to clean water and poor personal hygiene (Vanduyne *et al.*, 2016).

Parasites commonly found in contaminated vegetables include nematodes (*Strongyloides stercoralis*, *Ascaris lumbricoides*), protozoa (*Entamoeba histolytica*) and cestodes (*Taenia species*). These parasites can cause a wide range of illness, gastrointestinal distress to more severe conditions like malnutrition and organ damage, particularly in vulnerable populations such as children and the elderly (WHO, 2017).

However, poor agricultural practices (use of human faces as manure) improper handling inadequate sanitation can expose vegetables to various forms of parasitic contamination vegetables which are often grown in open field or watered with polluted water, are susceptible to parasitic contamination(Amaechi, 2015). These parasiteS, when consumed, can cause a wide range of disease that negatively impact public health, especially among vulnerable group such as children, the elderly, immune deficient individuals. (Yahaya and Abdullahi, 2019).

Parasitic contamination in food is a growing concern worldwide, particularly in developing countries where agricultural practices, water sanitation, and food handling standard are not observed (WHO, 2015). In these Vegetables remain a significant public health issue. Parasitic infection transmitted through contaminated vegetables pose serious health risks, express in regions where hygiene practices are often substandard (Kumar *et al.*, 2015).

1.2 Statement of the problem

Sokoto state is located in the north-western part of Nigeria, as it shares many environmental characteristics with other northern state of the country, this region is highly pronounced with agricultural activities. The cultivation and sale of vegetables is a significant economic activity in Sokoto. These Vegetables are majorly sold at Kasuwan Daji market and are consumed by large percentage of the population in Sokoto state (Salim, 2019).

The potential of these Vegetables with parasites remain a significant topic of concern due to poor hygiene and sub-standard agricultural practices, parasitic contamination of vegetables have been identified as serious health concerns for public especially in developing regions of the world, which contribute to substantial health and economic impacts (Regere *et al*, 2010).

1.3 justification of study

These are limited data on the prevalence and types of Parasitic contamination in vegetables sold in Kasuwan Daji market Sokoto, as this has been the leading cause of infection such as intestinal worms, protozoa, and nematodes have Identified as significant contributors to health problem in developing regions (Magen and sharma 2015). More so this parasite leads to vulnerability of individual system affected, causing wide range of disease due to lack of awareness about risk of parasite infection among both sellers and consumer, makes vegetables a more potential source of Parasitic contamination. Understanding parasitic contamination help for advocating for the necessary prevention and intervention strategies to enhance/promote healthier society. (WHO, 2022)

Furthermore this para reduce the economic values of vegetables infested, Affected vegetables tends to show variation in morphology often time showing perforated holes in the leaves and decaying of leaves. The economic impact highlights the need for intensive research and awareness among farmers and traders who are involved in storing and supplying vegetables (Garett, 2017).

1.4 Aims and objectives of the study

This study aimed to investigate the prevalence of parasitic contamination of vegetables sold at Kasuwan Daji market Sokoto.

While the specific objective are:

1. To determine the prevalence of parasitic contamination in vegetables sold at Kasuwan Daji market Sokoto state.
2. To access hygiene practices of vegetables vendors.

CHAPTER TWO

2.0

LITERATURE REVIEW

2.1. Conceptual Review

Parasite is an organism that live in or on a host organism and derive nutrients at the host's expense. Parasites are organisms that live on or within another organism (the host) and depend on it for survival, often causing harm in the process (CDC, 2023). In the context of foodborne diseases, intestinal parasites such as *Giardia lamblia*, *Entamoeba histolytica*, *Ascaris lumbricoides*, and *Trichuris trichiura* are of major concern because they infect humans through the ingestion of contaminated food and water (WHO,2022). Presence of a harmful biological agent (here parasites) on or in a food item (here vegetables) so that there is potential for harm to the consumer. Contamination refers to the presence of infectious agents or harmful substances on a surface, object, or food product, making it unsafe for consumption (FAO, 2022). In vegetables, contamination can result from exposure to contaminated water, soil, manure, or unhygienic handling practices during harvesting, transportation, or marketing. Vegetables are edible plant parts such as leaves, roots, stems, fruits, and bulbs that are consumed either raw or cooked for their nutritional value (Okafor et al., 2023). They are rich in vitamins, minerals, and antioxidants, but when consumed raw and improperly washed, they can serve as vehicles for transmission of intestinal parasites. Prevalence refers to the

proportion or percentage of a particular population or sample that is infected or contaminated at a specific time (Singh & Sharma, 2021). Prevalence indicates the percentage of vegetable samples found to contain one or more parasitic organisms.

2.2 Health Benefits of Vegetables

Vegetables are essential components of a healthy human diet and are widely recognized for their rich content of vitamins, minerals, dietary fiber, antioxidants, and various bioactive compounds. Their consumption is strongly associated with reduced risk of acute and chronic diseases, improved physiological functions, and overall enhanced well-being (Boffeta and Fadne, 2017). In both developed and developing countries, increased vegetable intake is considered one of the most cost-effective public health interventions for disease prevention and nutrition improvement (Aune *et al.*, 2019)

Prevention of chronic diseases regular intake of vegetables significantly reduces the risk of several chronic diseases, Cardiovascular Diseases (CVD) Vegetables help lower blood pressure, reduce cholesterol levels, and improve vascular health due to their high potassium and fiber content. Antioxidants like flavonoids, carotenoids, and vitamin C reduce oxidative. Helps improve insulin sensitivity and help regulate blood sugar levels. Non-starchy vegetables such as spinach, cucumber, and cabbage are recommended for diabetes prevention and management. Immune System Support many vegetables (e.g., carrots, tomatoes, pepper, spinach) are high in immune-boosting micronutrients like vitamins A, C, E, and zinc. These

nutrients support antibody production, enhance white blood cell activity, reduce susceptibility to infections, vegetables also contain anti-inflammatory compounds that help modulate immune responses (Gupta and Lakshmi *et al.*, 2018)

Vegetables have high water and fiber content but low calories, making them ideal for weight control, eating vegetables increases fullness and reduces overall calorie intake the low glycemic load of most vegetables also helps stabilize blood sugar, preventing fat accumulation (Wang, 2015). Vegetables like carrots, leafy greens, pumpkin, and tomatoes contain these nutrients maintain eye structure and function, prevent degenerative eye diseases, and improve visual acuity. Bone and dental Health vegetables such as broccoli, kale, lettuce, and okra provide essential bone nutrients like calcium, magnesium, vitamin K, and folate. These nutrients help, Improve bone density, Prevent osteoporosis, enhance dental enamel strength, support collagen formation, Vitamin K from leafy vegetables is particularly vital for bone metabolism and blood clotting. Chlorophyll and various antioxidants found in vegetables promote liver detoxification by supporting elimination of heavy metals and improving bile secretion (WHO 2015). Vegetables provide vitamins A, C, and E, which are essential for collagen production, Skin elasticity, Wound healing, Protection against UV damage. Their hydration and antioxidant effects also contribute to brighter skin and healthy scalp function. Improve brain function, reduce oxidative damage to neurons lower risk of cognitive decline and dementia, folate particularly aids neurotransmitter synthesis and mood regulation(Keum *et al.*, 2019)

Importance for Vulnerable Groups Vegetable consumption is especially important for Pregnant women, aids in children growth and cognitive development, promote digestive health, disease prevention, bone strength in elderly (Slavin and Lloyd, 2018). Vegetables are nutrient-dense foods that supply the body with essential vitamins, minerals, antioxidants, and dietary fiber needed for maintaining overall health. Regular consumption of vegetables is strongly associated with a reduced risk of chronic diseases such as cardiovascular diseases, diabetes, obesity, and certain cancers (Ellinger and Bub *et al.*, 2015)

Vegetables also contribute to improved weight management and overall well-being because they are low in calories but high in fiber and water, which help increase satiety and reduce overeating (Norat and Tonstand *et al.*, 2023). Compounds like lutein and beta-carotene found in carrots, spinach, and tomatoes support eye health, while vitamins A and C contribute to healthy skin, wound healing, and strong immunity. By providing a wide range of nutrients and protective compounds, vegetables play a crucial role in disease prevention, healthy aging, and maintaining optimal body functions (Kroke *et al.*, 2021).

