The Diagnostics, 1(2): 13-24, May 2018

Full Length Review Paper

Food-Safety regarding intestinal parasites on edible fruits and vegetables

Agbalaka, P.I., *Obeta, M.U. and Daniel, K.R.
Federal School of Medical Laboratory Science, Jos. Plateau State, Nigeria
*Corresponding Author: uchejesoobeta@gmail.com; GSM: +234(0)8039664892

ABSTRACT

Edible raw fruits and vegetables which include apple (*Malus domestica*), pineapple (*Ananas comosus*), oranges (*Citrus sinensis*), strawberry (*Fragaria ananassa*), watermelon (*Citrullus lamatus*), bananas (*Musa acuminate*), cabbage (*Lycopersicon esculentum*), lettuce (*Lactuca sativa*), spinach (*Spinach oleraccea*), potatoes (*Solanum tuberosum*), carrots (*Daucus carota*) cauliflower (*Brassica oleracea*), cucumber (*Cucumis sativus*), tomatoes (*Solanum lycopersicum*), eggplants (*Solanum melongene*), olive (*Oleae uropaea*) and pepper (*Capsicum annuum*) which are regarded as components of a healthy diet vary greatly in their contents of energy and nutrients. They help in protecting human body from a number of diseases by providing roughages, vitamins, minerals and dietary fiber. Phytochemicals in some fruits and vegetables function as antioxidants, phytoestrogens and anti-inflammatory agents. However, edible raw and un-hygienically prepared fruits and vegetables are risk factors for human parasitic infections like *Giardiasis, Entamoebiasis, Toxoplasmosis, Cryptospordiosis, Cyclosporiasis, Isosporiosis, Hymenolepisiasis, Taeniasis, Fascioliasis, Toxocariasis, Ascariasis, Srongyloidiasis, Trichostrongyliasis,* and *Ancylostomiasis*. Prevention of fruits and vegetables from causative agents of parasitic infections is most efficient in ensuring safety from food-borne illness. Fruits and vegetables producers, vendors, processors, and consumers should be aware of health risks associated with contaminated edible raw fruits and vegetables. Control measures include proper washing and cooking of edible raw fruits and vegetables, proper hand-washing before meals and after visiting toilets. Health education on fruits and vegetables safety should be taught in schools, community health centers and to vendors of fruits and vegetables.

Keywords: Fruits, Vegetables, Parasites, Food-Safety, Health Education.

INTRODUCTION

Vegetables are portions of the herbaceous plants' fruits, flowers, leaves, stems, roots or tubers used as food while fruits are plants' fleshy seed-associated structures that are edible in the raw state (Amaechi *et al*., 2016). Plants referred to as only fruits include Apple (*Malus domestica*), Pineapple (*Ananas comosus*), Orange (*Citrus sinensis*), Strawberry (*Fragaria ananassa*), Watermelon (*Citrullus lamatus*), and Banana (*Musa acuminate*). Those considered as only vegetables include Cabbage (*Lycopersicon esculentum),* Lettuce (*Lactuca sativa*), Spinach (*Spinach oleraccea*), Potato (*Solanum tuberosum*), Carrot (*Daucus carota*) and Cauliflower (*Brassica oleracea*) while those referred to as both fruits and vegetables include Cucumber (*Cucumis sativus*), Tomato (*Solanum lycopersicum*), Eggplant (*Solanum melongene*), Olive (*Oleae uropaea*) and Pepper (*Capsicum annuum*).

Fruits and vegetables are low in calories, fat and sodium, and supply fiber, vitamins, minerals, and other health-promoting phytochemicals. Some of these phytochemicals also help plants to thrive, thwart competitors, predators and

pathogens (Luke, 2017). The importance of fruits and vegetables in supplying most of the vitamins and minerals such as carotene, ascorbic acid, riboflavin, iron, iodine, calcium cannot be over emphasized. Fruits and vegetables also produce valuable roughages and fiber which promote digestion and help to prevent constipation in humans (Klamsmewyer *et al.*, 2004).

