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Original Research Article

Parasitic contamination of some fruits, vegetables, and nuts sold in Jos, Plateau State, Nigeria

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Fruits, vegetables, and nuts are major sources of vitamins and minerals which help in promoting good health but could also constitute risk to human health when consumed unclean. This study aimed at determining the prevalence of parasitic contamination of some fruits, vegetables, and nuts collected from three local markets in Jos town, Plateau State, Nigeria. A total of 270 samples of different types of fruits, vegetables, and nuts were washed separately in saline water and sedimentation method was used to concentrate the parasites which were examined using light microscope. Out of the 270 samples examined, 113 (41.85%) were contaminated with at least one type of parasite. *Trichostrongylus* (37.14%) and *Entamoeba histolytica* (36.89%) were the most frequently detected parasites while *Ascaris lumbricoides*, *Blastocystic hominis*, *Giardia lamblia*, and *Dipylidium caninum* (0.24%) were the least detected. It was also observed that decreased parasitic contamination was significantly ($p<0.05$) associated with washing the products before being displayed for sale. The findings of this study suggest that there is a potentially high risk of acquiring parasitic infections from the consumption of raw fruits, vegetable, and nuts sold in Jos, Plateau State. Efforts should be made by the relevant bodies to reduce the rate of parasitic contamination of these commodities by educating the vendors and the consumers at large.

Key words: Parasitic contamination, fruits, vegetables, nuts, Jos.

INTRODUCTION

A fruit is the mature ovary of a plant. So a tomato is botanically a fruit but is commonly considered a vegetable. According to this definition squash, pepper and eggplants are also fruits (Vegetable Research and Information Centre, 2019). In botanical terms, fruit is defined as "a ripened ovary" while in horticultural science it is described as "the plant product, which is edible on ripening" (Peter, 2007). The fruit has also been described as "a seed receptacle developed from a mature fertilized ovary" (Prasanna et al., 2007). Fruits are an important part of human diet. They are commercially important and nutritionally indispensable food commodity (Prasanna et al., 2007). Man has kept these commodities in his diet to provide variety, taste, interest, aesthetic appeal and to meet certain nutritional requirements (Wills et al., 1996). Fruits are edible products of the perennial higher plants with high water content, soft texture, sweet, sour and semi-astringent flavors. Also because of their exotic flavour and taste, considerable attention is paid in different parts of the world. Fruits are consumed by man, mainly because of their organoleptic and chemical properties. They play a vital role in human nutrition, by supplying the necessary growth factors essential for maintaining normal health. Fruits along with vegetables are termed as 'protective foods' (Sharma and

Singh, 2000). Almost all fruits have some medicinal value in one way or the other. Physicians recommend fruits for the treatment of many ailments like scurvy, night blindness, asthma, fever, anemia, ulcers etc. (Peter, 2007).

Vegetable is usually used to designate the tender edible shoots, leaves, fruits, and roots of plants that are eaten whole or in part, raw or cooked, as a supplement to starchy foods and meats. Most of them are herbaceous and the definition does not include sweet dessert fruits. Vegetables are usually harvested when the plant is fresh and high in moisture and are thus distinguished from field crops, which are harvested at the mature stage for their grains, pulses, oil seeds or fibre. This high moisture content of vegetables makes their handling, transport and marketing a special problem, particularly evident in the tropics (Williams et al., 1991).

Nuts and seeds may be considered an important component of a healthy diet and are regularly consumed, either as snacks or part of a meal. In general, they are dense in a variety of nutrients and provide protein, fat (mostly unsaturated fatty acids), dietary fibre and many bioactive constituents such as vitamins (e.g. folic acid, niacin, vitamin E, vitamin B6), minerals (e.g. copper, magnesium, potassium, zinc), antioxidants, phytoestrogens and other phytochemicals (Dreher et al., 1996).

