

Public Health Risk of Consuming Fruits and Vegetables Sold in Two Major Markets in Lafia, Nasarawa State, Nigeria

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ABSTRACT

Fresh fruits and vegetables are great sources of vitamins and minerals; however, they can be vectors of various parasitic infections. Therefore, this study aimed at assessing the occurrence and prevalence of parasitic infections contaminating the fruits and vegetables obtained from Modern and Tomato markets located in Lafia metropolis, Nasarawa state, Nigeria. The study design involved a cross-sectional survey. A total number of 178 fruit and vegetable samples including 72 fruits (apple orange, tomato, mango) and 106 vegetables (garden egg, spring onion, spinach, water leaf, carrot) were collected and tested for parasites using standard parasitology methods. According to the results, about 13.48% of all samples contained at least one parasitic infection. It should be noted that fruits contained fewer parasites (5.56%) than vegetables (18.87%). Statistical analysis showed that there was a significant difference ($P = 0.01093$) between contamination rates of fruits and vegetables. *Ascaris lumbricoides* was identified in 50.00% of fruit samples, *Trichuris trichiura* occurred in 25.00% of samples, *Entamoeba histolytica* and *Giardia lamblia* were found in 12.50% of the fruit samples. In the case of vegetables, *Ascaris lumbricoides* was also the major type of parasites (59.09%), *Strongyloides stercoralis* occurred in 22.73%, while *Entamoeba histolytica* and *Trichuris trichiura* were present in 9.09% of samples. Parasites occurred more frequently in samples obtained from Modern market (20.00%), than in samples purchased from Tomato market (6.82%). Furthermore, knowledge, attitude and practice of fruit and vegetables vendors' ($n=40$) regarding parasitic contamination of products revealed that only 62.50% of vendors knew about parasitic infections in fruits and vegetables, while improper handling practices (e.g. keeping the produce on the floor) were common. These findings suggest that there is a significant public health risk due to the consumption of raw or poorly washed produce. Proper consumer food safety education, improved hygiene conditions in markets, installation of display stands should be considered.

Keywords: Public health implication, Fruits, Vegetables, Parasitic helminths, Markets

1. Introduction

The edible portions of plants that do not include starchy roots, tubers, cereals, nuts, seeds, medicinal herbs and stimulants are called fruits and vegetables¹. Plants have very important contributions in the human nutrition because of their health promoting properties such as supplying essential vitamins, minerals, dietary fiber, antioxidants, phytoestrogens and anti-inflammatory agents^{2,3}. These natural constituents in plant foods have proven effective in reducing the likelihood of contracting non-communicable diseases like cardiovascular diseases, obesity, diabetes and certain types of cancers^{4,5}. The recommended daily intake of fruits and vegetables for healthy adults by the WHO and FAO is 400 grams to prevent diet-related diseases⁶. The ingestion of contaminated food leads to various health issues from simple digestive disturbances to serious ones, such as malnutrition, anemia and mental impairment especially in children, pregnant females and immune-compromised individuals⁶.

Food safety is not guaranteed in most low and middle-income countries, like Nigeria, because of poor sanitary practices in agriculture as well as at points of sales of fruits and vegetables that increase their risk of parasitic contamination. Factors such as using contaminated irrigation water, improper use of animal wastes as fertilizers, unhygienic harvesting practices, inadequate storage facilities for fresh produce at points of sales are among the causes for the presence of pathogens in plants⁶. Besides increasing the risk of foodborne disease outbreaks, all these practices facilitate the spread of parasites like *A. lumbricoides*, *T. trichiura*, *G. lamblia* and *S. stercoralis*.

High levels of parasitic contaminants in fruits and vegetables offered for sale in the outdoor markets in different urban centers of Nigeria have been reported in several studies. Lafia city, the capital of Nasarawa State, is characterized by a high consumption of fresh fruits and vegetables, mostly in raw form, increasing thus the risk of acquiring diseases via food. The risk is higher in light of certain factors, for instance, the use of wastewater as irrigation source, poor hygiene practices among vendors and poor conditions of fruit and vegetable stalls⁷. For this reason, the present study was conducted to investigate the occurrence and prevalence of parasitic contaminants in fresh fruits and vegetables in two main markets in Lafia. This study also aims to assess the food safety knowledge, attitude and practices of the vendors.

