Prevalence and Produce-Specific Risk of Parasitic Contamination of Fresh Fruits and Vegetables in Local Markets of Iddo Community, Gwagwalada Area Council, FCT, Abuja, Nigeria: A Cross-Sectional Study

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ABSTRACT

Fresh fruits and vegetables are essential dietary components but can serve as vehicles for transmitting parasitic infections, particularly in settings with inadequate sanitation. This study assessed the prevalence and produce-specific risk of parasitic contamination in commonly consumed fruits and vegetables sold in local markets of Iddo community, Gwagwalada Area Council, Federal Capital Territory, Abuja, Nigeria. A cross-sectional, purposive study was conducted in December 2023 across three markets: Iddo Modern Market, Barko Market, and Fruits Market. A total of 150 samples comprising five fruits (orange, pawpaw, watermelon, pineapple and banana) and five vegetables (cucumber, cabbage, carrot, pumpkin leaf and garden egg leaf), with 15 samples per produce type, were examined using sedimentation and flotation techniques with microscopic identification. Chi-square analysis was used to assess associations between parasitic contamination and produce types, with statistical significance set at $P \leq 0.05$. Of 150 samples, 80 (53.33%) were contaminated with at least one parasite. Cabbage (66.7%) and carrot (66.7%) had the highest contamination rates, followed by banana (60.0%) and cucumber (60.0%); orange had the lowest (26.7%). Among contaminated samples, vegetables accounted for 62.7% and fruits 37.3%. The submitted analysis reported a significant association between contamination and produce type ($\chi^2 = 90.601$, df = 63, P = .013). More than half of the fresh produce examined was contaminated with at least one parasitic form. Cabbage and carrot had the highest observed contamination rates, followed by banana and cucumber, while orange had the lowest. The Chi-square analysis indicated an association between the analysed parasite observations and produce type, because 71 cells (88.8%) had expected counts below 5, this inferential result is interpreted cautiously. The findings support strengthened hygiene practices among vendors, safer agricultural and water-management practices, consumer education, and targeted market surveillance to reduce foodborne parasitic infections. Future studies should incorporate repeated seasonal sampling and molecular characterization to improve species-level identification and strengthen epidemiological inference.

Keywords: parasitic contamination; fruits; vegetables; prevalence; food safety; Iddo; Abuja; Nigeria

INTRODUCTION

Fresh fruits and vegetables are globally recognised as essential sources of vitamins, dietary fibre, minerals and phytochemicals that promote health and prevent chronic diseases such as cardiovascular diseases, stroke and cancer [1,2]. Dietitians routinely recommend daily consumption of vegetables for their role in health promotion and disease prevention [1]. However, the consumption of raw or minimally processed produce has been associated with the transmission of a wide range of parasitic infections [3,4].

Vegetables, particularly those eaten raw and without peeling, require moist environments for growth and have been demonstrated to serve as vehicles for protozoan cysts and helminth eggs [5,6]. The consumption of raw vegetables plays a major epidemiological role in the transmission of foodborne parasitic diseases [4]. Parasitic infections may be acquired through contaminated vegetables, other foodstuffs and water [5]. Infective forms of parasites can be transmitted through vegetables at multiple stages, including planting, harvesting,

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transportation, storage and marketing [7].

Globally, an estimated 3.5 billion people have been reported to be infected with parasites, with 450 million at risk and approximately 200,000 deaths annually [8]. Soil-transmitted helminths such as *Ascaris lumbricoides* infect over one billion people worldwide, while *Trichuris trichiura* infects 79 million and *Ancylostoma duodenale* and *Necator americanus* infect 740 million [9]. In developing countries such as Nigeria, poor environmental sanitation, the use of untreated human and animal dung as fertilizer, and contaminated irrigation water contribute significantly to the parasitic contamination of produce [10,11].