2.3 Hygiene and Contamination of Vegetables

Vegetable hygiene refers to the practices put in place during farming, harvesting, transportation, storage, and preparation to ensure that vegetables remain clean, safe, and free from harmful contaminants. Because most vegetables especially leafy ones like lettuce, cabbage, spinach, and herbs are consumed fresh or minimally cooked, maintaining hygiene is

crucial for preventing foodborne infections (Bechthod, 2016). Proper hygiene begins at the farm, where farmers must use clean water for irrigation, protect crops from animal wastes, and avoid using untreated manure or sewage sludge. Clean farming tools, sanitary harvesting methods, and appropriate post-harvest washing all contribute to reducing microbial load. At the market level, vegetables should be displayed in clean areas protected from dust, insects, and waste water, while handlers are expected to maintain personal hygiene to minimize contamination (Haller *et al.*, 2018)

Contamination of vegetables can occur at any point from cultivation to consumption, making it a major public health concern. During cultivation, vegetables can become contaminated through soil that contains parasite eggs, infectious bacterial spores, or chemical pollutants (Gupta and Lakshmi *et al.*, 2019). Irrigation water contaminated with sewage or run-off from animal farms is one of the leading sources of microbial contamination, introducing pathogens such as *Giardia lamblia*, *Ascaris lumbricoides*, *Entamoeba histolytica*, *Cryptosporidium*, *Salmonella*, and *E. coli* (Keum, 2023). The use of untreated or improperly composted manure further increases the risk of transmitting parasitic ova and cysts. During harvesting and transportation, contaminated tools, dirty containers, and unhygienic handling by workers can introduce additional pathogens. In open markets, the risk increases due to exposure to flies, dust, polluted air, and repeated touching by many customers, all of which promote microbial contamination. Poor storage conditions such as high temperatures and humidity encourage

the multiplication of pathogens, worsening the safety of vegetables over time (Prakash *et al.*, 2021).

Hygiene at the household and commercial preparation stages is equally important in preventing contamination. After purchasing vegetables, inadequate washing, use of contaminated water, and cross-contamination with raw meat, dirty hands, or unclean utensils can introduce or spread pathogens. Many parasites and bacteria are resistant to casual rinsing and may require thorough washing, soaking, or disinfection to reduce contamination (Boffeta and Fadnes, 2017). Consumers are advised to wash vegetables under running clean water, use salt or vinegar solutions when necessary, store vegetables under cool conditions, and avoid preparing them on surfaces used for raw animal products. Vendors, on the other hand, should wash vegetables with clean water, avoid placing them on the floor, cover them to protect from flies, and maintain general market hygiene. Strengthening hygiene throughout the entire supply chain—from farm to table—is essential for reducing the burden of foodborne diseases, preventing outbreaks, and ensuring that vegetables remain nutritious, safe, and suitable for human consumption (Aune *et al.*, 2023).

2.4 Factors Influencing Vegetable Contamination

Vegetable contamination is multi-factorial: it results from interacting biological, chemical, environmental, infrastructural and human-behavior drivers that operate along the entire farm-to-fork chain, understanding these drivers helps target interventions (e.g., safer irrigation,

improved vendor hygiene, better storage) and explains why contamination patterns vary by crop type, geography and season (Petri & Singh, 2023).

Pre-harvest (field) factors are activities done before harvest in which water contaminated are used for irrigation or wash water (surface water, drainage, untreated wastewater or polluted groundwater) can directly deposit bacteria, viruses, protozoan cysts and parasite eggs onto leaves, roots and soil where vegetables grow; when water is applied by overhead irrigation or splash, pathogens may be trapped inside leaf structures and be hard to remove later. Soil and amendments are another critical factor—use of raw or insufficiently composted animal manure, nightsoil or sludge introduces high loads of fecal bacteria and helminth ova that can survive for weeks to months and adhere to roots and leaf surfaces. Wildlife, livestock and domestic animals entering fields (or bird droppings) further seed fields with pathogens. Crop type and plant morphology matter too: leafy, curly or rough-surfaced vegetables (lettuce, cabbage, spinach) trap and retain contaminants more than smooth fruits (tomatoes), increasing risk (Xiao & Griffiths, 2023).

Contamination introduced in the field can be amplified or added to during harvest, transport, market display and processing. Dirty harvest tools, contaminated crates and buckets, washing in contaminated basins, and unhygienic hands of workers and vendors are frequent contributors studies consistently show cross-contamination from wash water and handler hygiene as important risk points (Adamu, 2019). Temperature and time are key amplifiers,

warm temperatures and long transport or display times allow rapid microbial multiplication. Lack of cold-chain or sheltered display (open markets, roadside stalls) increases bacterial counts. Repeated handling by multiple customers, storage on contaminated surfaces, or mixing clean and dirty batches (e.g., re-packing onto used containers) further raise contamination levels before the product reaches the consumer (Abourgrain *et al.*, 2016).

Environmental and chemical drivers such as pesticides, antimicrobial-resistance, soil pollutants are an important non-microbial contamination pathway. Improper pesticide application (wrong dose, pre-harvest interval not observed) leaves residues that pose chronic health risks. A related and emerging issue is the presence of antimicrobial-resistant bacteria and antimicrobial resistance genes on produce, linked to antibiotic use in animal agriculture, contaminated manure, and environmental dissemination. This creates a dual hazard (foodborne infection plus resistant organisms). Environmental conditions (pH, temperature, humidity, UV exposure) also affect survival of microbes and persistence of chemical residues in/on vegetables (Alahalsi and Madi *et al.*, 2019).

2.5 Parasites Associated with Vegetables

Vegetables especially leafy and raw-eaten varieties such as lettuce, cabbage, spinach, celery, coriander, and carrots are increasingly recognized as important vehicles for the transmission of human intestinal parasites. Because many vegetables are grown close to the soil, irrigated with water from natural or untreated sources, and consumed without adequate cooking, they

become significant carriers of parasitic eggs, cysts, larvae, and oocysts (Abera et al., 2024). The presence of these parasites on vegetables poses a serious public health risk, especially in regions with poor sanitation, improper agricultural practices, and inadequate hygiene during handling (Petras and Kassa, 2019).