Consumption of diet rich in vegetables may reduce the risk of stroke, help reduce blood cholesterol levels and lowers the risk of cardiovascular diseases, type 2 diabetes, and certain cancers of the mouth, stomach, colon and rectum. Potassium in some vegetables may also reduce risk of kidney stones and bone-calcium loss while antioxidants in vegetables help protect the body from oxidant stress, diseases and cancers by boosting immunity (Gruda, 2005). Fibers absorbed in the colon retain good amount of moisture in fecal matter and aid its smooth passage from the body, thus offering protections against hemorrhoids, colon cancer and chronic constipation. The foliate in vegetables helps in the formation of red blood cells, reduces the risk of neural tube defects, spin bifida and anencephaly during fetal development in pregnancy while the potassium content may help to maintain healthy blood pressure. Consumption of vegetables generally help to maintain healthy body weight (Steimetz *et al.,* 1996).

Fruits, on the other hand, are rich sources of fiber, carbohydrate and antioxidants, and Halvorsen *et al*. (2002) reported that oranges, carrots, garden eggs, tomatoes and cucumber have very high antioxidant value. Antioxidants are known to neutralize free radicals which are harmful molecules that damage the body cells and cause inflammation (Aprikian *et al*., 2003).

There has been an increase in the number of reported cases of food-borne illness linked to consuming fresh fruits and vegetables. The consumption of raw vegetables plays a major epidemiological role in the transmission of parasitic food-borne diseases and intestinal parasites which are widely prevalent in developing countries, probably due to poor sanitation and inadequate personal hygiene (Kang *et al.*, 1998). Fruits and vegetables can be agents for transmission of protozoan cysts and oocytes of *Giardia lamblia*, *Entamoeba histolytica*, *Toxoplasma gondii*, *Cryptospordium* species, *Cyclospora cayatanensis and Isospora* species as well as eggs and larvae of helminthes like *Hymenolepis nana*, *Taenia* spp., *Fasciola* spp., *Toxocara* spp., *Trichostrongylus* spp., (Darchenkova, *et al.*, 2006; De Oliveira and Germano, 1992), *Ascaris lumbricoides*, *Trichuris trichiura*, *Strongyloides stercoralis*, Hookworm spp., (Ikpeze and Chima, 2017). Intestinal parasitic infections are among the most common infections worldwide although in many of them the environmental risk factors have not been clearly elucidated but outbreaks of food-borne illness have been caused by sprouts, melons, lettuce and tomatoes contaminated with harmful parasites. Infants, the elderly, and those with impaired immune systems are particularly vulnerable and at more risk of food-borne illness.

FRUITS AND VEGETABLES SAFETY

Safety of fruits and vegetables is a discipline describing handling, preparation and storage of food in ways that prevent food-borne illness. This includes a number of routines that should be followed to prevent potential health hazards. In this way food safety of fruits and vegetables often overlaps with food defense to prevent harm to consumers. The tracks within this line of thought are safety between industry and the market; and then between the market and the consumer. In considering industry to market practices, safety of fruits and vegetables include the origins of food (including the practices relating to food labeling, food hygiene, food additives and pesticide residues) as well as policies on biotechnology and food, and guidelines for

the management of governmental import and export inspection and certification systems for food. In considering market to consumer practices, the usual thought is that food ought to be safe in the market and the concern is safe delivery and preparation of the food for consumer (Fortin *et al.*, 2017). The safer choices for fresh produce are washed fresh fruits and vegetables, including lettuce and salads that are more likely to make people sick with a food-borne illness. Some of the fruits and vegetables are shown in Plate 1.