2. Materials and Methods

2.1. Study area

Nasarawa State, found within Nigeria's North-Central geopolitical axis, falls under the category of Guinea Savannah ecological zone with geographical location coordinates of 8.4998° N, 8.1997° E⁷. The climatic condition experienced within Nasarawa is tropical with an average rainfall. There is variation in topography with the existence of plains and rolling lands that have elevations ranging between 300 ft above sea level. The research was conducted in Lafia, the capital of Nasarawa State. Lafia town serves as the administrative headquarters of the Lafia local government area. Being the largest urban area in the Nasarawa State, Lafia is vital in agricultural activities, especially in the production of major cash crops like yam, cassava and melon (**Figure 1**).

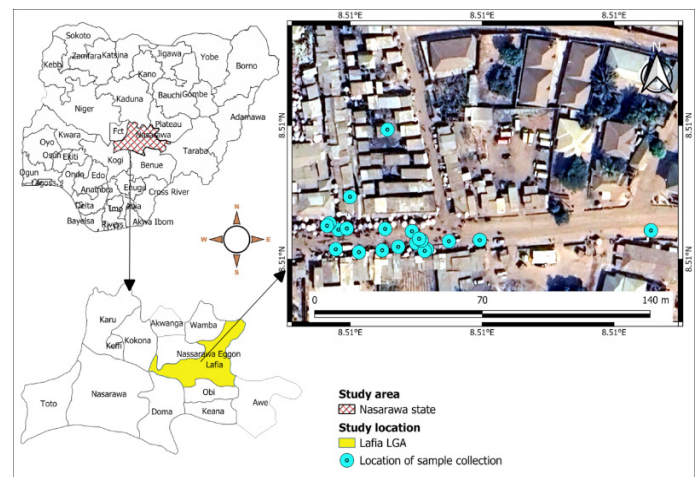


Figure 1: Map of Nasarawa State and the Location of Sample Collection (Generated using QGIS version 3.40.1-Bratislava).

2.2. Sample collection

The samples were taken from the two largest markets, which include Lafia Modern Market and Lafia Tomato Market. A total number of 178 samples, consisting of 72 fruits and 106 vegetables were randomly taken from various sellers. The fruits involved in this study are orange (*Citrus sinensis*), tomato (*Lycopersicon esculentum*), mango (*Mangifera indica*) and apple (*Malus domestica*). On the other hand, the vegetables are garden egg (*Brassica oleracea*), spinach (*Spinacia oleracea*), spring onion (*Allium* spp.), water leaf (*Talinum fruticosum*) and carrot (*Daucus carota*). These samples were packed in sterile plastic bags that were labeled.

2.3. Sample processing and parasitological analysis

2.3.1. Sedimentation technique: The ten grams of the samples were washed using normal saline 0.9% in order to remove the parasitic stages (ova, larvae, oocysts and cysts). This was done after which fifteen milliliters of the washing fluid was transferred into the centrifuge tube using a sieve in order to remove unwanted particles. The process was done by centrifuging the fluid in the tube at 3000 rpm for five minutes in order to remove the parasitic stages, Ishaku et al. and Cheesbrough^{8,9}. A drop of the supernatant was removed and placed on a slide covered by a coverslip.

2.3.2. Saturated sodium chloride flotation technique: According to Cheesbrough⁹, the samples were rinsed using saturated sodium chloride before being strained to filter out large debris. They were thereafter introduced to a tube and allowed to stand in an upright position on the rack. Additional fluid was added into the tube to make sure that the tube is completely full. Subsequently, a clean cover glass was placed onto the tube. It was allowed to stay there for around 30 to 45 minutes so that the eggs/cysts could float. The cover glass was thereafter taken out from the tube using an upward pull and placed downward on a slide. It was thereafter analyzed under a microscope using both 10x and 40x objectives.

2.3.3. KAP survey: The survey questionnaire was conducted among 40 traders dealing with fruits and vegetables, with an equal number of participants coming from each of the two markets and who were randomly selected when collecting the sample. This tool was used to gauge their awareness on the contamination of their commodities by parasites, attitude toward hygiene and behaviors.

2.4. Data analysis

Version 2.1.2. of Minitab statistical software was used for analysis of data. The comparison of prevalence of contamination among sample types and markets and within various produce items was made by using descriptive statistics (in percentages) and χ^2 test. In all cases, probability $p < 0.05$ was taken as significant.

3. Results

Overall, of parasites Contamination of fruits and vegetables in modern Markets and Tomatoes markets.