In Nigeria, studies have indicated high prevalence rates of parasitic contamination in locally consumed produce, ranging from 52.7% to 60% [12,13]. However, there remains a lack of comprehensive data on the occurrence and distribution of parasites in commonly consumed fruits and vegetables within specific market settings in the Federal Capital Territory (FCT). The Iddo community in Gwagwalada Area Council relies heavily on fruits and vegetables as dietary staples, yet the extent of parasitic contamination in these food items within local markets has not been adequately investigated.

This study aimed to determine the prevalence of parasitic contamination in commonly consumed fruits and vegetables sold in local markets of Iddo community, to identify produce-specific contamination patterns, and to evaluate the association between parasitic contamination and types of produce. The findings will contribute to evidence-based strategies for improving food safety and protecting public health.

MATERIALS AND METHODS

Study area

This study was conducted in Iddo community, located in Gwagwalada Area Council, approximately 35 km from the Federal Capital Territory (FCT), Abuja, Nigeria. The town lies between latitude 8°55′ and 9°00′ North and longitude 7°00′ and 7°05′ East. The climate is typically tropical, with temperatures ranging from 30°C to 37°C and average annual rainfall of approximately 1,650 mm [14]. Residents are primarily small-scale farmers engaged in crop production, livestock rearing, trade and commerce [15]. Open-air market purchases, improper handling practices and consumption of unwashed produce are common habits that may predispose residents to parasitic contamination.

Study design

A cross-sectional, purposive study was conducted in December 2023 to assess the occurrence of parasitic contamination in fruits and vegetables across three local markets: Iddo Modern Market, Barko Market and Fruits Market in Iddo community.

Sample collection

Five types of fruits (orange, pawpaw, watermelon, pineapple and banana) and five types of vegetables (cucumber, cabbage, carrot, pumpkin leaf and garden egg leaf) were purposively selected based on their popularity and frequent availability in local markets. From each of the three markets, five samples of each produce type were collected (5 samples × 10 produce types × 3 markets), yielding a total of 150 samples. Vendors' stalls were visited in random sequence across diverse sections of each market. Visibly damaged, bruised or spoiled produce was avoided. Samples were collected in clean, labelled plastic bags with essential information including produce type, market location, date and time of collection, and unique sample identifiers. Sterile gloves were worn throughout sampling. Samples were transported in insulated containers to the Department of Biological Sciences laboratory, University of Abuja, for parasitological analysis.

Laboratory analysis

Each sample was washed thoroughly with sterile distilled water. Leafy vegetables and soft fruits were homogenized in a blender. For each sample, 100 g of material was weighed and homogenised with 500 mL of physiological saline solution (0.9% NaCl) at a 1:5 (w/v) ratio [16]. A 15-mL portion of the homogenate was

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transferred into centrifuge tubes and centrifuged at 1,500 rpm for 10 minutes. The supernatant was carefully decanted, and the sediment was washed with physiological saline solution to concentrate parasitic material [17]. Prepared smears were created from washed sediments on clean microscope slides. A drop of Lugol's iodine solution was added to enhance visualization. Slides were examined under a compound light microscope at 10× and 40× magnification. For lighter parasites (e.g., *Giardia lamblia*, *Cryptosporidium parvum*), a flotation technique using zinc sulphate solution with centrifugation at 1,000 rpm for 5 minutes was employed. Special staining methods, including acid-fast staining for *Cryptosporidium* and trichrome staining for *Giardia*, were used where necessary. Parasite eggs, cysts, larvae and oocysts were identified based on morphological criteria as outlined by the World Health Organization [18]. Positive control samples containing known parasites and negative controls devoid of parasites were included in each batch. Qualified laboratory technicians assisted in sample preparation, microscopy and parasite identification.

Statistical analysis

Data were analysed using SPSS version 27 (IBM Corp., Armonk, NY). Descriptive statistics (frequencies and percentages) were used to summarize findings. Chi-square tests were used to assess associations between parasitic contamination and types of fruits and vegetables, with statistical significance set at $P \leq 0.05$. The submitted chi-square output contained 212 valid parasite-observation records; this figure represents the analytical records used in that output and should not be interpreted as 212 independently sampled produce units, since the study collected 150 produce samples. The chi-square table also indicated that 71 cells (88.8%) had expected counts below 5; consequently, the reported association is presented as an observed statistical result and interpreted with appropriate caution rather than as definitive evidence of a produce-specific causal effect.