Plate 1: Examples of edible-raw fruits and vegetables. Fruits only are 1) Banana (*Musa acuminate*). 2) Water melon (*Citrullus lamatus*). 3) Pineapple (*Ananas comosus*). 4) Orange (*Citrus sinensis*); Vegetables only are 5) Carrot (*Daucus carota*). 6) Cabbage (*Brassica oleraca*). 7) Lettuce (*Eruca sativa*). 8) Spinach (*Amaranthus* species). Both fruits and vegetables are 9) Garden eggs (*Solanum melongena*). 10) Cucumber (*Cucumis sativus*). 11) Green pepper (*Capsicum species*). 12) Tomatoes (*Solanum lycoperiscum*)

EPIDEMIOLOGY OF SOME GIT PARASITES THAT CONTAMINATE FRUITS AND VEGETABLES

Studies worldwide have shown that fruits and vegetables can transmit protozoan cysts and oocytes of *Giardia lamblia*, *Entamoeba coli*, *Entamoeba histolytica*, *Toxoplasma gondii*, *Cryptospordium* spp., *Cyclospora* spp., and *Isospora* spp.), and helminthes eggs and larvae of *Hymenolepis nana*, *Taenia solium*, *Fasciola* spp., *Toxocara* spp., *Trichostrongylus* spp., (Daryanit *et al.*, 2008; Monge *et al.*, 1996), *Ascaris lumbricoides*, *Trichuris trichiura*, Hookworms and *Strongyloides stercoralis* (Ikpeze and Chima, 2017). The rate of parasite contamination of vegetables differs throughout the world where increase in the

number of reported cases of food borne illness linked to consuming fresh fruits and vegetables have been reported (Abougrain *et al.,* 2010). In areas where waste water is used to irrigate edible raw fruits and vegetables, the consumption of such fruits and vegetables without proper washing have often resulted to parasitic infections (Damen *et al.,* 2007).

Gastrointestinal tract (GIT) parasites are regarded as infections due to poverty but while still found in North America and Europe, their prevalence is highest in areas of intense poverty in low and middle-income countries in sub-Saharan Africa, Asia, Latin America and the Caribbean (Brooker *et al.,* 2006; Hotez *et al.,* 2009). In North America and Europe, these infections are most prevalent in immigrant and refugee communities (Barnett *et al.,* 2004; Stauffer *et al.,* 2009). Generally, epidemiological data for GIT protozoa, Cestodes and Trematodes (excluding Schistosomiasis) infections are limited, since they have not been studied systematically or included in global burden of disease studies. Accurate figures for their prevalence would almost be impossible to obtain. Despite their relative low frequency compared with the Nematodes, they can cause significant morbidity in a large number of individuals (Horten *et al*., 2003). STHs like *Ascaris lumbricoides*, hookworms and *Trichuris trichiura* are most prevalent, infecting an estimated one-sixth of the global population, and in Nigeria, approximately 55 million people were infected with Ascariasis, 38 million with Hookworms and 34 million with Trichuriasis (Hotez *et al.,* 2009).

Generally, symptoms signaling the presence of gastrointestinal parasites are related to the intensity of infection. Thus, a light protozoan or helminth infection is often asymptomatic whereas a mild and heavy infection can be associated with painful and severe symptoms. However, subtle damage and deregulation can occur in the absence of a noticeable infection. For example, it has been observed that minor levels of GIT nematodes impair functions such as milk production in animals (Suarez *et al.,* 2009), and in humans the effects of GIT parasites depend on the species, co-infection of species, duration of infection, and worm burdens. The distributions of worms among host is highly skewed such that the minority of individuals, almost entirely young, have moderate-to-heavy infections and are more likely to be clinically affected. Intensity of infections also depends on the size and nutritional status of the host. Treating worms can lead to improvements in growth and nutritional status but deworming alone does not treat and underlying nutritional deficits that have been caused or made worse by infection.

Moreover, the predominant mechanisms by which GIT parasites cause harm to human host are by feeding on host tissues and blood, leading to loss of iron and protein (especially in hookworm infections). There is mal-digestion or mal-absorption of nutrients. Others are by provoking inflammatory responses that may affect appetite and food intake or modify the metabolism and storage of key nutrients such as iron. They also elicit typical responses to infection such as fever and increased metabolic rate. Elicit immune responses to infection which may result in the diversion or use of nutrients and energy for purposes that would not have been necessary. While it is likely that impaired child development operates through these mechanisms, the causal links underlying stunting, physical and intellectual development are yet to be well-established.