Table 1: Contamination of Fruits and Vegetables Collected from Selected Markets.

| Market | No. of fruits examined | No. contaminated (%) | No. of vegetables | No. contaminated (%) | Total No. Examined | Total No. contaminated (%) |
|-----------------|------------------------|----------------------|-------------------|----------------------|--------------------|----------------------------|
| Modern Market | 36 | 2(5.56) | 54 | 16(29.63) | 90 | 18(20.00) |
| Tomatoes market | 36 | 2(5.56) | 52 | 4(7.69) | 88 | 6(6.82) |
| Total | 72 | 4(5.56) | 106 | 20(18.87) | 178 | 24(13.48) |

$\chi^2 = 6.477$, $df = 1$, $p = 0.01093$.

3.1. Parasitic contamination in fruits

Amongst the total 72 samples of fruits analyzed, only 4 fruits types (5.56%) were infected with parasitic worms as shown in Table 2 below. *Ascaris lumbricoides* is the most frequently isolated (3 or 42.6%) parasite species found on tomatoes. *Trichuris trichiura* was the second most commonly identified (2 or 28.56%) parasite species found on oranges. On the other hand, there was no isolation of *Strongyloides stercoralis* in all the fruits that were analyzed. Statistically significant difference ($\chi^2 = 6.0$, $df = 2$, $P = 0.0498$) was found between these parasite species (Table 2).

Table 2: Prevalence of Parasites in Contaminated Fruits at Selected Markets in Lafia.

| Parasites | Fruit Type | | | | Total (72) | Prevalence (%) |
|----------------------------------|-------------|-------------|--------------|----------------|------------|----------------|
| | Apple 14(%) | Mango 12(%) | Orange 18(%) | Tomatoes 28(%) | | |
| <i>Ascaris lumbricoides</i> | 0(0.00) | 0(0.00) | 0(0.00) | 3 (10.71) | 3 | 42.86 |
| <i>Entamoeba histolytica</i> | 0(0.00) | 0(0.00) | 0(0.00) | 1 (3.57) | 1 | 14.29 |
| <i>Giardia lamblia</i> | 0(0.00) | 1 (8.33) | 0(0.00) | 0(0.00) | 1 | 14.29 |
| <i>Strongyloides stercoralis</i> | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 0 | 0.00 |
| <i>Trichuris trichiura</i> | 0(0.00) | 0(0.00) | 1 (100) | 1 (3.57) | 2 | 28.56 |
| Total (%) | 0(0.00) | 1(8.33) | 1 (5.56) | 5 (17.86) | 7 | 100.00 |

$\chi^2 = 53.053$, $df = 4$, $P < 0.001$

3.2. Parasitic contamination in vegetables

The prevalence of parasites among all 106 samples tested was 22(20.75%). *Ascaris lumbricoides* was the leading parasite detected, as seen in 13(59.09% of all contaminated vegetables), mainly in the samples from Spring onion 10(50.00%), followed by 3(18.75%) samples from Spinach. The second most common parasite was *Strongyloides stercoralis*, at 5(22.73%), occurring in Carrot, Spinach and Water leaf. *Entamoeba histolytica* and *Trichuris trichiura* each occurred in 2 (9.09%) samples from Vegetables. *Giardia lamblia* was absent in all vegetable samples. There was difference in the prevalence of parasite species among vegetables in Lafia markets ($\chi^2 = 108.68$, $df = 4$, $p < 0.001$) (Table 2).

Table 3: Prevalence of Parasites in Contaminated Vegetables at Selected Markets in Lafia.

| Parasites | Vegetable Type | | | | | Total 106 | Prevalence (%) |
|----------------------------------|----------------|------------------|---------------|--------------------|------------------|-----------|----------------|
| | Carrot 28(%) | Garden Egg 26(%) | Spinach 16(%) | Spring Onion 20(%) | Water 16Leaf (%) | | |
| <i>Ascaris lumbricoides</i> | 0(0.00) | 0(0.00) | 3(18.75) | 10(50.00) | 0(0.00) | 13 | 59.09 |
| <i>Entamoeba histolytica</i> | 0(0.00) | 0(0.00) | 2(12.5) | 0(0.00) | 0(0.00) | 2 | 9.09 |
| <i>Giardia lamblia</i> | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 0(0.00) | 0 | 0.00 |
| <i>Strongyloides stercoralis</i> | 1(3.57) | 0(0.00) | 2(12.5) | 0(0.00) | 2(12.50) | 5 | 22.73 |
| <i>Trichuris trichiura</i> | 1(3.57) | 0(0.00) | 0(0.00) | 1(0.50) | 0(0.00) | 2 | 9.09 |
| Total (%) | 2(7.14) | 0(0.00) | 7(43.75) | 11(55.00) | 2(12,50) | 22 | 100.00 |