Ethical considerations

This study was approved by the Department of Biological Sciences, University of Abuja, FCT, Abuja, Nigeria.

RESULTS

Overall prevalence

Of the 150 samples of fruits and vegetables examined across the three markets, 80 (53.33%) were positive for at least one parasitic contaminant, while 70 (46.67%) were negative (Table 1; Figure 1).

Table 1. Overall prevalence of parasitic contamination in fruits and vegetables at Iddo markets, FCT, Abuja (N = 150).

Produce type	No. examined	Positive (≥1 parasite), n	Positive (%)	Negative, n	Negative (%)
Orange	15	4	26.67	11	73.33
Pawpaw	15	8	53.33	7	46.67
Watermelon	15	7	46.67	8	53.33
Pineapple	15	8	53.33	7	46.67
Banana	15	9	60	6	40
Cucumber	15	9	60	6	40
Cabbage	15	10	66.67	5	33.33
Carrot	15	10	66.67	5	33.33
Pumpkin leaf	15	7	46.67	8	53.33
Garden egg leaf	15	8	53.33	7	46.67
Total	**150**	**80**	**53.33**	**70**	**46.67**

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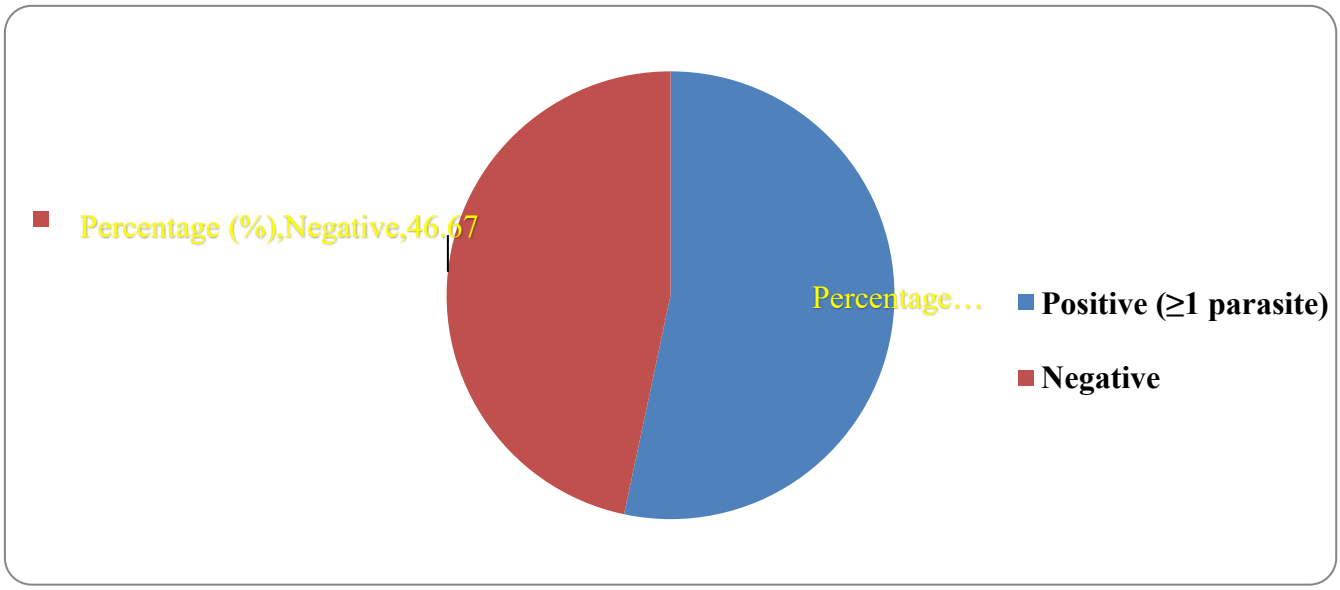

Figure 1. Overall prevalence of parasitic contamination in fruits and vegetables sold in Iddo markets, Abuja.