Parasites found in the human GIT can be largely categorized as protozoa and helminthes. Protozoa are unicellular or single celled organisms which multiply in human host and classified into the four Phyla Sacormastigophora (which contains *Entamoeba histolytica*, and *Giardia lamblia*), Apicomplexa (which contains the

sporozoa Coccidia and Haematozoa), Ciliophora (containing ciliates), and Microspora (Arora *et al*., 2010). GIT protozoa cause significant morbidity in children and as opportunistic infections in HIV/AIDS and the immunosuppressed in developing countries who are already malnourished or have limited access to medical services (Nissapotorn *et al.,* 2008). Consequently these subjects suffer from repeated severe diarrhea episodes that can be fatal (Kurniawan *et al.,* 2009). *Giardia lamblia is* the most prevalent parasitic cause of diarrhea in both developed and developing countries of the world, and is the third leading cause of death from parasitic diseases worldwide, with its greatest impact on the people of developing countries. It was estimated that approximately 50 million people worldwide suffer from invasive amoebic infection each year, resulting in 40-100 thousand deaths annually. Giardia cyst are highly resistant to environmental conditions, being able to survive in cold mountain streams, stomach acid, chlorine and even in UV-treated wastewater (Li *et al.,* 2009; Caccio *et al.,* 2003). Other protozoa of common occurrence in man are *E. histolytica, E. coli, G. intestinalis, T. hominis, and B. coli* and are all found in moist habitats, commonly in soil, fresh and marine water. Each is a single cell, predominantly microscopic, ranging in size from 2 to more than 100µ. They are characterized by having pseudopods for motility, and trophozoites and cyst stages in their life cycle. Amoeba usually are acquired by humans through feacal-oral transmission or mouth to mouth contact as in *Entamoeba gingivalis*.

Helminths are multicellular bilaterally symmetrical, elongated, flat or round parasitic worms which belong to two phyla namely, Platyhelminthes and Nemathelminthes. Platyhelminthes are subdivided into the Classes Cestoda and Trematoda while Nemathelminths contain the Class Nematoda. Usually helminthes cannot multiply in their host. *Ancylostoma duodenale, Necator americanus, Ascaris lumbricoides* and *Trichuris trichiura* are among the most prevalent STHs and are estimated to infect about a sixth of the global population, being most prevalent in tropical and sub-tropical regions of the developing world with inadequate water and sanitation facilities (Savioli *et al.,* 2004). Detection of *Taenia* in stool is not common but the incidence of neurocysticercosis (Larval *Taenia solium* infection) can be an indicator of the presence of this tape worm, and is the leading cause of epilepsy in the developing world (Preux *et al.,* 2005; Prasad *et al.,* 2008). The major intestinal flukes that could be ingested with raw vegetables include *Fasciolopsis buski, Heterophyes, Metagonimus yokogawai* and *Echinostoma ilcanum*.

SOURCES OF CONTAMINATION OF FRUITS AND VEGETABLES

Fruits and vegetables have become contaminated with parasites capable of causing human diseases while still on plants in the fields or orchards or during harvesting, transportation, processing, distribution and marketing (Pires *et al*., 2012). The primary sources of fruits and vegetables contamination are through human and animal raw excreta used as fertilizer or when contaminated water is used for irrigation (Okonkwo and Onwuliri, 1998), Open defeacation, and land used for cultivation of fruits and vegetables being often fertilized with untreated human and animal waste (WHO 1999). Also, *Toxocara* eggs in dog feaces (Ikpeze, 2005) and *Toxoplasma gondii* oocysts in cat feces (Ikpeze and Okechukwu, 2008) could contaminate soil, water and foods.

