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Communicating the Parasitic Contaminants in Readily Consumed Fruits Sold in Abeokuta, Ogun State Nigeria and its Public Health Implications

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Abstract
Fruits are of great importance for an adequate and balanced human diet but if consumed when contaminated can cause food borne diseases. The study aimed to determine the parasitic contamination of the fruit samples sold in Abeokuta, Ogun state, Nigeria. One hundred and twenty (120), twenty (20) each of African star apple (*Chrysophyllum albidum*), Apple (*Malus domestica*), Banana (*Musa acuminate*), Tangerine, (*Citrus tangerina*), Sugar cane (*Saccharum officinarum*) and Orange (*Citrus sinensis*) were purchased from vendors. Normal saline washings from whole samples were processed using standard parasitological techniques and examined microscopically. Ten (10) parasitic contaminants were observed from the examined fruits, and Eighty-three (69.2%) of one hundred and twenty (120) examined fruits were contaminated with at least one parasitic contaminant. The most observed parasitic contaminants were *Ascaris lumbricoides* (58.8%) while the lowest were *Microsporidia sp.* and *Trichinella spiralis* (1%) respectively. The majority of the fruit has a single contaminant (64.7%). The highest contamination was recorded in Tangerine (85%) while the lowest was in Apple and Orange (55%) respectively. The parasitic prevalence and degree of contamination were not significant within the fruits (χ^2 =7.698, p>0.05) and (χ^2 =8.633, p>0.05) respectively while parasitic intensity was significant (χ^2 =67.81, p<0.05). The majority (80%) of the observed contaminants are of significant public health importance. Therefore, there is a need to encourage proper washing of fresh and raw fruits and also educate the people along the production chain on how to improve hygiene practices and handling of fruits in other to meet the sustainable development goal (SDG3).
Keywords: Abeokuta; Contaminants; Fruits; Parasite, Public health

Introduction

Fruits are a part of the diet for humans and an important component of a healthy diet because they contain essential vitamins necessary for growth and body nourishment [1]. The consumption of fruits especially ready to consume in Nigeria, has greatly increased based on their proven medical and nutritional benefits [2]. However, beneath the colourful allure of these readily available fruits lies a potentially hidden peril (the presence of parasitic contaminants). Fruit consumption has been a significant method of spreading pollutants, particularly parasitic organisms and increasing foodborne illnesses [3].

Countries such as Nigeria are endowed with a favourable climates and seasons, which enable the growth of varieties of fruits [4]. They are also affordable, accessible and readily available to consumers [5]. Besides the health and economic benefits of fruits, there is much concern about their contamination by human pathogens, after they have been consumed fresh, or moderately cooked [6].

In Nigeria, the cultivation of fruits for commercial and domestic purposes is mostly carried out by peasant farmers who depend on irrigation or natural rainfall [7]. The use of untreated wastewater and contaminated water sources for irrigation, postharvest processing, and the sanitary state of storage, among other things, all affect the level of contamination [8].

Fruits can be easily contaminated with biological, chemical, and physical hazards because they are often grown in open environments [9]. Remarkably, the consumption of fruits has been directly linked to the development of roughly 12% of food-related disorders for decades [10]. More so, the consumption of contaminated food has been linked to the transmission of various gastrointestinal parasites such as *Ascris lubricoides*, *Entamoeba, Giardia*, and *Cryptosporidium*, as well as the ova and larvae of helminths such as

Toxoplasma, *Taenia*, *Strongyloides*, and Hookworm [11-12]. These parasites are known to cause several species-related gastrointestinal infections in humans [13-14]. Clinical diseases such as cryptosporidiosis, giardiasis, ascariasis, amoebiasis, strongyloidiasis, taeniasis, and hookworm disease have also been linked with contaminated fruit [15-16]. Additionally, the mortality rate associated with these diseases in developing countries is estimated at 2.2 million annually [16].