Eating vegetables is highly beneficial in that it helps in maintaining good health and preventing diseases. People who eat more vegetables and fruits as part of an overall healthy diet are likely to have a reduced risk of some chronic diseases. Ingestion is one of the commonest means of transmission of parasites which can get to the intestine by ingestion of the food or water contaminated with faeces containing the infective stages of the parasites or ingestion of improperly cooked food, meat and vegetables or the ingestion of raw vegetables and fruits (Ochei and Kolhatkar, 2000). Consumption of fruit and vegetable products is commonly viewed as a potential risk factor for infection with enteropathogens such as *Salmonella* and *Escherichia coli*. Routes of contamination are varied and include application of organic wastes to agricultural land as fertilizer, contamination of waters used for irrigation with faecal matter, direct contamination by livestock, wild animals and birds and postharvest issues such as worker hygiene (Heaton and Jones, 2007).

Several studies on the contamination of fruits, vegetables and nuts have been documented in different parts of the world. In a study conducted in Bassa and Dekina Local Government areas, the three major markets and Commercial Township-of Kogi State, (Omowaye and Odikamnoro, 2013) reported that 107 (4.41%) of the 2426 of fresh fruits and vegetables investigated were contaminated with potential parasites. Parasites were detected in 58 out of 252 (23.02%) freshly harvested vegetable samples collected from selected organic and conventional farms in Northern and Southern Luzon Provinces in the Philippines (Ordoñez et al., 2018). According to Istifanus and Panda (2018), 26 (14.3 %) out of 182 of four different types of fruits samples, and 82 (13.8 %) out of 594 of six different types of vegetable samples sold in open markets in Bauchi were contaminated with various parasitic ova and cysts. Amawulu et al. (2019) reported that out of the 40 fruits examined in Yenagoa, Nigeria, 8 (20%) were infested with parasites. Therefore the aim of this study was to assess the prevalence of parasitic contamination of some fruits, vegetables, and nuts obtained from three markets in Jos North Local Government Area, Plateau State, Nigeria.

MATERIALS AND METHODS

Study area

The study was conducted in Angwan Rukuba, Farin gada and Terminus markets in Jos North Local Government Area, Plateau State, Nigeria. Plateau State is located in Nigeria's middle belt, with an area of 26,899 square kilometers. The State has an estimated population of about three million people. It is located between latitude 08°24'N and longitude 008°32' and 010°38'E. The state is named after the picturesque Jos Plateau, a mountainous area in the north of the state with captivating rock formations (Hodder, 1959). Jos North Local Government Area of Plateau State. extends over an area of 291km with a total population of 429300, projected from the 2006 National Population and Housing Census, with 26666 (62%) being urban dwellers and 163134 (38%) being rural dwellers (*www.jotscroll.com/forums/23/posts/214/jos-north-local-governement-area-jos-plateau-state.html*). Sellers from Angwan Rukuba and Farin gada markets mostly get their fruits, vegetables and nut supplies directly from the local farmers while sellers from Terminus often go to some other markets to purchase their fruits, vegetables and nuts to sell to people. People from other Local Government Areas and some nearby States usually come to Farin gada market to buy fruits and vegetables. Parasitic contaminations of these fruits, vegetables and nuts poses a great risk not only to the people in Jos but also to those in other Local Governments and States.

Sample collection

The samples were collected between November and December, 2018. Collection of samples was carried out with slight modification of the method described by Tefera et al. (2014). Thirty (30) samples each of nine different types of fruits, vegetables, and nuts, which include; carrot (*Caucus carota*), water melon (*Citrullus lanatus*), cucumber (*Cucumis sativus*), cabbage (*Brassica oleracea*), lettuce (*Lactuca serriola*), spinach (*Spinacia oleracea*), Olive (*Olea europaea*), tiger nut (*Cyperus esculentus*), and dates (*Phoenix dactylifera*) were purchased from farmers and vendors in three local markets, namely; Farin-gada market, Angwan-Rukuba market and Terminus market in Jos North LGA, Plateau State, Nigeria. Five (5) of each sample were collected randomly per week in each market from ten (10)

pieces randomly selected. The samples were collected separately in a properly labeled plastic or polythene bag and transported to the laboratory in the Department of Zoology, University of Jos for examination.