Vegetables commonly become contaminated with parasites at different stages of production and distribution. At the farm level, the use of untreated wastewater, sewage-contaminated rivers, and poorly composted animal manure introduces large quantities of parasite eggs and cysts into the soil and irrigation system. Parasites such as *Ascaris*, *Trichuris*, *Giardia*, *Entamoeba*, and *Cryptosporidium* are highly resistant in the environment and can survive for long periods on vegetable surfaces (Singh *et al.*, 2018). During harvesting, transportation, and marketing, further contamination may occur from unwashed hands, dirty containers, flies, and contact with contaminated surfaces (WHO, 2017). In open markets, vegetables are often displayed on the ground or exposed to dust, leading to additional exposure. Because many parasitic forms adhere tightly to vegetable surfaces—particularly rough, curly, or folded leaves, they are not easily removed by simple rinsing, increasing the risk of ingestion (Amoah *et al.*, 2018).

A wide range of parasites has been associated with contaminated vegetables. Protozoan parasites are among the most frequently reported. *Giardia lamblia* cysts and *Entamoeba histolytica* cysts are common contaminants and cause diarrheal diseases through ingestion of

contaminated raw vegetables (Alimi, 2020). *Cryptosporidium* oocysts, known for their high resistance to disinfectants, are another major protozoan found on fresh produce. Helminth parasites are also widely reported in vegetable-based contamination (Eraky and Rashed *et al.*, 2017). These include *Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Strongyloides stercoralis*, *Taenia* species, Hookworm larvae, and *Fasciola* species. Their eggs and larvae are shed in human or animal feces and easily adhere to soil particles and vegetable surfaces. In areas with poor sanitation infrastructure, these helminths are commonly transmitted to humans through raw salads and inadequately washed vegetables (Garadaghi, 2019).

The health implications of consuming vegetables contaminated with parasites are significant. Depending on the parasite species, infections may lead to diarrhea, malnutrition, anemia, abdominal discomfort, weight loss, intestinal obstruction, and in severe cases, life-threatening complications. Vulnerable groups such as children, pregnant women, the elderly, and immunocompromised individuals face heightened risks. (Ofori and Obeng, 2021).

2.5.1 *Entamoeba histolytica*

Entamoeba histolytica is a protozoan parasite responsible for amoebiasis, an intestinal infection affecting millions of people worldwide, particularly in developing countries with poor sanitation (WHO, 2022). The parasite exists in two forms: the trophozoite, which is the active, invasive form, and the cyst, which is environmentally resistant and infectious (Petri &

Singh, 2023). Humans acquire infection primarily through ingestion of cysts present in contaminated food and water, including raw vegetables that have been exposed to faecally polluted soil or water (FAO, 2022). Morphology and life cycle of the trophozoites of *E. histolytica* are motile, pear-shaped, and 15–20 µm in size, capable of invading the intestinal mucosa. Cysts are round, 10–15 µm in diameter, and contain up to four nuclei (Petri & Singh, 2023). The life cycle is direct: humans ingest mature cysts, which excyst in the small intestine, releasing trophozoites. These trophozoites colonize the large intestine, multiply, and produce cysts that are excreted in feces. Environmental cysts contaminate vegetables through irrigation with untreated water, fertilization with human or animal manure, or unhygienic handling during harvesting and marketing (WHO, 2022).

Mode of transmission via vegetables especially leafy greens like lettuce, spinach, and cabbage, are particularly susceptible to contamination due to their rough surfaces and crevices that trap cysts (Okafor *et al.*, 2023). The use of untreated wastewater for irrigation, fertilization with inadequately composted manure, and washing vegetables in contaminated water are key routes for *E. histolytica* transmission. Consumption of raw or underwashed vegetables provides a direct route for cyst ingestion, initiating infection in humans (FAO, 2022; Okafor *et al.*, 2023).

Infected individuals may be asymptomatic carriers or develop symptomatic amoebiasis, ranging from mild diarrhea to severe dysentery with blood and mucus in stool. Extraintestinal

infection, such as liver abscess, can occur when trophozoites invade the bloodstream (Petri & Singh, 2023). Children, immunocompromised individuals, and populations in regions with poor hygiene are particularly at risk. Contaminated vegetables are a significant source of infection in endemic areas, highlighting the importance of safe handling, washing, and cooking practices (WHO, 2022).

Transmission occurs through ingestion of cysts on contaminated vegetables or water. Studies in Nigeria and Ghana have detected *Giardia* cysts on lettuce, cabbage, and carrots sold in local markets (Kudah *et al.*, 2018). In a recent Ethiopian survey, *Giardia* cysts were found in 18% of vegetable samples, with higher prevalence in leafy vegetables irrigated with wastewater (Abera *et al.*, 2024).

2.5.2 *Cryptosporidium* spp

Cryptosporidium is a genus of protozoan parasites that cause cryptosporidiosis, a diarrheal disease affecting humans and animals worldwide. It is recognized as a significant foodborne and waterborne pathogen, particularly in developing countries with inadequate water treatment and poor sanitation (Xiao & Griffiths, 2023). The parasite is highly resistant to environmental stressors and common disinfectants such as chlorine, allowing oocysts to survive for extended periods in soil and on vegetable surfaces (FAO, 2022).

Morphology and Life Cycle of the infective stage of *Cryptosporidium* is the oocyst, which is spherical to slightly ovoid, measuring approximately 4-6 µm in diameter. Oocysts contain

sporozoites that excyst in the small intestine after ingestion (Xiao & Griffiths, 2023). The life cycle is direct, involving both asexual and sexual stages within the host epithelium. The oocysts are excreted in feces in a fully infective form, which allows them to contaminate water, soil, and vegetables. The high environmental resistance of oocysts makes *Cryptosporidium* a notable risk in raw or inadequately washed produce (WHO, 2022).

Mode of Transmission via Vegetables particularly leafy greens such as lettuce, spinach, and cabbage, can become contaminated when irrigated with contaminated water, fertilized with untreated manure, or handled with poor hygiene practices (Okafor *et al.*, 2023). The small size and sticky surface of oocysts enable them to adhere to the rough surfaces and crevices of vegetables. Consumption of raw or minimally washed vegetables is a major route of transmission to humans (FAO, 2022). Studies in Nigeria and other African countries have detected *Cryptosporidium* oocysts on market vegetables, demonstrating the public health significance of contaminated produce (Abera *et al.*, 2024).

Clinical Significance of Cryptosporidiosis typically manifests as watery diarrhea, abdominal cramps, nausea, vomiting, and low-grade fever. In immunocompetent individuals, infection is often self-limiting; however, in immunocompromised persons, such as HIV/AIDS patients or malnourished children, the disease can be severe, chronic, and potentially life-threatening (Xiao & Griffiths, 2023). The presence of *Cryptosporidium* on vegetables represents a critical

food safety concern, as even a small number of oocysts can cause infection due to the parasite's low infectious dose.

2.5.3 *Ascaris lumbricoides*

Ascaris lumbricoides is a large intestinal nematode and one of the most common soil-transmitted helminths (STHs) worldwide. It is responsible for ascariasis, a disease that affects millions of people, particularly in tropical and subtropical regions with poor sanitation and hygiene (WHO, 2022). Humans become infected by ingesting embryonated eggs of *A. lumbricoides* through contaminated food, water, or soil. Vegetables, especially those consumed raw like lettuce, cabbage, and spinach, serve as a significant vehicle for transmission in endemic areas (Okafor *et al.*, 2023).