In Nigeria and other developing countries, ready-to-eat fruit is becoming rampant due to its high patronage [5]. Surprisingly, some of these fruits are usually not properly washed before being consumed. More so, most vendors now have knowledge of proper personal and public hygiene because such produce is exposed to contaminated air, unclean environments, and packaging materials [17]. Parasitic contaminant in fruit has been largely reported from various studies across the country, for example, 4.41%, in Kogi State [18], 45% in Bauchi State [15], 20% in Yenagoa [19], 37.5 % in Laffi, Nigeria [20], 48.7 % Kwara, Nigeria [14] and 37.4 in Ede Town Nigeria [21] among others.

Even though the health risks associated with consuming contaminated fruits are well-documented, there is a need for continuous monitoring of the occurrence rate and public health implications of parasitic contaminants on the readily consumed fruits sold in Abeokuta, in other inform intervention strategies and meet the sustainable development goals (SDG3) that connote good health and wellness.

Materials and Methods

Study Area

The study was conducted in Abeokuta (Coordination 7.1475° N, 3.3619° E.), Ogun State, South-west Nigeria, in November 2021. The people of Egbas were the first to settle in the area. Although, the Yoruba tribe makes up the majority of the population in Abeokuta many other ethnic groups have also settled as a result of civilization (urbanization and industry). They are well-known for their traditional sculpture and carving, an estimated; 593,140 people live in and around Abeokuta [22]. The map of Abeokuta from Ogun state, Nigeria adopted from Oyedepo et al. [23], is shown in Figure 1.