Laboratory examination

Sedimentation method was carried out as described by Bekele and Shumbej (2019). Each sample (fruits, vegetables, and nuts) surface was washed separately in 500 mL of normal saline for detaching diagnostic stages of the parasites such as ova, larvae, cysts, oocysts of helminths and protozoan parasites commonly assumed to be associated with the contaminated vegetables. After 30 mins sedimentation of the washing solution, 15 mL of the sediment was centrifuged at 3,000 rpm for 5 mins, then supernatant was decanted leaving the sediment. The sediment was examined under a light microscope. For identification of protozoan oocysts modified Ziehl-Neelsen staining technique was employed. Finally the sediment was agitated gently by hand for each part to redistribute the parasitic stages, then used dropper to drop the sediment on glass slide and covered with cover slip. The glass slide was examined under light microscope using ×10 and ×40 objectives and the parasites were identified using identification key(FAO, 2010).

The zinc sulphate floatation technique described by Judith et al. (2018) was also used for concentrating the cysts and ova of the parasites. The samples were washed in distilled water and the washings were centrifuged at 250 rpm for 1 min then supernatant was decanted using a Pasteur pipette. Two mL of the sediment was placed in a 15mL test tube which was filled with zinc sulphate solution to the brim and a cover slip was placed on top. The cover slip was removed after 20 mins to allow enough time for the cysts and ova to float. To identify the cyst and ova of parasites, cover slip was placed face downwards on a slide and was examined under ×10 and ×40 objectives with a drop of iodine.

Statistical analysis

Data collected were analyzed using SPSS version 23. The Chi-square ($\chi 2$) analysis was used to determine association between parasitic contamination rate and types of samples. Values of P less than or equal to 0.05 were considered significant.

RESULTS

The results of the study showed that out of 270 samples examined, 113(41.85%) samples were identified to be contaminated with at least one type of parasite. Cabbage had the highest (66.67%) infestation, followed by water melon (53.33%), spinach (50.00%), olives (43.33%), dates (36.67%), carrot, lettuce, and tiger nut (33.33%), while cucumber had the least (26.67%) infestation (Table 1).

Trichostrongylus species (37.14%) and *Entamoeba histolytica* (36.89%) were the most detected parasites (Table 2) followed by *Strongyloides stercoralis* (18.20%), *Taenia saginata* (1.94%), *Schistosoma mansoni* (1.94%), *Iodamoeba butschlii* (0.73%), *Diphyllobothrium. latum* (0.73%), *Schistosoma heamatobium* (0.49%), *Hymenolepis diminuta* (0.49%), *Fasciola hepatica* (0.49%), *Ascaris lumbricoides* (0.24%), *Blastocyst hominis* (0.24%), *Giardia lamblia* (0.24%), and *Dipylidium caninum* (0.24%).

Trichostrongylus species were highest in spinach samples and least in samples of olives and tiger nuts*. E. histolytica* was detected in samples of olive with highest and least occurrences in samples of carrot and tiger nuts respectively. Larvae of *S. stercoralis* were highest in cabbage samples and least in water melon samples. *T. Saginata* was detected in spinach and cabbage samples only whiles *S. mansoni* was detected in dates and olive samples only. *I. butschlii* was detected in dates and water melon samples. *D. latum* was detected in water melon and olive samples only. *H. diminita* was detected in carrot and cabbage samples only whereas *S. haematobium* and *B. hominis* were detected only in water melon samples. *F. hepatica* and *A. lumbricoides* were detected only in olive samples. *G. lamblia* and *D. caninum* was detected only in carrot and cabbage samples respectively.

The parasitic contamination among the different fruits, vegetables and nuts was not significantly different (P = 0.880) (Table 3).The highest prevalence of intestinal parasites was recorded in spinach (32.28%) followed by olives (27.91%), cabbage (10.19%), water melon (8.98%), dates (7.28%), lettuce (4.37%), cucumber (3.39%), tiger nut (3.16%), and carrot (2.43%).