Morphology and life cycle of adult *A. lumbricoides* worms are cylindrical, pinkish-white, and can reach lengths of 15-35 cm in humans. The life cycle is direct and involves several stages starting from embryonated eggs are ingested, hatch in the small intestine, and larvae penetrate the intestinal wall to enter the bloodstream. They migrate to the lungs, ascend the bronchial tree, are swallowed, and mature into adults in the small intestine. Female worms produce thousands of eggs daily, which are excreted in feces and can contaminate soil and vegetables. The eggs are highly resistant, capable of surviving harsh environmental conditions for months (CDC, 2023; FAO, 2022).

Mode of Transmission via Vegetables can become contaminated with *A. lumbricoides* eggs through contact with contaminated soil, irrigation with untreated water, or use of human and animal feces as fertilizer. Leafy vegetables are particularly susceptible because their large surface area and uneven textures allow eggs to adhere and persist until consumption (Okafor *et al.*, 2023; Abera *et al.*, 2024). The ingestion of raw or inadequately washed vegetables is the primary route for human infection, making foodborne transmission a major public health concern.

Ascariasis can be asymptomatic in light infections, but moderate to heavy worm burdens can cause gastrointestinal symptoms, including abdominal pain, bloating, diarrhea, and malnutrition, particularly in children (WHO, 2022). Larval migration can also cause pulmonary symptoms such as cough and eosinophilia. Severe infections may lead to intestinal obstruction, especially in areas with high worm prevalence. The disease contributes to stunted growth, impaired cognitive development in children, and reduced productivity in adults, making it a significant public health problem in endemic regions (CDC, 2023)

2.5.4 *Trichuris trichiura*

Trichuris trichiura, commonly known as the whipworm, is a soil-transmitted helminth that causes trichuriasis in humans. It is widely prevalent in tropical and subtropical regions with inadequate sanitation and hygiene (WHO, 2022). Infection occurs primarily through the ingestion of embryonated eggs from contaminated soil, water, or food. Vegetables,

particularly leafy greens like spinach, lettuce, and cabbage, can serve as important vehicles for transmission when grown in contaminated soil or irrigated with untreated water (Okafor *et al.*).

Adult *T. trichiura* worms are thin anteriorly and thick posteriorly, giving them a whip-like appearance. Males measure approximately 30-35 mm, while females are slightly longer, 35-50 mm (CDC, 2023). The life cycle starts when embryonated eggs are ingested, hatch in the small intestine, and larvae migrate to the cecum and colon, where they mature into adults. Female worms produce thousands of eggs daily, which are excreted in feces and can persist in soil for months under favorable conditions. Contamination of vegetables occurs when these eggs come into contact with crops during cultivation or handling (FAO, 2022).

When Vegetables become contaminated with *T. trichiura* eggs through contact with contaminated soil, irrigation water, or improper fertilization practices using untreated human or animal feces (Abera *et al.*, 2024). Leafy vegetables with uneven surfaces are particularly susceptible as eggs can adhere to the crevices. Consumption of raw or inadequately washed, vegetables provides a direct route for human infection, making proper handling and washing essential to prevent disease (Okafor *et al.*, 2023).

Trichuriasis can range from asymptomatic to severe, depending on worm burden. Light infections may cause minor gastrointestinal disturbances, whereas heavy infections can lead to abdominal pain, diarrhea, anemia, growth retardation, and impaired cognitive development

in children (WHO, 2022). In endemic areas, trichuriasis often co-occurs with other soil-transmitted helminth infections, compounding nutritional and developmental consequences. The role of contaminated vegetables in transmission emphasizes the need for safe agricultural and market practices (FAO, 2022).

2.5.5 *Strongyloides stercoralis*

Strongyloides stercoralis is a soil-transmitted nematode that causes strongyloidiasis, a parasitic infection affecting millions of people worldwide, particularly in tropical and subtropical regions with poor sanitation (Genta, 2022). Unlike other intestinal helminths, *S. stercoralis* can complete its life cycle both inside and outside the human host, enabling persistent infections and autoinfection. Humans become infected primarily through skin contact with contaminated soil, but vegetables grown in contaminated soil or irrigated with untreated water can carry larvae, posing a foodborne risk in endemic areas (FAO, 2022)

The infective stage of *S. stercoralis* is the filariform larva, which penetrates the skin and enters the circulatory system. The larvae migrate to the lungs, ascend the trachea, are swallowed, and mature into adult female worms in the small intestine. Adult females reproduce parthenogenetically, producing rhabditiform larvae that are excreted in feces or develop into infective larvae, causing autoinfection (Genta, 2022). This complex life cycle allows *S. stercoralis* to persist in the host for decades and makes it a challenging parasite to eliminate from contaminated environments.

Transmission via Vegetables can become contaminated when cultivated in soil containing infective larvae or irrigated with contaminated water (Okafor *et al.*, 2023). Leafy vegetables, such as lettuce, cabbage, and spinach, are particularly vulnerable due to their textured surfaces, which allow larvae to adhere and survive until consumption. While the primary route of infection is through skin penetration, accidental ingestion of larvae via contaminated raw vegetables has been reported as a secondary route of transmission in endemic areas (FAO, 2022).

Strongyloidiasis can be asymptomatic or symptomatic, depending on the host's immune status. In light infections, individuals may experience mild gastrointestinal disturbances, including abdominal pain, diarrhea, and nausea. Heavy infections or immunocompromised individuals can develop hyperinfection syndrome, which can be fatal due to widespread dissemination of larvae to organs such as the lungs, liver, and central nervous system (Genta, 2022). The persistence of *S. stercoralis* in endemic populations, coupled with potential contamination of vegetables, highlights its significance as a public health concern.

2.5.6. Hookworm

Hookworms, primarily *Ancylostoma duodenale* and *Necator americanus*, are soil-transmitted nematodes responsible for hookworm infection, a major public health concern in tropical and subtropical regions (WHO, 2022). Infection occurs when larvae penetrate the skin of humans, typically through bare feet contacting contaminated soil. However, vegetables grown in

contaminated soil or irrigated with untreated water may indirectly carry hookworm larvae, posing a risk of infection through accidental ingestion or poor hygiene practices (FAO, 2022; Okafor *et al.*, 2023).

Adult hookworms are small, cylindrical nematodes measuring 7-13 mm for *N. americanus* and 8-11 mm for *A. duodenale*. The anterior end contains a mouth with cutting plates or teeth that attach to the intestinal mucosa, feeding on blood (CDC, 2023). The life cycle is direct: eggs are excreted in feces and hatch into larvae in soil. These larvae develop into infective filariform larvae that can penetrate human skin. Once inside, they migrate via the bloodstream to the lungs, ascend the trachea, are swallowed, and mature into adults in the small intestine (Genta, 2022).

Although the primary route of infection is skin penetration, vegetables can become contaminated when grown in soil containing hookworm larvae or irrigated with untreated wastewater (Okafor *et al.*, 2023). Leafy vegetables, with rough surfaces, can retain larvae, and handling contaminated produce without proper hand hygiene may facilitate indirect transmission. Consuming raw vegetables washed in contaminated water may also pose a minor risk, particularly in regions with poor sanitation (FAO, 2022).

Hookworm infection can cause a range of clinical manifestations, from asymptomatic light infections to severe disease in heavy infections. Chronic blood loss due to intestinal attachment can lead to iron-deficiency anemia, protein malnutrition, and stunted growth in

children (WHO, 2022). Pulmonary migration of larvae may cause transient respiratory symptoms, while gastrointestinal symptoms include abdominal pain and diarrhea. The risk of hookworm transmission through contaminated vegetables underscores the importance of food hygiene alongside soil and water sanitation (Genta, 2022).