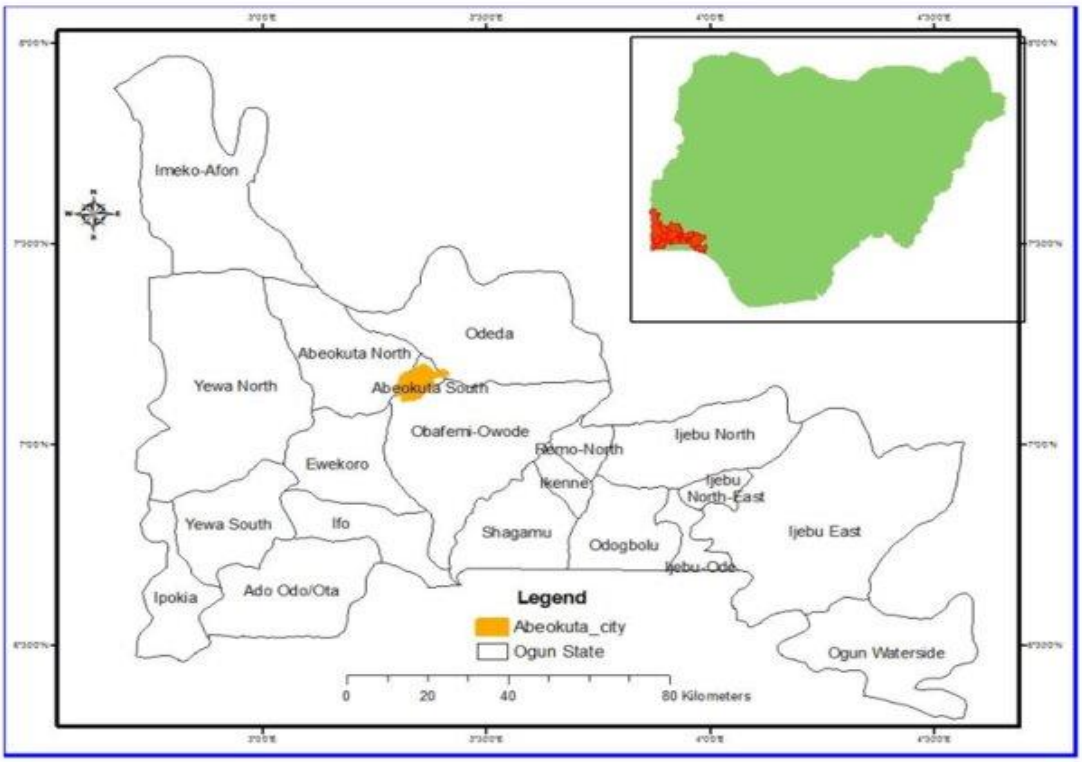

Figure 1: Map of Abeokuta city from Ogun State, Nigeria

Sample collection

A total of one hundred and twenty (120) samples, twenty (20) pieces each of African star apple (*Chrysophyllum albidum*) apple (*Malus domestica)*, banana (*Musa acuminata)*, tangerine (*Citrus tangerine)*, sugar cane (*Saccharum officinarum)* and orange (*Citrus sinensis*) were purchased from various fruit vendors (stationed and mobile), then placed in sterile plastic bags, and immediately transported to the laboratory for examination. The botanical classification of the fruits used for the study is shown in Table 1

Table 1: Botanical classification of fruits examined in the study

Common Name	Order	Family	Genus	Species
African Star Apple	Ericales	Sapotaceae	*Chrysophyllum*	*albidum*
Apple	Rosales	Rosaceae	*Malus*	*domestica*
Banana	Zingiberales	Musaceae	*Musa*	*acuminata*
Orange	Sapindales	Rutaceae	*Citrus*	*sinensis*
Sugarcane	Poales	Poaceae	*Saccharum*	*officinarum*
Tangerine	Sapindales	Rutaceae	*Citrus*	*tangerine*

Parasitological Examination

Parasitological contamination was carried out by employing a method similar to that described by Orpin et al. [1], a whole piece of each fruit sample was washed separately in 500 cm^3 of normal saline in a jar to detach the parasitic stages (ova, larvae, cysts, and oocysts) of helminths and protozoan parasites. The fruit was subsequently removed from the jar, and the washing solution was allowed to stand overnight for sedimentation. Afterwards, the supernatant was decanted, and 15 cm^3 of the sediment left was transferred to a centrifuge tube. The tube was centrifuged at 3000 rotations per minute (rpm) for five minutes to concentrate the parasites. After centrifugation, the supernatant was decanted carefully from the tube without shaking. Then the sediment was agitated gently by hand to redistribute the parasitic stages. Finally, the sediment was examined under a binocular compound microscope (Olympus type) to identify parasitic contaminants.

Data Management and Analysis

Data were analyzed using SPSS software version 21.0 (SPSS Inc., Chicago, IL, USA), while the Chi-square test was used to test for parasite intensity and prevalence within fruits. $p < 0.05$ was considered statistically significant in the study

Results and Discussion

Observed parasites and number of contaminants

The statistics of the observed fruit parasites and the number of contaminants are presented in Table 1, this shows that ten (10) parasitic contaminants were observed in the examined fruit with *Ascaris lumbricoides* (58.8%) being the most abundant followed by Hookworm (11.8%) while the lowest are both *Microsporidia sp.* and *Trichinella spiralis* (1%) respectively. The frequency of the observed parasitic contaminants appears in the following order, *Ascaris lumbricoides*> Hookworm> *Balantidium coli*> *Entamoeba coli*> *Taenia sp.*= *Entamoeba histolytica*> *Trichuris trichuria*> *Chilomastix mesnilii*>*Microsporidia sp.* =*Trichinella spiralis*. The majority of the examined fruits have mono-contaminants (64.7%) while others have poly-contaminants (35.3%).