The results of the study showed that samples collected from "Farin Gada" (53.33%) had the highest parasitic contamination, followed by samples collected from "Angwa Rukuba" (37.78%), and "Terminus" (34.44%) markets. The percentage contamination was not significantly different among samples collected from the different markets (P= 0.112), Table 3.

Samples from farmers contributed for 53.33% of the positive samples while 36.11% of the contamination was contributed by roadsides with no statistically significant difference (P = 0.110), Table 3.

Another factor associated with parasitic contamination of fruits and vegetables is the process of washing these commodities before displaying them for sale. According to this study, majority (65.55%) of these produce were not washed prior to their display for sale while only 34.4% were washed before their display for sale. 71.68% of the unwashed fruits, vegetables and nuts were contaminated with one or more of the studied parasites, while 28.32% of the washed fruits, vegetables and nuts were contaminated with intestinal parasites. The cross tabulation of washing the produces before display for sale and result of parasitological analysis showed a significant difference in contamination rate among washed and unwashed

Table 1. Prevalence and Distribution of Parasites among Contaminated Fruits, Vegetables, and Nuts Sold in Selected Markets in Jos, Plateau State.

			Number of parasite spp detected		
Kind of produce	**Number examined**	**Number contaminated(%)**	**Farin gada**	**Angwa rukuba**	**Terminus**
Water Melon	30	16(53.33)	22(73.33)	10(33.33)	5(16.67)
Cucumber	30	8(26.67)	9(30.00)	2(6.67)	3(10.00)
Carrot	30	10(33.33)	4(13.33)	2(6.67)	4(13..33)
Spinach	30	15(50.00)	70(233.33)	55(183.33)	8(26.67)
Cabbage	30	20(66.67)	21(70.00)	11(36.67)	10(33.33)
Lettuce	30	10(33.33)	8(26.67)	6(20.00)	4(13.33)
Olives	30	13(43.33)	49(163.33)	54(180.00)	12(40.00)
Tiger Nut	30	10(33.33)	3(10.00)	4(13.33)	6(20.00)
Dates	30	11(36.67)	9(30.00)	6(20.00)	15(50.00)
Total	270	113(41.85)	195(72.22)	150(55.56)	67(24.81)

Table 2. Frequency of Parasites in Fruits, Vegetables, and Nuts Sold at Selected Marketed in Jos

Detected parasite	**Frequency**	**% prevalence**
Iodamoeba butschlii	3	0.73%
Strongyloides stercoralis	75	18.20%
Entamoeba histolytica	152	36.89%
Schistosoma haematobium	2	0.49%
Ascaris lumbricoides	1	0.24%
Diphyllobothrium latum	3	0.73%
Blastocystic hominis	1	0.24%
Giardia lamblia	1	0.24%
Hymenotepis diminita	2	0.49%
Taenia saginata	8	1.94%
Dipylidium caninum	1	0.24%
Trichostrongylus	153	37.14%
Fasciola hepatica	2	0.49%
Schistosoma mansoni	8	1.94%
Total	412	100

produce (P = 0.000), Table 3.

The means of display for selling is also another factor assessed for association with parasitic contamination of fruits and vegetables. Various means of display were observed among the vendors as follows: 38.89% of the produce was displayed on the floor by the road sides, 35.18% of the produce were displayed on tables by the road side while 25.93% were displayed on wheel barrows. 48.67% of the produce displayed on the floor was contaminated with one or more parasites, 31.86% of the produce displayed on table, and 19.47% of the produce displayed on wheel barrow were contaminated with intestinal parasites. The cross tabulation of means of display of the produce for sale and the results of parasitological analysis showed a significant difference in contamination rate among the means of display (P = 0.000), Table 3.

DISCUSSION

The detection of intestinal parasites at various stages of developments in fruits, vegetables, and nuts studied is indicative of faecal contamination from human and or animal origin. As in many tropical countries, intestinal parasites are widely distributed not only due to the favorable climatic conditions that support the survival and dissemination of the parasites but also due to the unsanitary conditions that facilitate faecal pollution of water, food stuffs, and soil (Omowaye and Audu, 2012). The present study attempted to assess the level of contamination and prevalence of different intestinal parasites from different fruits, vegetables, and nuts sold in selected markets of Jos Town.