2.6 Prevention and Control Measures

Parasitic contamination of vegetables poses a significant public health challenge, particularly in developing countries where raw vegetables are commonly consumed (FAO, 2022). Preventing and controlling such contamination requires integrated strategies across the entire food supply chain, from farm to fork. Effective measures aim to reduce the risk of transmission of protozoan and helminth parasites such as *Giardia lamblia*, *Entamoeba histolytica*, *Ascaris lumbricoides*, *Trichuris trichiura*, *Strongyloides stercoralis*, and hookworms (WHO, 2022).

Farm-Level Control Measures At the farm level, adopting Good Agricultural Practices (GAP) is essential. This includes the use of safe irrigation water, proper composting of manure to inactivate parasite eggs and larvae, crop rotation, and avoiding the use of untreated human or animal feces as fertilizer (Abera *et al.*, 2024). Farmers are also encouraged to implement personal hygiene practices, such as washing hands after soil contact and wearing protective gloves or footwear, to prevent contamination of vegetables during cultivation (FAO, 2022).

Post-harvest handling and market-level measures proper post-harvest handling is critical in preventing parasitic contamination. Vegetables should be washed thoroughly with clean, safe water, stored on clean surfaces, and transported in containers that minimize exposure to contaminated soil or surfaces (Okafor *et al.*, 2023). Market hygiene practices, such as ensuring clean stalls, avoiding direct contact with bare ground, and providing safe water for washing vegetables, reduce the risk of contamination before consumption. Vendors should also be trained in food safety and hygiene practices to maintain produce quality (Adebayo *et al.*, 2021).

Consumers play a key role in preventing infections by adopting proper vegetable handling and consumption practices. Vegetables should be washed under running water, soaked in safe water if necessary, and peeled or cooked when possible to eliminate parasite eggs and larvae (WHO, 2022). Hand hygiene before and after handling vegetables, along with the use of clean kitchen utensils and surfaces, further reduces the risk of foodborne parasitic infections (FAO, 2022).

2.6.1 Proper Washing and Disinfecting of Vegetables

Proper washing and disinfecting of vegetables are critical measures in preventing foodborne parasitic infections. Vegetables, especially leafy greens, are prone to contamination with protozoan and helminth parasites such as *Giardia lamblia*, *Entamoeba histolytica*, *Ascaris lumbricoides*, and *Trichuris trichiura* during cultivation, handling, and marketing (FAO,

2022). Effective washing and disinfection reduce microbial load and remove parasite eggs, cysts, and larvae, thereby protecting consumers from infection (Okafor *et al.*, 2023).

The first step in reducing parasitic contamination involves thorough washing under running water. This mechanical action helps remove soil, debris, and some parasites attached to vegetable surfaces (WHO, 2022). Leafy vegetables should be separated and rinsed multiple times, and attention should be given to crevices where parasite eggs may adhere. Using a brush or gentle rubbing for firm vegetables like cabbage can further enhance removal of surface contaminants (FAO, 2022). In addition to washing, the use of safe disinfectants can significantly reduce parasitic load. Common disinfectants include chlorine solutions, vinegar, and commercial vegetable sanitizers, which are effective in inactivating parasite cysts and larvae (Adebayo *et al.*, 2021). For example, a 1-2% chlorine solution or dilute sodium hypochlorite solution is widely recommended for soaking vegetables for 10-15 minutes, followed by thorough rinsing with clean water to remove chemical residues. This step is especially important in areas where irrigation water or soil may be contaminated with fecal matter.

2.6.2 Good Agricultural Practices for Vegetables

Good Agricultural Practices are a set of principles, guidelines, and procedures aimed at ensuring the safety, quality, and sustainability of agricultural produce, including vegetables. GAP focuses on minimizing contamination from microbial, chemical, and parasitic sources

during cultivation, harvesting, handling, and post-harvest processes (FAO, 2022). Implementing GAP is essential in reducing parasitic infections, such as those caused by *Ascaris lumbricoides*, *Trichuris trichiura*, *Strongyloides stercoralis*, and *Giardia lamblia*, associated with raw vegetables (Abera *et al.*, 2024).

One of the critical components of GAP is the use of safe irrigation and washing water. Water contaminated with human or animal feces can introduce parasite eggs and larvae to vegetables, making them a potential vehicle for infection (Okafor *et al.*, 2023). GAP guidelines recommend using treated water for irrigation and washing, and avoiding surface water sources that are exposed to sewage or runoff from livestock areas. Regular testing of irrigation water quality is also encouraged to ensure safety and compliance with food safety standards (FAO, 2022). It emphasizes proper soil and fertilizer management to reduce parasitic contamination. The use of raw human or animal feces as fertilizer is strongly discouraged because it can contain infective parasite stages (WHO, 2022). Instead, farmers are advised to use well-composted manure or organic alternatives, ensuring sufficient time and temperature for pathogen inactivation. Crop rotation, soil drainage, and avoiding vegetable cultivation in areas prone to fecal contamination are additional GAP measures to minimize contamination risk (Adebayo *et al.*, 2021). During harvesting and post-harvest handling, GAP promotes personal hygiene, clean equipment, and proper storage. Farmers and laborers should wash hands with safe water, wear clean gloves, and avoid handling vegetables with contaminated tools or bare hands. Vegetables should be stored on clean

surfaces, separated from soil and animal contact, and transported in clean containers to prevent cross-contamination before reaching markets or consumers (Okafor *et al.*, 2023).

2.6.3 Government Food Safety Policies

Government food safety policies are frameworks and regulations established to protect public health by ensuring the safety and quality of food, including fresh vegetables. These policies aim to minimize biological, chemical, and physical hazards, including parasitic contamination, along the food supply chain (FAO, 2022). Effective implementation of these policies ensures that vegetables sold in markets, such as Kasuwan Daji in Sokoto, comply with hygiene and safety standards to prevent foodborne parasitic infections *Entamoeba histolytica*, *Ascaris lumbricoides*, *Trichuris trichiura*, and *Giardia lamblia* (Okafor *et al.*, 2023).

In Nigeria, several agencies regulate food safety, including the National Agency for Food and Drug Administration and Control (NAFDAC), the Standards Organisation of Nigeria (SON), and the Federal Ministry of Health (FMH). NAFDAC oversees food hygiene, safety inspections, and certification of food products, while SON sets quality standards for agricultural produce (Adebayo *et al.*, 2021). These agencies work together to implement legislation and enforce compliance to reduce contamination and protect consumers from parasitic and microbial hazards (FAO, 2022).

Government policies include specific standards and guidelines for fresh produce to prevent contamination. These cover safe irrigation water use, prohibition of untreated manure, mandatory washing and handling procedures, storage requirements, and traceability systems

(WHO, 2022). Policies also require periodic inspections and monitoring of farms, markets, and processing facilities to ensure compliance with hygiene and food safety standards (Okafor *et al.*, 2023), effective enforcement is essential to ensure that policies translate into safe food for consumers. Regulatory agencies conduct inspections, market surveillance, and laboratory testing of vegetables for microbial and parasitic contamination (Adebayo *et al.*, 2021). Non-compliance may result in fines, closure of establishments, or withdrawal of contaminated produce from the market. Health education campaigns complement enforcement by raising awareness among farmers, vendors, and consumers about the importance of food safety practices (FAO, 2022).