Table 2: Statistics of observed parasites and the number of contaminants

Observed Parasite	Frequency	Percentage	Cumulative Percent
A. lumbricoides	60	58.8	58.8
Hookworm	12	11.8	70.6
Entamoeba coli	06	5.9	76.5
Taenia sp.	04	3.9	80.4
Entamoeba histolytica	04	3.9	84.3
Chilomastix mesnilii	02	2.0	86.3
Balantidium coli	09	8.8	95.1
Trichuris trichuria	03	2.9	98.0
Microsporidia sp.	01	1.0	99.0
Trichinella spiralis	01	1.0	**100.0**
Total	**102**	**100.0**	
Degree of Contaminants			
Mono-contaminant	66	64.7	64.7
Poly-contaminants	36	35.3	**100.0**
Total	**102**	**100.0**	

Parasites prevalence

The parasitic prevalence within fruits is presented in Table 2, Eighty-three (69.2%) fruit samples out of one hundred and twenty (120) examined were contaminated with at least one parasitic contaminant. Tangerine (85%) has the highest parasitic prevalence, followed by African star apple (80%) while the lowest was equally recorded in both apple and orange (55%). Furthermore, the parasitic prevalence within the fruits is not significant ($\chi^2 = 7.698$, $p<0.05$). The parasite prevalence within the fruits appears in the order of Tangerine > African star apple> Banana> Sugarcane> Apple = Orange.

Table 3: Parasitic prevalence within fruits

Fruits	No. Examined	Contamination		χ^2 Test	
		Contaminated (%)	Not Contaminated (%)	Value	P
Banana	20	15(75.0)	05(25.0)	7.698	0.174
African Star Apple	20	16(80.0)	04(20.0)	df =5	
Tangerine	20	17(85.0)	03(15.0)		
Sugarcane	20	13(65.0)	07(35.0)		
Apple	20	11(55.0)	09(45.0)		
Orange	20	11(55.0)	09(45.0)		
Total	**120**	**83(69.2)**	**37(30.8)**		

p- Value not significant at p<0.05

Parasites intensity

The parasite intensity within the fruits is presented in Table 3, the total parasite intensity was recorded with *A. lumbricoides* (58.8%) and hookworm (11.8%). The fruit with the highest parasitic intensity for *A. lumbricoides* was recorded in the African Star Apple (80%) while the lowest was in the apple (16.7%). Hookworm has the highest intensity in Tangerine (19.0%) and the lowest is African star apple (10.0%). *E. coli* has the highest intensity in apple (16.7%) while the lowest in tangerine (4.8%). *Taenia sp.* has the highest intensity in orange (15.4%) and the lowest in African Star Apple (5.0%). *E. histolytica* has the highest intensity in apples (16.7%) while the lowest in sugar cane (7.7%). *C. mesnilii* has the highest intensity in sugar cane (7.7%) while the lowest in apple (5.6%). *B. coli* have the highest intensity in apples (22.2%) and the lowest in sugar cane (7.7%). *T. trichuria* has the highest intensity in apples (11.1%) and the lowest in sugar cane (7.7%). *Microsporidia sp. and T. spiralis* were only observed in orange (7.7%) and apple (5.6%) respectively. The parasite intensity was significant within the fruits (χ^2 = 67.81, p<0.05).

Degree of contaminants

The degree of parasitic contamination within the fruits is presented in Table 4, the highest percentage of mono-contaminant was recorded in sugar cane (84.6%) while the lowest was in apples (38.9). the highest percentage of poly-contaminants was recorded in apple (61.15%) while the lowest was in sugar cane (15.4%). The degree of parasitic contamination was not significant within the fruits (χ^2 = 8.633, p>0.05).

Public Health Implications

The public implication according to the Centers for Disease Control and Prevention [24] is presented in Table 6. Eight (80%) of the observed parasites are considered pathogenic while two (20%) are non-pathogenic. They are 50% helminths and protozoan respectively with faecal-contaminated soil, water, surfaces, fingers and foods the oval and cyst of the parasite are the major media of exposure. The symptoms emanating from injection to these contaminants are characterized by abdominal pain/discomfort, diarrhoea, dysentery, anaemia, growth retardation in children and worm infestation. Diseases caused by Ascariasis, Taeniasis/ Cysticercosis, Balantidiasis, Trichuriasis, Microsporidiosis and Trichinellosis or Trichinosis.