The overall prevalence of 41.85 % recorded in this study is similar to the findings of (Glenn et al., 2012) in metro Manila markets in Philippine where 45.0% of the vegetables were contaminated. Similarly, Bekele and Shumbej (2019) reported the prevalence of 42.6 % contamination in fruits and vegetables in Tarcha town , South west Ethiopia. Malann and Tim (2016) also recorded 42 % contamination in fruits sold in three markets in Gwagwalada Area Council, Abuja. In a study in Izzi Local Government of Ebonyi State, Uhuo et al. (2015) reported

Table 3. Factors Associated with Parasite Contamination of Fruit, Vegetables, and Nuts Sold in Jos markets

	Result of parasitological analysis			
Variables	**Post (%)**	**Total**	**χ2**	**P value**
Market				
Farin gada	48(53.33)	90		
Angwa rukuba	34(37.78)	90	4.371	0.112
Terminus	31(34.44)	90		
Total	113(41.85)	270		
Kind of Produce				
Water melon	16(53.33)	30		
Cucumber	8(26.67)	30		
Carrot	10(33.33)	30		
Spinach	15(50.00)	30		
Cabbage	20(66.67)	30	9.734	0.880
Lettuce	10(33.33)	30		
Olives	13(43.33)	30		
Tiger nut	10(33.33)	30		
Dates	11(36.67)	30		
Total	113(41.85)	270		
Source of the produce				
Farmers	48(53.33)	90		
Roadside	65(36.11)	180	2.558	0.110
Total	113(41.85)	270		
Wash before display				
Yes	32(34.41)	93		
No	81(45.76)	177	21.248	0.000
Total	113(41.85)	270		
Means of display				
On the floor	55(52.38)	105		
On table	36(37.89)	95	14.565	0.000
On wheel barrow	22(31.43)	70		
Total	113(41.85)	270		

that 42 % of fruits and vegetables bought directly from the local farmers were infected with soil transmitted parasites. However, the result of this study was slightly higher than the 37.0 % reported in Gaza Palestine (Rodina and Saleh, 2007). (Damen et al., 2007) reported 36.0% contamination in Jos Nigeria, (Uga et al., 2009) reported 26.0% prevalence of infestation in Hanoi market in Vietnam. (Alli et al., 2011) reported 35.4% prevalence of infestation in market in Ibadan Nigeria while Omowaye and Audu (2012) reported 11.87% prevalence of infestation in Kogi market in Kogi Nigeria. The high prevalence recorded in this study during the cold season was due to the improper handling of the products by farmer/transporters and the contamination of the water and farms with animals faecal matter. Higher prevalence of contamination than the one recorded in this study have been reported in other studies. 56.25 % contamination of fruits and vegetables has been reported in Jos South LGA (Idahosa, 2011). Ojemudia (2011)) reported 56.3% prevalence of infestation in different markets in Jos Nigeria, (Abougrain et al., 2009) in Iran reported 58.0%, (Amaechi et al., 2011) reported 65.8% prevalence of infestation on vegetables and 34.2% prevalence of infestation on fruits in markets in Owerri Nigeria. The difference in the prevalence recorded in some of the studies done in other places could be attributed to the differences in sample sizes used- the techniques employed. The particular period of the year at which these studies were conducted could also affect the outcome. (Damen et al., 2007) reported that there were high recovery of more stages of parasites on vegetables and fruits at the summer because the organisms are attached more to them than in the winter when rain washes some of them off into water bodies and unhygienic practices in those areas. The difference in the prevalence obtained from this study and other previous studies could probably be due to variations in geographical locations, climatic and environmental conditions, the kind of sample and sample size examined, the sampling techniques, methods used for detection of the intestinal parasites, and socioeconomic status. So long as these factors differ, consequently discrepancy in results would be expected.