Impact on public health government food safety policies significantly reduce the risk of parasitic infections from vegetables by regulating production, handling, and marketing practices. Compliance with these regulations ensures that vegetables reaching consumers are safe, thereby reducing the prevalence of infections such as ascariasis, trichuriasis, amoebiasis, and cryptosporidiosis (WHO, 2022; Okafor *et al.*, 2023). Continuous review and updating of policies, combined with capacity building and infrastructure improvements, are necessary to maintain food safety in the face of population growth and increasing vegetable consumption.

2.6.4 Health Education

Health education is a strategic approach to informing and empowering individuals and communities about health risks and preventive measures. In the context of parasitic

contamination of vegetables, health education plays a crucial role in reducing infection rates by promoting safe food handling, proper hygiene, and awareness of parasitic diseases (WHO, 2022). Educating farmers, vendors, and consumers ensures that knowledge translates into behavior changes that minimize the risk of foodborne parasitic infections.

Health education efforts target multiple stakeholders along the vegetable supply chain. Farmers are educated on safe agricultural practices, including proper irrigation, composting of manure, and minimizing contact with contaminated soil (FAO, 2022). Vendors are trained on hygiene practices, such as washing vegetables with clean water, handling produce safely, and storing vegetables in clean conditions (Okafor *et al.*, 2023). Consumers are taught to wash, disinfect, and, when possible, cook vegetables before consumption to reduce exposure to parasites. Various methods are used to deliver health education effectively. Workshops, training programs, community outreach, posters, and media campaigns are commonly employed to disseminate information (Adebayo *et al.*, 2021). Interactive approaches, such as demonstrations of proper vegetable washing and safe handling practices, are particularly effective. Health education materials are tailored to local literacy levels and cultural contexts to ensure understanding and adoption of recommended practices.

Health education is critical in preventing infections caused by parasites such as *Ascaris lumbricoides*, *Trichuris trichiura*, *Giardia lamblia*, and *Cryptosporidium* (FAO, 2022; WHO, 2022). By increasing awareness of contamination sources and transmission routes,

individuals are more likely to adopt preventive behaviors, including personal hygiene, safe vegetable handling, and adherence to food safety standards. In communities with poor sanitation, health education complements infrastructural improvements to maximize public health impact. For health education to be sustainable, it must be integrated into government policies and food safety programs. Collaboration with agencies such as NAFDAC, SON, and local health departments ensures that education aligns with regulatory standards and reaches a broad audience (Okafor *et al.*, 2023). Continuous evaluation of health education programs is necessary to assess behavior change and reduce parasitic contamination of vegetables in markets and households.

CHAPTER THREE

3.0

MATERIALS AND METHOD

3.1 Study Area

This study was conducted at Kasuwan Daji Market, one of the largest and most popular open markets located in Sokoto metropolis, Sokoto State is situated in the northwestern part of Nigeria, Agriculture is the mainstay of Sokoto's economy, it is home to about 3.7 million people who in one way or the other consumes vegetables. Characterized by a semi-arid climate with distinct wet and dry season. The rainy season, which lasts from June to September, during this season crops and vegetables are been cultivated on a large scale (Ibrahim, 2017).

Kasuwan Daji Market serves as a major commercial hub for the trade of various agricultural products including cereals, legumes, livestock, and most importantly, fresh vegetables such as lettuce, cabbage, spinach, carrots, tomatoes, green peppers, and onions. These vegetables are brought in daily from peri-urban farms, neighboring states, and rural areas surrounding Sokoto.

3.2 Research Design

This study employed a descriptive cross-sectional design to assess the prevalence of parasitic contamination in selected vegetables sold at Kasuwan Daji Market, Sokoto. The study

involved systematic collection, laboratory analysis, and interpretation of data concerning the presence of intestinal parasites on fresh vegetable (Anuar *et al*, 2015). This study employed a descriptive cross-sectional research design to evaluate the presence and extent of parasitic contamination in fresh vegetables sold in selected markets within Sokoto metropolis. The descriptive design enabled the systematic identification, quantification, and analysis of parasites present on vegetable samples at a single point in time(Daryani *et al.*, 2012). This approach was chosen because it is suitable for estimating the prevalence of a condition (in this case, parasitic contamination) in a defined population and helps in establishing baseline data necessary for public health interventions(Fattal *et al*, 1986).

The study was both qualitative and quantitative in nature. Qualitative elements involved the identification of the types of parasites found, while quantitative elements involved the measurement of the contamination rate and statistical analysis of variables such as vegetable type and market location (Al-Binali *et al.*, 2006).

3.3 Sample Collection

A simple random sampling method was used to select vegetable vendors within the market. Various types of vegetables commonly eaten raw or semi-cooked were selected, including: Lettuce, Cabbage, Spinach. Each vegetable sample (200 g) was purchased and was collected in a clean, sterile polyethylene bag, labeled, and transported immediately to the laboratory, laboratory analysis was conducted within 24 hours of collection.

3.4 Laboratory procedure for Detection and Identification of the Parasites

Each vegetable sample (approximately 200 g) was placed in a clean bucket and washed thoroughly with 500 mL of normal saline (0.9%). The washing process involved manual agitation for 15-20 minutes to ensure detachment of parasitic forms (ova, cysts, larvae) from the vegetable surface (Omowaye and Audu, 2012). The wash solution was then filtered through a double-layered muslin cloth to remove plant debris (Idahosa, 2011).

The filtrate obtained was poured into conical sedimentation tubes and left to stand undisturbed for 12–24 hours to allow the parasitic forms to settle at the bottom. After sedimentation, the supernatant was carefully decanted, leaving behind the concentrated sediment. The sediment was transferred into labeled centrifuge tubes and centrifuged at 3000 revolutions per minute (rpm) for 5 minutes. The supernatant was discarded, and the final pellet (sediment) was retained for microscopic analysis. A drop of the sediment was placed on a clean glass slide and covered with a coverslip. The slide was examined under light microscopy at 10× and 40× magnifications. Identification of cyst or oocyst was based on morphological characteristics described by Cheesbrough (2009) and WHO protocols.

3.5 Statistical Analysis

Data obtained from the laboratory examination of vegetable samples were entered into Microsoft Excel and analyzed using descriptive statistical methods. The prevalence of parasitic contamination was calculated by dividing the number of positive samples by the

total number of samples examined, multiplied by 100 to obtain percentage prevalence. Results were presented in tables and charts for clarity. Frequencies and percentages were used to summarize the distribution of parasites across different vegetable types. Comparative analysis of contamination levels among vegetables (such as lettuce, spinach, and cabbage) was performed using percentage differences. All analyses were conducted at a 95% confidence level, and findings were interpreted based on established epidemiological standards. Findings indicate that a majority of vendors use unhygienic handling methods, which can facilitate parasitic contamination of vegetables. Placing vegetables on bare soil exposes them to parasites present in the environment (FAO, 2022; Obebe et al., 2020). On the other hand, washing vegetables before display and using clean surfaces can reduce the risk of contamination, although it may not eliminate all parasite stages if the water or surfaces are contaminated.

This information highlights a critical gap in food hygiene practices among vendors and underscores the need for health education, improved market infrastructure, and enforcement of food safety standards to protect consumers from parasitic infections.