Table 4: Parasite intensity within fruits

Observe parasite	Examined Fruit						Total %	χ^2 Test	
	Banana (%)	African Star Apple (%)	Tangerine (%)	Sugar Cane (%)	Apple (%)	Orange (%)		Value	P
A. lumbricoides	15 (88.2)	16 (80.0)	14(66.7)	07(53.8)	03(16.7)	05(38.5)	60(58.8)	67.81	0.02*
Hookworm	02(11.8)	02(10.0)	04(19.0)	02(15.4)	-	02(15.4)	12(11.8)	df =45	
E. coli	-	01(5.0)	01(4.8)	-	03(16.7)	01(7.7)	06(5.9)		
Taenia sp.	-	01(5.0)	-	-	01(5.6)	02(15.4)	04(3.9)		
E. histolytica	-	-	-	01(7.7)	03(16.7)	-	04(3.9)		
C. mesnilii	-	-	-	01(7.7)	01(5.6)	-	02(2.0)		
B. coli	-	-	02(9.5)	01(7.7)	04(22.2)	02(15.4)	09(8.8)		
T. trichuria	-	-	-	01 (7.7)	02(11.1)	-	03(2.9)		
Microsporidia sp.	-	-	-	-	-	01(7.7)	01(1.0)		
T. spiralis	-	-	-	-	01(5.6)	-	01(1.0)		
Total	**17(100)**	**20(100)**	**21(100)**	**13(100)**	**18(100)**	**13(100)**	**102(100)**		

*significant at $p<0.05$.

Table 5: Degree of contaminates within fruits

Degree of contaminants	Examined Fruit						Total	χ^2 Test	
	Banana (%)	African Star Apple (%)	Tangerine (%)	Sugar Cane (%)	Apple (%)	Orange (%)		Value	P
Mono-contaminant	13(76.5)	13(65.0)	14(66.7)	11(84.6)	07(38.9)	08(61.5)	66(64.7)	8.633	0.13
Poly-contaminants	04(23.5)	07(35.0)	07(33.3)	02(15.4)	11(61.1)	05(38.5)	36(35.3)	df =5	
Total	**17(100)**	**20(100)**	**21(100)**	**13(100)**	**18(100)**	**13(100)**	**102(100)**		

P value not significant at $p<0.05$

Table 6: Parasitic contaminants, type, medium of spread and clinical manifestation (Centers for Disease Control and Prevention, CDC) *

Detected parasites	Type	Description of Medium of spread	Symptoms	Disease
Ascaris lumbricoides	Helminth	Contaminated soil with parasite eggs in their feces	Few or no symptoms at all, abdominal pain, worm infestation mostly in children leading to intestinal blockage, slow growth in children and cough.	Ascariasis
Hookworm	Helminth	Contaminated soil with parasite eggs in their feces	Abdominal pain, diarrhoea, loss of appetite, weight loss, fatigue and Anemia	-
Entamoeba coli	Protozoa	Contaminated soil with parasite eggs in their feces	-	Non-pathogenic
Taenia sp.	Helminth	Close contact with pigs and eating undercooked / meat pork	Mild abdominal discomfort	Taeniasis, Cysticercosis,
Entamoeba. histolytica	Protozoa	contaminated surface, fingers, water with faeces	Mild diarrhoea, stomach pain, and stomach cramping/ amebic dysentery which can cause bloody poop, and fever. Liver abscess (rear).	Amebiasis
Chilomastix mesnilii	Protozoa	Contaminated surface, fingers, water with faeces	-	Non-pathogenic
Balantidium coli	Protozoa	consuming food or water contaminated with infective feces	Mostly asymptomatic, by can cause diarrhea and abdominal pain	Balantidiasis
Trichuris trichuria	Helminth	Contaminated soil with parasite eggs in their feces	Mostly asymptomatic, but could cause abdominal pain, diarrhoea, rectal prolapse and possibly growth retardation in children	Trichuriasis
Microsporidia sp.	Protozoa	Contaminated soil containing faeces with infective form resistant spore	Associated diarrhoea	Microsporidiosis
Trichinella spiralis	Helminth	consumption of meat infected with cysts, encasing larvae	Diarrhea, abdominal pain, vomiting /eosinophilia, fever, myalgia, and periorbital edema	Trichinellosis or Trichinosis.