OCCURRENCE OF PARASITES ON FRUITS AND VEGETABLES

Contamination of fruits and vegetables by parasites have long been established. Among the protozoa incriminated are *G. lamblia*, *E. histolytica*, and *B. coli.*

Helminthes such as *Taenia solium*, *T. saginata*, *E. granulosus*, *A. lumbricoides*, *S. stercoralis*, *T. trichiura*, *Enterobius vermicularis*, and *Ascaris duodenale* have been associated with fruits and vegetables contamination (Ikpeze and Chima, 2017; Okoronkwo and Onwuliri, 1998).

Salad and fruits have because of their nutritional benefits and the fact that they are prepared in very short time, and mostly consumed raw or after minimal processing have become excellent media for transmission of these parasites. *Lactuca sativa* (lettuce), *Cucumis sativa* (cucumber), *Lycopersicon esculentum* (tomato), *Spinach oleracea* (spinach), *Brassica oleracae* (cabbage), *Raphanus sativum (*radish) are among the most common vegetables used for salad. Food-borne parasites such as *Giardia lamblia, Entamoeba histolytica and Ascaris lumbricoides* have been the main causes of fruits and vegetables borne-illness. Measures to minimize the risk of parasitic contamination at all points from the field to the table through good agricultural practices would be the most effective strategy to assure that fresh produce are safe for human consumption (Swerdlow *et al.*, 1992).

RISK FACTORS ASSOCIATED WITH FRUITS AND VEGETABLES BORNE-ILLNESS

Four major risk factors for fruits and vegetable borne-illness outbreaks are holding temperature control for safety (TCS) foods at wrong temperatures, using contaminated utensils and equipment, failing to follow personal hygiene rules, and purchasing food from unsafe sources.

Cooked vegetables, meat, dairy and sliced fruits are just a few of the foods considered to be 'TCS' foods. When foods that will not be eaten immediately, such as foods in a buffet line is prepared, it should be kept or held at the right temperature in order to prevent pathogens from growing to dangerous levels. Hot food should be held at 135°F or hotter; cold food should be held at 41°F or colder. The temperature of held food should be checked frequently.

Dirty or contaminated utensils and equipment can transfer contamination to food. Contamination can happen in other ways such as lack of proper cleaning and sanitation, when dangerous pathogens build up on food residue or utensils or equipment. Therefore all utensils and equipment must be cleaned and sanitized before and after used. Good personal hygiene is essential for eliminating tens of thousands of pathogens that could otherwise be transferred to food. Some hygienic necessities for food preparation include showering, wearing clean clothes and washing of hands. Little children should not be allowed to take candy from strangers while adults should never purchase food from unapproved suppliers. Government regulators have created policies, systems and benchmarks to help ensure that food factories, slaughter houses and farms are in a safe condition. Since approved suppliers must have been inspected and found to be compliant with these safety rules, it is better to always purchase food from them.

SYMPTOMS AND PATHOLOGY OF GIT PARASITES INFECTIONS FROM CONTAMINATED FRUITS AND VEGETABLES

Parasitic pathogens may give rise to diseases that are more serious than the uncomfortable but relative temporary inconvenience of diarrhea, and vomiting which are the most common symptoms of the food poisoning. Diseases most commonly associated with fruits and vegetables include Giardiasis, Amoebiasis, Balantidiasis, Taeniasis, Ascariasis, Strongyloidiasis, Trichuriasis, Hookworm, Cyclosporiasis, and Cryptosporidiosis.

Infection with *G. lamblia* is often accompanied by diarrhea, flatulence, vomiting, weight loss and mal-absorption. The presence of *G. lamblia* in the glandular crypts of duodenal-jejunal mucosa may not

cause any pathology. These flagellates do not invade the tissues, but feed on mucous secretions. With the help of sucking disc the parasites attaches itself to the surface of the epithelial cells in the duodenum and jejunum and in an appreciable number of cases it may cause duodenal and jejunal irritation leading to duodenitis and jejunitis. Patient may complain of dull epigastric pain flatulence and chronic diarrhea of steatorrhoea type. Stool is voluminous, foul smelling and contains large amount of mucus and fat but no blood. This is due to mal-absorption since the parasites are coated on the mucosa, thus absorption suffers. Patient loses weight, when the parasites localizes in the biliary tract, it may lead to chronic cholecystitis and jaundice (Arora, *et al*., 2010).