$\chi^2 = 108.68$, $df = 4$, $P < 0.001$

3.3. Hygiene conditions of produce display

From observation of the method used by vendors in displaying the fruits and vegetables sold by them, a clear contrast existed. Most of the fruit sellers (67.007%) used tables to display their products, which is fairly hygienic (Figure 2). However, most of the vegetable sellers (44.44%) used the ground as their surface, leaving them at risk of contamination with dirt, followed by those that used Wheelbarrows (22.22%), then Rubbers (19%) while only 15% contaminants were found on vegetables displayed on Table (Figure 3).

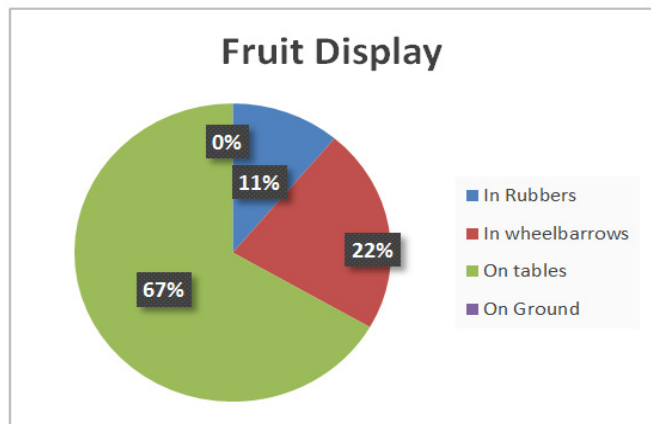


Figure 2: Hygiene Conditions under which the Fruits are displayed.

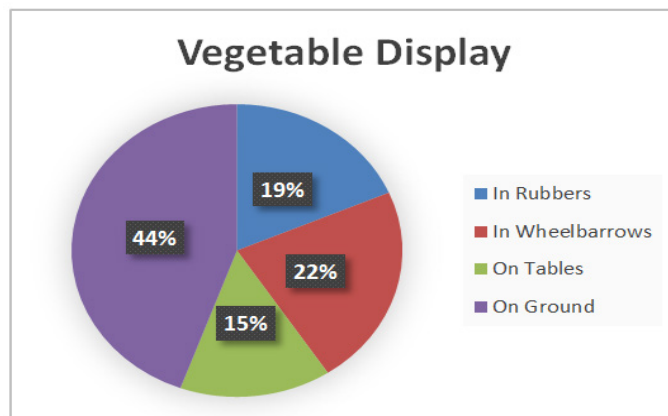


Figure 3: Hygiene Conditions under which the Vegetables are displayed.

3.4. Knowledge, attitude and practices (KAP) of vendors

However, it was found through the KAP survey that there are large areas of ignorance when it comes to food safety issues. The majority of the participants in the study, out of the total 40 people, did not know that the produce can cause parasitic infections. This was found to be statistically significant ($\chi^2 = 6.25, P = 0.01242$). The vendors obtained the produce from places such as Jos, Plateau state, which is 70 percent of the time, while only 30 percent obtain it from Lafia (Table 4).

Table 4: Knowledge, Attitude and Practice of Vendors on the Contamination of Fruits and Vegetables.

| Question | Response | Frequency | Proportion | χ^2 | df | P value |
|---|------------|-----------|------------|----------|----|---------|
| Are you aware of parasitic contamination of fruits and vegetables | Yes | 15 | 37.50 | 6.25 | 1 | 0.01242 |
| | No | 25 | 62.50 | | | |
| Total | | 40 | 100.00 | | | |
| Where do you source for your fruits and vegetables | Jos | 28 | 70.00 | 16 | 1 | P<0.001 |
| | Lafia | 12 | 30.00 | | | |
| Total | | 40 | 100.00 | | | |
| Which water source do you use to wash your fruits and vegetables | Borehole | 24 | 60.00 | 50.375 | 2 | P<0.001 |
| | Tap Water | 15 | 37.50 | | | |
| | Well water | 1 | 2.50 | | | |
| Total | | 40 | 100.00 | | | |