The high contamination in Cabbage (66.67%) recorded in this study is consistent with Bekele and Shumbej (2019) who reported that cabbage (71.1%) was found to be the most contaminated product with parasites, followed by lettuce and green pepper (44.4% each), avocado (37.8%) and carrot (33.3%). Tomato (24.4%) was found to be the least contaminated. Damen et al. (2007) also recorded the highest prevalence of 64% in cabbage while tomatoes had the least prevalence of 20%. The result of this study is at

variance with Ordoñez et al. (2018) who reported that among the different types of vegetables, from selected organic and conventional farms in the Philippines, deep red lettuce had the highest contamination rate (75 %). Eraky et al. (2014) also recorded that lettuce was the highest contaminated vegetable (45.5%) in Benha, Egypt followed by watercress (41.3%), parsley (34.3%), green onion (16.5%), and leek (10.7%). These results indicate a significant seasonal variation ($P < 0.05$), with highest prevalence in summer (49%) and the lowest in winter (10.8%). High contamination of cabbage and water melon might probably be due to direct contact with contaminated soil and water since they are found near the soil surface. It might also be explained by the fact that cabbage has larger and uneven surfaces, which help the parasites in attaching to their surface easily whereas the smooth surface of vegetables might hinder the rate of parasitic attachment and contribute to the lower contamination rate (Bekele and Shumbej, 2019).

The results obtained from this study showed that pathogenic organisms are associated with fruits, vegetables, and nuts in varying numbers of eggs, cysts and larvae. In this study, eggs of *Trichostrongylus* and cysts of *E. histolytica* were the most frequently detected parasites with a prevalence of 37.14% and 36.89 % respectively, followed by larvae of *S. stercoralis* which was the third most frequently detected parasite in this study with a prevalence of 18.20 %. The high contamination of fruits and vegetables in this study is agrees with Kudah et al. (2018) who reported that the commonest parasites were *Strongyloides stercoralis* (36.4%, 31.4–41.6), *Balantidium coli* (13.6%, 10.2–17.6) and *Cryptosporidium oocyst* (11.1%). Amawulu et al. (2019) also recorded parasites in the order of occurrence as *Entamoeba histolytica* (58.5%), *Ancyclostoma duodenale* (14.6%), *Ascaris lumbricoides* (17.1%) *Trichuris trichura* (12.2%) and *Strongyloides stercoralis* (2.44 %). The high occurrence of *Strongyloides* species in this study concurred with Omowaye and Audu, (2012). However, this is in contrast with Benti and Gemechu (2014) who reported high contamination with *A. lumbricoides* (22.22 %) and *G. lamblia* (18.06 %) while *E. histolytica* had the least prevalence (8.33 %) on vegetables in selected farms of Eastern Showa, Ethiopia. Malann and Tim (2016) also reported *Ascaris lumbricoides* as the most frequently encountered parasites with a prevalence of 22.6% in vegetables sold in Gwagwalada, Abuja. The variations of these results with other studies might be attributed to differences in geographical locations, climate conditions, and the type of soil Mariam et al. (2008). Multiple species contamination was observed in all kinds of produces examined in this study. This might indicate the possibility of high level contamination of the fruits, vegetables, and nuts, which perhaps results in multiple parasitic infections in human. It might also indicate the persistence of intestinal parasitic infection in the area (Idahosa, 2011)). The presence of parasites such as *E. histolytica*, *S. strongyloides*, and protozoans as *Giardia intestinalis* may be due to the contaminated water source for the crops. Some of the farms were located near sewers which could be an ideal source of parasitic protozoans. The use of contaminated water for watering crops could be a potential source of contamination with these parasites.

The contamination rate was significantly different for the samples collected from the different markets. Samples collected from "Farin Gada" showed higher rate parasitic contamination. This is similar to the study which showed that parasitic contamination was higher for vegetables from Agartha market (67.8%) than from the main market (47.2%) (Kudah et al., 2018), this might be associated with the unhygienic practices of the sellers and markets conditions.