Produce-specific contamination rates

Contamination rates varied across produce types. Cabbage (66.7%) and carrot (66.7%) exhibited the highest contamination rates, followed by banana (60.0%) and cucumber (60.0%). Pawpaw, pineapple and garden egg leaf each recorded 53.3%, while watermelon and pumpkin leaf recorded 46.7%. Orange exhibited the lowest contamination rate (26.7%) (Figure 2).

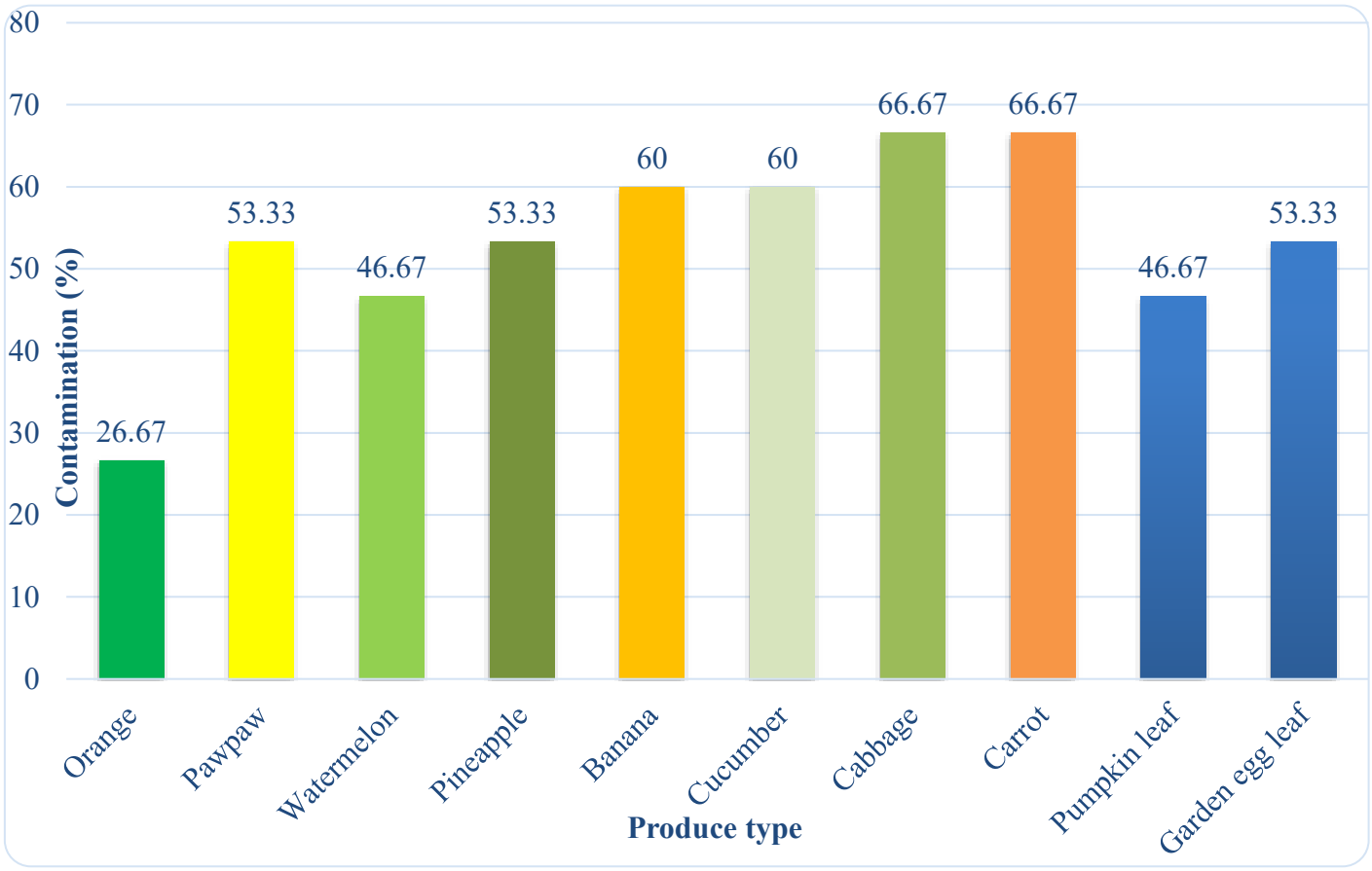

Figure 2. Prevalence of parasitic contamination by produce type sold in Iddo markets, Abuja.

Comparison between fruits and vegetables

When samples were categorized by produce class, vegetables accounted for 62.7% (50/80) of contaminated samples, while fruits accounted for 37.3% (30/80). Among vegetables, cabbage and carrot were the most contaminated (66.7% each), while among fruits, banana was the most contaminated (60.0%) and orange the least (26.7%).

Association between parasitic contamination and produce type

Chi-square analysis produced a statistically significant Pearson chi-square result for the association between the analysed parasite observations and produce type ($\chi^2 = 90.601$, df = 63, P = .013) (Table 2). The likelihood ratio was also significant (102.740, df = 63, P = .001). However, 71 cells (88.8%) had expected counts below 5, with a minimum expected count of 0.11. The statistical association is therefore retained as part of the original analysis but should be interpreted cautiously, particularly because the analytical records are not equivalent to 212 independently sampled produce units.

Table 2. Chi-square test of association between parasitic contamination and types of fruits and vegetables.

Test	Value	df	Asymptotic significance (2-sided)
Pearson Chi-square	90.601[a]	63	0.013
Likelihood ratio	102.74	63	0.001
Linear-by-linear association	6.189	1	0.013
N of valid cases	212	—	—

[a] 71 cells (88.8%) have expected count less than 5. The minimum expected count is 0.11.

DISCUSSION

The overall parasitic contamination rate of 53.33% observed in this study indicates that more than half of the fresh fruits and vegetables sold in Iddo markets harboured at least one parasitic contaminant. This finding is consistent with studies conducted in other parts of Nigeria, where contamination rates of 52.7% to 60% have been reported [12,13]. Comparable rates have also been documented in Kenya and Brazil [27,28], underscoring that parasitic contamination of fresh produce is an important public health concern.