CHAPTER FOUR

4.0

RESULT

Out of the 54 vegetable samples collected of which *eighteen(18)* are Lettuce (*Lactuca sativa*), *eighteen(18)* Cabbage (*Brassica oleralea*), *eighteen(18)* Spinach (*Spinacia Oleralea*) examined, 47(87%) were identified to be positive for parasitic contamination. Lettuce recorded the highest prevalence 18(100%), followed by spinach 16(88.8%), and Cabbage recorded the least prevalence of 13(72.2%) (Table 1).

A total of seven (7) parasite were identified from the vegetable sample collected, which are, *Ascaris lumbricoides* 20(28.2%), *Giardia lamblia* 11(15.4%) *Entamoeba histolytica* 10(14.0%), *Trichuris trichura* 9(12.7%), *Cryptosporidium* 8(11.3%), *Ancylostoma duodenale* 7(9.9%), *Strongyloides stercaralis* 6(8.5%) (Table 2).

The result based on the vegetable handling and hygiene practices by the vendors showed that 18(33.3%) of vendors placed their vegetable on bench before sell while 36(66.7%) placed their vegetable on the bare-land (Table 3).

In respect to the washing of vegetable before sell, the result indicated that 4(22.2%) of vendors wash their vegetable before sell while 14(77.8%) of the vegetable vendors do not wash their vegetable before sell (Table 4).

Table 1: Prevalence of Parasitic Contamination in Vegetables

Vegetable sample	Sample examined	Positive sample	Prevalence (%)
Lettuce	18	18	100%
Spinach	18	16	88.8%
Cabbage	18	13	72.2%
Total	54	47	87.0%

Table 2: Prevalence of Parasite Species Identified in the Contaminated Vegetables

Parasite species	Frequency	Percentage(%)
<i>Trichuris trichiura</i>	9	12.7%
<i>Giardia lamblia</i>	11	15.4%
<i>Entamoeba histolytica</i>	10	14.0%
<i>Ancylostoma duodenale</i>	7	9.9%
<i>Strongyloides stercoralis</i>	6	8.5%
<i>Ascaris lumbricoides</i>	20	28.2%
<i>Cryptosporidium spp</i>	8	11.3%
Total	71	100%

Table 3: Vegetable Handling Hygiene by Vendors

Hygiene practices and Vegetable Handling	Frequency	Percentage (%)
Bench	18	33.3%
Bare-land	36	66.7%
Total	54	100%

Table 4: Washing of Vegetable Before sell

Washing vegetable before sell	Frequency	Percentage (%)
Yes	11	20.4%
No	43	79.6%
Total	54	100%

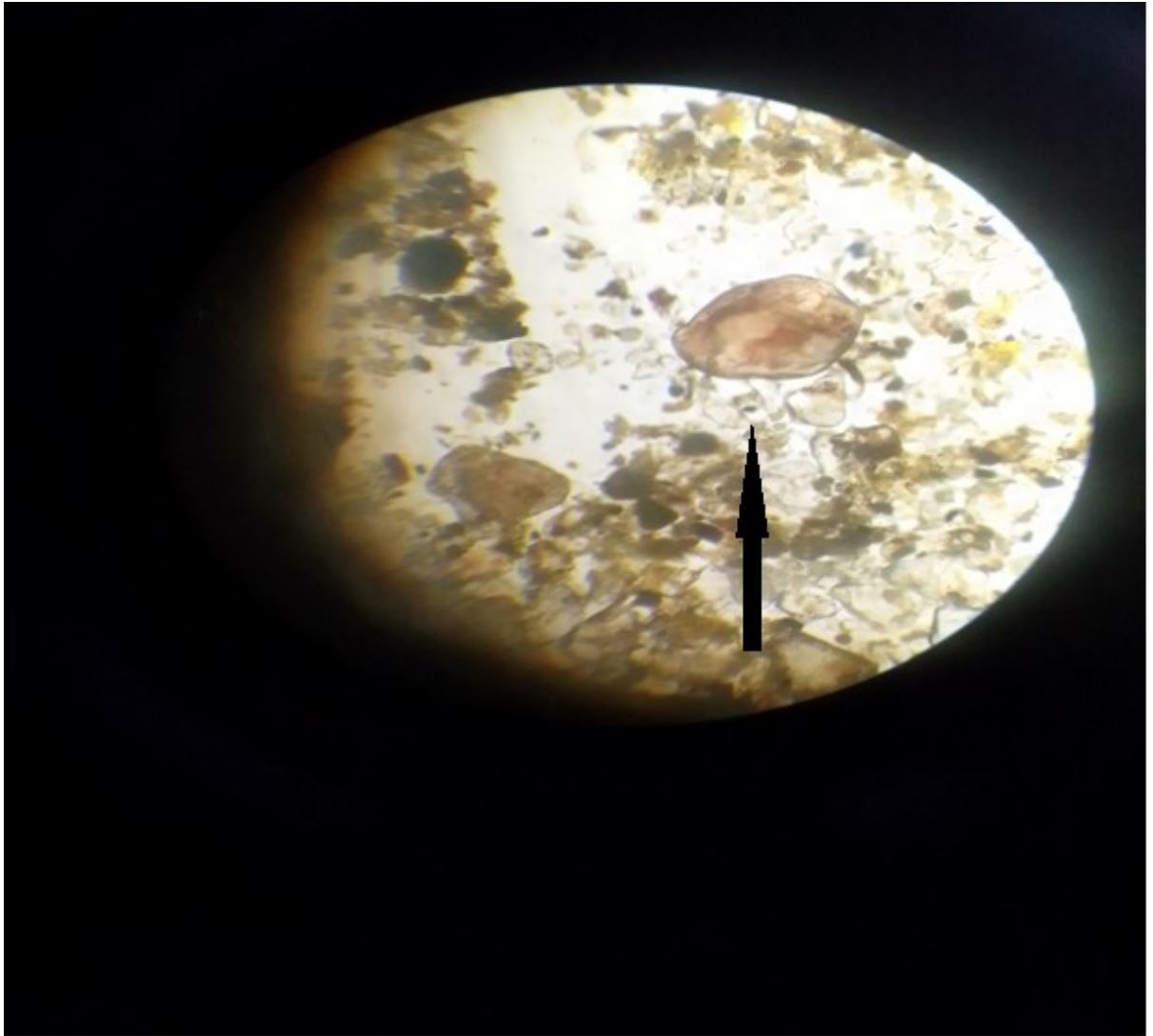


PLATE 1 Egg of *Giardia lamblia* Identified in Vegetable Sample (Source; Self, 2025)