*https://www.cdc.gov/dpdx/

Discussion

Given that some fruits are ready to eat and are sometimes not thoroughly cleaned, the presence of parasites on these fruits poses a serious threat to public health. Furthermore, after just using their hands or clothes to brush away any apparent dirt, individuals frequently pick up fallen fruits and consume them [14]. In fields, during harvesting, transport, processing, distribution, and marketing, or even in the home, fruits can become contaminated with pathogenic parasites while still on the plant. These parasites are typically distributed through polluted water and inadequate hygiene practices [1]. According to the current study, 69.2% of the fruits that were evaluated had a high level of parasite contamination (protozoan and helminth contamination), which is typically caused by human and animal excrement. This is more than the findings of other research, which include those from Sharkyia, Egypt [25], Laffi, Nigeria [20], Kwara, Nigeria [14], Ede Town Nigeria [21] and Ibadan [12], which reported 39, 37.5, 48.7, 37.4 and 11.6% respectively. From the investigation, ten (10) distinct parasite contaminants were found, of which two (*Entamoeba coli* and *Chilostix mesnilii*) are non-pathogenic and others have been shown to be zoonotic i.e. able to infect both animals and humans [14, 24]. This is more than the six (6) parasitic contaminants from Akure, Nigeria [26], but it is comparable to the eleven (11) parasitic contaminants in Jos, Nigeria [27] and Kwara, Nigeria [14]. The most often encountered parasitic contamination in fruits was Ascaris lumbricoides (58.8%), with African star apple (66.7%) having the highest parasitization rate. This is in contrast to lower detection rates, such as 1.95% in Sharkyia, Egypt [25], but it is lower than the 89.3% detected in Laffi, Nigeria [20] and correlates with 56.31% in rural Zamfara States, Nigeria [7]. The use of untreated night soil is the reason for the high concentration of *A. lumbricoides* in the fruits. The African star apple's regular contact with polluted soils may be the cause of its apparent parasitic intensity. Moreover, it is commonly known that *A. lumbricoides* is the most common helminth in the tropics [21]. Tangerine (19.0%) had the highest level of parasite contamination, with hookworm (11.8%) being the second most common type. This is marginally less than the 13.0% from Ede Town, Nigeria [21], but it is greater than the 6.7% and 9.1% reported from Anambra State, Nigeria [28] and Gusau, Zamfara State, Nigeria [29] respectively. Although the isolated parasites varied, Ascaris lumbricoides and hookworms were present in nearly all of the fruits that were studied. The refractory quality of the eggs, which allows them to live in adverse environments and remain unaffected by desiccation for months, may be the cause of this parasite's widespread dispersion [21,25]. This may also indicate that there is water contamination due to careless defecation, which contaminates farms and water sources [27]. Apples (16.7%) had the highest level of contamination with *Entamoeba coli* (5.9%), which is the third most observed. Perhaps because of their tiny size, they can attach themselves to the pores in apples. The methods of research, the kind of soil, water used for irrigation, climate type, locations, and hygienic practices can all be connected to variations in the degree of contamination [30].

Conclusion

In conclusion, the study examines the parasitic contaminants in ready-to-eat fruits sold by vendors around Abeokuta, Ogun State, Nigeria. It revealed that the majority of the examined fruit was contaminated. The recovery of parasites (protozoans and helminths) from fruit is of great public health significance. The potential risk of contracting intestinal parasite infections remains with the ingestion of unwashed fruits.

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