The significant association between parasitic contamination and produce type ($\chi^2 = 90.601$, P = .013) suggests variation in contamination among the produce types examined. Cabbage and carrot recorded the highest contamination rates, each at 66.7%. Cabbage has an extensive exposed leaf surface and folds that can retain soil particles and parasitic stages during cultivation, irrigation and handling [19,20]. Carrots, as root vegetables grown in direct contact with soil, are particularly vulnerable to soil-transmitted helminths such as *Ascaris lumbricoides* and *Strongyloides stercoralis,* especially when untreated animal or human manure is used as fertilizer [10,11].

The high contamination rates observed in banana and cucumber (60.0% each) are also noteworthy. Banana may become contaminated through contact with soil and water during cultivation, harvesting and marketing [11]. Cucumber is frequently consumed raw, and environmental contamination may persist on its surface if adequate washing is not undertaken [4]. These findings are broadly consistent with previous reports of substantial parasitic contamination of vegetables in Nigeria [21].

The relatively lower contamination rate observed in orange (26.7%) may be related to its thick peel, which provides a physical barrier between environmental contaminants and the edible portion [22]. Nevertheless, contamination of the external surface can still be relevant because handling and cross-contamination may occur during marketing and preparation.

Vegetables accounted for a greater proportion of contaminated samples than fruits, contributing 62.7% of contaminated samples compared with 37.3% for fruits. This observation is consistent with reports that leafy and root vegetables may be more exposed to contaminated soil, irrigation water and organic fertilizers during cultivation [6,20]. Some vegetables are also consumed raw or only lightly cooked, increasing the opportunity for transmission [5]. Similar patterns have been reported in Ghana and Ethiopia [23,24].