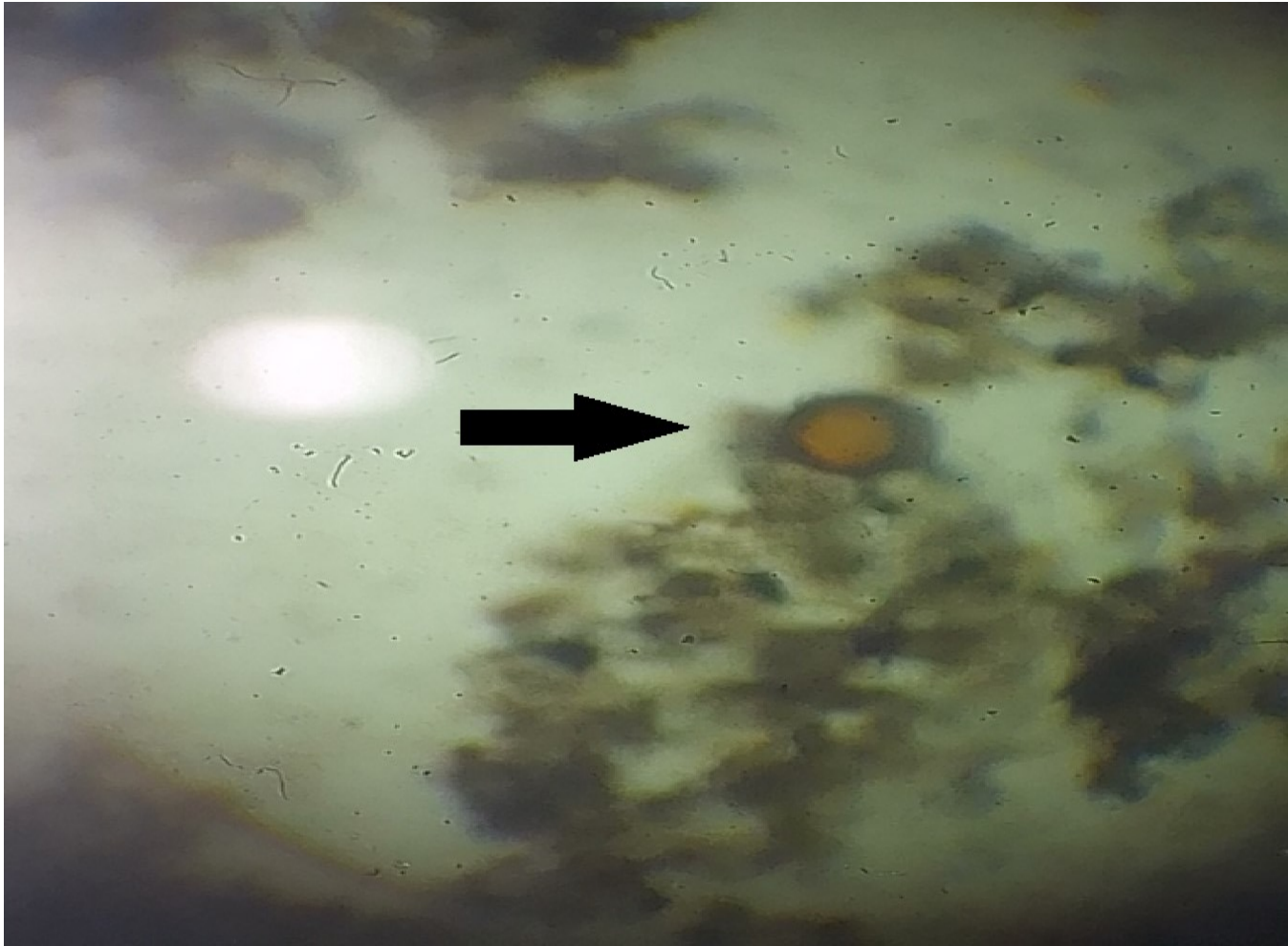


PLATE 2 Egg of *Ascaris lumbricoides* Identified in Vegetable Sample (Source; Self, 2025)



PLATE 3 Egg of *Trichuris trichura* Identified in Vegetable Sample (Source; Self, 2025)

CHAPTER FIVE

5.0 DISCUSSION, CONCLUSION, RECOMENDATION

5.1 Discussion

This study investigated the prevalence of parasitic contamination of vegetables sold at Kasuwan Daji Market, Sokoto. A total of 15 vegetable samples were examined, out of which 47 (87%) were contaminated with at least one type or more than one type of parasite. The findings revealed varying degrees of contamination among the vegetable types analyzed. The parasites identified in the contaminated samples included *Ascaris lumbricoides*, *Giardia lamblia*, *Entamoeba histolytica*, *Trichuris trichura*, *Cryptosporidium*, *Ancylostoma duodenale*, and *Strongyloides stercoralis*. These organisms are of significant public health concern as they are known to cause gastrointestinal disorders, diarrheal diseases, and nutritional deficiencies, especially among children and immune-compromised individuals (Mohammed & Bala, 2020), the high prevalence rate (80%) observed in this study indicates poor sanitary conditions during vegetable cultivation, handling, and marketing. The contamination might have originated from the use of wastewater or contaminated manure for irrigation, improper handling by vendors, or unhygienic display of vegetables in open markets. These findings align with the work of (Bassey *et al.*, 2023) who reported that vegetables sold in open Nigerian markets are frequently contaminated due to inadequate sanitation and lack of public health awareness.

Among the vegetables examined, lettuce had the highest contamination rate, the high level of contamination observed in lettuce may be due to its leafy structure, which provides a large surface area for attachment and retention of parasitic cysts and eggs. Similar trends have been reported by (Adamu *et al.*, 2022) and (Olawale *et al.*, 2023), who observed higher contamination rates in leafy vegetables compared to those with smooth surfaces.

The prevalence recorded in Kasuwan Daji is comparable to several recent Nigerian market surveys and to meta-analytic estimates from other African settings. For example, market-based surveys in different Nigerian states have reported contamination rates ranging from moderate to very high (Eberemu *et al.*, 2013), and meta-analyses in Ethiopia and East Africa report pooled prevalences around 40% or higher depending on methods and location (Girma *et al.*, 2024). These comparisons support the conclusion that fresh produce sold in open markets in the region remains an important potential route of enteric parasite exposure.

The questionnaire used for the study to evaluate the food handling processes and hygiene practices of the vegetables vendors revealed that majority of the vendors practice poor handling process such placing vegetables on the bare land and not washing vegetable before sale, these findings indicate that a majority of vendors use unhygienic handling methods which facilitate parasitic contamination of vegetables.

5.2 Conclusion

The results of this study clearly demonstrate that vegetables sold at Kasuwan Daji Market, Sokoto, are highly contaminated with intestinal parasites, posing a potential risk for foodborne parasitic infections among consumers. The high contamination rate of 80% underscores the urgent need for improved hygiene and sanitation in vegetable production and marketing chains. Among the vegetables studied, lettuce was the most contaminated, followed by spinach and cabbage, indicating that leafy vegetables are more susceptible to parasitic contamination due to their surface characteristics. The presence of parasites such as *Giardia lamblia*, *Entamoeba histolytica*, and *Ascaris lumbricoides* further highlights the potential for disease transmission through consumption of raw or poorly washed vegetables, the study concludes that improper handling, inadequate washing, use of contaminated irrigation water, and poor sanitary practices are the major contributing factors to the parasitic contamination of vegetables in Kasuwan Daji Market.

5.3 Recommendations

Based on findings this study, the following are recommended

1. Public health education should be organized for vegetable farmers, vendors, and consumers on the dangers of consuming unwashed vegetables and the importance of maintaining hygiene during production and sale.

2. Consumers should thoroughly wash vegetables with clean water and, where possible, disinfect them using safe agents such as vinegar or salt solutions before consumption, especially when eaten raw.
3. Farmers should avoid the use of untreated wastewater for irrigation. Government and local authorities should provide access to clean and safe irrigation water sources.
4. Sanitation officers should routinely monitor vegetable markets to ensure that vendors comply with sanitary regulations and good handling practices.
5. Future studies should include molecular identification of parasites and assess seasonal variation in contamination levels to provide deeper insight into the epidemiology of vegetable-borne parasites in Sokoto and other regions.

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