4. Discussion

The results from the current investigation demonstrated that the fresh fruits and vegetables sold in Lafia markets are contaminated with parasites that are of public health importance, with an overall parasitic contamination of 13.48%. This rate is lower when compared to the findings from Abuja market (33.3%), as reported by Moshood¹⁰, yet much higher than in Ibadan market (5%) as reported by Obebe, et al.⁶. Indeed, the current findings reflect the reality of the challenges associated with food safety in developing countries due to the poor post-harvest handling practices and environmental conditions in the markets^{6,7,11}. Parasites including *Ascaris lumbricoides*, *Strongyloides stercoralis*, *Trichuris trichiura*, *Entamoeba histolytica* and *Giardia lamblia* suggest that there is a lot of faecal pollution of the environment caused by the usage of contaminated water for irrigation/ washing and poor handling of the produce.

It is also apparent that there is a statistically significant difference in the prevalence of parasitic contamination of fruits and vegetables (18.87% vs. 5.56%), which is consistent with

previously reported research studies^{8,12}. It can be explained by morphologic and physiological features of fruits and vegetables, as well as different handling procedures. Specifically, vegetables like spinach and spring onions show very high rates of contamination and this might be attributed to their large and rough surface area that facilitates the accumulation of parasites. Moreover, they remain in prolonged contact with the soil while growing up, as well as with the ground when being exposed at the vendor stands^{13,14}. This view is supported by a similar study by Abubakar, et al.⁹, who observed a high prevalence of vegetable contamination in Keffi markets (Nasarawa State). Fruits, on the other hand, were demonstrated to have rather smooth surfaces and were mostly displayed on the table.

Ascaris lumbricoides was the parasite that had been isolated the most frequently from the samples collected during this study. The reason for this can be related to the fact that *Ascaris lumbricoides* is the most commonly found soil-transmitted helminth in Nigeria and most of tropical countries. Several reasons for its high prevalence include daily discharge of millions of eggs by infected people, high egg resistance to

environmental conditions, as well as easy dissemination through soil¹⁵. The findings concerning the second-most common parasite, *Strongyloides stercoralis*, should be highlighted too because larvae of this species can penetrate the skin⁶.

Statistically significant differences in parasitic contamination of fruits and vegetables in the two investigated markets (Modern Market and Lafia Tomato Market) were also observed. In particular, the prevalence of contamination in the former was significantly higher (20.00% vs. 6.82%). Such findings can be linked to the market size and the amount of waste produced in such markets. The higher the number of vendors and customers is, the greater amount of waste is accumulated within a shorter period and this, in turn, makes the contamination more probable.

The results obtained from the KAP survey help to explain the parasitological findings. First, a high percentage (62.5%) of respondents was not aware about the risk of parasitic infections. In fact, in this case, they cannot apply preventive measures. Second, the habit of laying the vegetables on the ground is one of the key sources of contamination with soil-transmitted helminths, such as *Ascaris* or *Trichuris*. Third, it can be stated that, despite the fact that 60% of respondents use borehole water, the remaining 40% use the tap well water, which increases the risk of re-contamination of the produce after washing. Finally, it can be mentioned that the majority of produce comes from the town of Jos, which means that contamination is likely to occur on the farm. Thus, it is crucial to follow GAPs.

The overall parasitic contamination of fresh fruits and vegetables (13.48%) in Lafia markets is lower than that in some other cities in Nigeria, for instance, in Abuja (33.3%)¹⁰ and Keffi (53.5%)⁷. On the contrary, in Ibadan the percentage of parasitic contamination was lower (5%)⁶. It is hard to say whether the discrepancy in the contamination level is real or methodical. However, regardless of this, the presence of the mentioned pathogenic parasites on produce consumed by the public is dangerous for people's health^{1,16}.

5. Conclusion

The current study reveals that fruits and vegetables consumed from markets within Lafia are contaminated by parasitic organisms of medical importance such as *Ascaris lumbricoides*, *Strongyloides stercoralis* and *Trichuris trichiura*. This observation can be attributed to poor sanitation of the markets, as indicated by the higher level of contamination at the Modern Market. In addition, the common practice of displaying vegetables on the ground indicates that vegetables can be easily contaminated. Moreover, most vendors lack the knowledge concerning the possibility of fruits and vegetables to act as vectors of disease. Based on these observations, an urgent action is required in order to combat this problem. Firstly, public health agencies should initiate food safety education campaigns aimed at raising the knowledge of vendors concerning the role of food hygiene in the spread of disease. Secondly, the market managers should improve their sanitation facilities through providing display tables and adequate amounts of clean water.

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