The findings have direct practical implications for food-safety practice in Iddo markets. Market vendors should keep produce off contaminated ground surfaces, use clean containers and display surfaces, minimize unnecessary handling, protect food from dust and flies, and maintain hygienic stalls. Farmers should be encouraged to use microbiologically safer irrigation water and properly treated or composted organic manure, while avoiding the use of untreated human waste on crops. Consumers should be advised to wash fresh produce thoroughly with safe water, peel produce where appropriate and cook vegetables when appropriate before consumption. Local regulatory and public-health authorities could strengthen periodic market inspection, vendor food-safety education, environmental sanitation, and surveillance of irrigation and washing water. These measures are particularly relevant for produce showing higher contamination rates in this study, including cabbage, carrot, banana and cucumber. The findings should, however, be used to guide risk-prioritisation rather than to imply that any single produce type is inherently unsafe.

Several environmental and handling factors may contribute to parasitic contamination, including the use of untreated human or animal dung as fertilizer by local farmers is a well-documented risk factor for parasitic contamination of produce in Nigeria, contaminated irrigation water, poor post-harvest handling, inadequate storage conditions and unhygienic market environments [10,11,25,26]. Open-air market settings may further facilitate contamination through dust, flies and repeated human contact.

This study has limitations. First, sampling was conducted in December 2023 and therefore represents a single time point within the dry season; the study cannot establish seasonal differences in contamination. Future investigations should repeat sampling during both wet and dry seasons and, preferably, across multiple sampling periods to determine temporal patterns. Second, parasite identification was based on morphological examination by microscopy, and molecular characterization such as PCR was not undertaken. Consequently, precise species-level confirmation could not be established for all detected forms, future studies should incorporate molecular methods where resources permit. Third, the sample comprised 150 produce units from three markets and may not represent all produce types, vendors or market conditions in the wider Gwagwalada Area Council.

Finally, the chi-square output contained a high proportion of cells with expected counts below 5, and the analytical N of 212 reflects parasite-observation records rather than 212 independent produce samples. The reported inferential statistics should therefore be interpreted cautiously, and future studies with larger samples and an analysis plan that accounts explicitly for repeated observations within produce samples should be considered.

CONCLUSION

This study revealed a parasitic contamination rate of 53.33% among fresh fruits and vegetables sold in selected local markets in Iddo Community, Gwagwalada Area Council, FCT, Abuja. Cabbage, carrot, banana and cucumber exhibited the highest contamination rates, while orange was the least contaminated. The reported association between parasitic contamination and produce type ($P = .013$) indicates that certain produce categories may represent higher-risk commodities. Vegetables accounted for a greater proportion of contaminated samples than fruits, with leafy and root vegetables posing the greatest concern. These findings underscore the urgent need for improved hygiene practices among vendors and consumers, stringent regulatory measures in local markets, and public awareness campaigns about the importance of thorough washing, peeling, and cooking of fresh produce before consumption. Future studies should investigate seasonal variations, molecular characterization of detected parasites, and the effectiveness of specific washing and disinfection protocols in reducing parasitic contamination.

Declarations

Ethics Approval and Informed Consent

This study was approved by the Department of Biological Sciences, University of Abuja, FCT, Abuja. The study did not involve human participants or animals; therefore, informed consent was not applicable.

Authors' Contributions

C.S. Ebiriekwe and V. Aro contributed to the conception and design of the study, data collection, laboratory investigation and manuscript preparation. C.C. Ndu, L.A. Waheed and S.M. Usman contributed to data collection, laboratory work, interpretation of results and critical review of the manuscript. All authors reviewed and approved the final manuscript and agreed to be accountable for the work. The corresponding author should confirm these individual contributions with all co-authors before submission.

Disclosure of Conflict of Interest

The authors declare that they have no competing interests.

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