Washing and the manner of display of products was found to affect the level of contaminations. 45.76 % and 34.41 % (as in table 3) of the products were displayed for sale without washing and on the floor respectively, exposing them to higher risk of contamination. The result of this study is consistent with the findings of others researchers from different areas. It has been reported that the flies can act as vectors for a number of pathogenic microorganisms including parasites like *Cryptosporidium parvum* and *Toxoplasma gondii* (Meerburg et al., 2007). Most of the fruit samples were sold to consumers displayed on the ground with little or no protection from contamination of pathogenic microorganisms, some were put directly put on the ground besides the main drainage gutter that ferries off waste and drainage water from the various neighborhood which pre disposes them to contamination. Besides, there might be bacterial and viral contamination of the produces during display for sale on the floor. This was seen with water melon (30%), mangoes (20 %), tomatoes (20%) and cucumber (20%). However, those that were not contaminated (apples 00%) were sold to consumers on protected make shift containers (Judith et al., 2018). The habit of eating raw vegetables like lettuce and cabbage without washing of hands was commonly practiced in the study areas. According to Ordoñez et al. (2018), improper handling of farm produce by farmers could also be a source of contamination. Farmers are commonly using gloves only during application of chemical fertilizers. Also, some farmers were observed washing their hands in water buckets used for watering crops. Amawulu et al. (2019) in their study reported that 54 % of the respondents accepted that the source of their fruit was from table stores while 32% had their fruits from open market; 58% bought fruits in partly covered vessels and 40% had fruits from the open shade. Fifty-two percent (52%) always wash their fruits before eating it, 18% wash with water and salt before eating it while 30% do not bother washing their fruits before eating. In Calabar markets, Ogban and Ukpong (2018) , found out that tiger nuts were usually displayed and exposed in wheel barrows, either stationed in the open market or moved around the city by hawkers. The points of sale in the open markets were characterized by proximity to solid waste dumps and clogged drainages. According to Kudah et al. (2018) washing vegetables the second time recovered 42.2%

parasites from vegetables obtained in Koforidua, Ghana. This may be an indication that two wash alone is not enough to remove all the parasites from the vegetables. However, Duedu et al. (2014) has shown that, washing vegetables with just water was not enough to remove any contaminating parasites. He recorded that using saline, phosphate buffered saline and tap water recovered 52%, 34% and 14% parasites respectively and use of saline was more effective in recovering of parasites. The findings of the present study are of public health importance, requiring an appropriate intervention to prevent transmission of parasitic diseases that can be acquired through consumption of contaminated fruits and vegetables.

CONCLUSION

In conclusion, the investigated fruits, vegetables and nuts sold within Jos metropolis were contaminated with parasitic cysts/eggs. Vegetables were more contaminated with parasitic cysts, eggs and larvae than fruits and nuts probably due to their rough/folded leaves. *Trichostrongylus* and *E. histolytica* were the most prevalent parasites that contaminated fruits, vegetables, and nut sold in selected markets in Jos. Variations in the contamination of the samples might be a reflection of the poor sanitary conditions of the locality. This study highlighted the importance of raw fruits, vegetables and nuts as potential sources of transmission of parasites to humans. The fruits, vegetables and nuts contaminated with the pathogenic parasites poses health risk to consumers if consumed without proper washing and or cooking.

Recommendations

Prevention of contamination remains the most effective way of reducing food borne parasitic infection. A comprehensive health education should be given to vendors, farmers and the general populace on the health risks associated with consumption of contaminated fruits, vegetables, and nuts. The consumers should always observe the basic principle of food and personal hygiene, that is, thorough washing of the fruits, vegetables, and nuts before eating and washing of hands before meal. The vendors of fruits, vegetables, and nuts should avoid the contact of the produces with soil while displaying for sale. Further studies should be conducted on the viability of parasitic contaminants of fruits, vegetables, and nuts. Also, other researches must be done to evaluate the level of parasitic contamination of farm products, water, and soil in which fruits, vegetables, and nuts are cultivated. This study should also be conducted periodically in different regions within and without the country to provide regular update of the statuses of the contamination of farm products. Also, organic manure should be sterilized or properly treated before use for cultivation of vegetables and other ready-to-eat farm produce. Government or market management authorities should make provision of safe water for washing of fruits, vegetables, nuts and other farm produce.

Conflict of Interests

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

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