Amoebiasis occurs when trophozoites of *E. histolytica* invade the walls of the large intestines and multiply in the sub mucosa, forming large flask-shaped ulcers and giving rise to diarrhea Intestinal amoebiasis indicates that organisms are confined to gastrointestinal tract. After an incubation period of 1-4 weeks, the amoebae invade the colonic mucosa, producing characteristic ulcerative lesions and a profuse bloody diarrhea (amoebic dysentery). The ulcers may be generalized involving the whole length of the large intestine or they may be localized in the ileo-caecal (caecum, ascending colon, ileo-caecal valve and appendix) or sigmoido-rectal (sigmoid colon and rectum) region. Ulcers are discrete with intervening normal mucosa. They vary in size from pin-head size to more than 2.5cm in diameter. They may be deep or superficial. Base of the deep ulcers is generally formed by muscular coat. However, superficial ulcers do not extent beyond muscularis mucosae. (Arora *et al.,* 2010).

Balantidiasis is similar to amoebiasis. Many individuals present no symptoms but in a majority of cases diarrhea or dysentery is often accompanied by abdominal pain, nausea and vomiting. Loss of appetite, headache, insomnia, muscular weakness and loss of weight have all been observed; and stools may contain blood and mucus in severe cases of dysentery. Infections with *B. coli* are often harmless but in rare cases the clinical manifestations which occur after the invasion of mucosa or sub-mucosa by trophozoites include production of irregular ulcers that are covered with pus and necrotic materials, alternating constipation, chronic recurrent diarrhea, bloody mucoid stool, nausea, epigastric pain, vomiting and anorexia, and extra-intestinal involvement such as liver abscess formation in cases of acute infection.

Cyclosporiasis is a parasitic disease caused by *Cyclospora cayenensis.* It causes self-limiting diarrhea, fever, fatigue and abdominal cramps lasting for 3-4days and is associated with poor sanitation. As with other coccidian parasites, it is more severe in immune-compromised patients, particularly with AIDS. In patients with AIDS, symptoms may persist for as long as 12weeks when biliary infection with accompanying symptoms has been observed. (Arora *et al.,* 2010).

Cryptosporidiosis is a disease caused by a protozoan parasite *C. parvum.* Humans become infected either from direct contact with infected animals or from ingestion of feacally contaminated food or water. Calves and other animals serve as a major source for human infection but human-to-human transmission is possible. Oocysts of *C. parvum* are not eliminated by chlorination and may persist in post-treatment water supplies. Symptomatic intestinal and respiratory cryptosporidiasis has been seen in both immune-competent and immune-deficient patients of all ages. However, once the primary infection has been established, the immune system of the host plays a very important role in determining the length and severity of the illness. People who are immune-competent usually develop a short-term, self-limited diarrhea

lasting approximately 2 weeks. In contrast, those who are immune-compromised initially develop the same type of illness but it becomes more severe with time and results in a prolonged, life-threatening, cholera-like illness.

Taeniasis occurs in all countries where beef or pork are eaten. The larval stage of *Taenia solium* causes Cysticercosis. Clinical feature may be absent, patient only become aware of the worm infection when segment of *Taenia* species are passed in stool. Migrating segments of *T. saginata* may occasionally cause appendicitis. Adult worms in small intestines usually produce no symptoms but sometimes cause vague abdominal discomfort, indigestion with constipation and loss of appetite. Cysticercosis is caused by larval stage of *T. solium* which is an important public health problem of the tropical countries including India. *Cysticerci* may develop in any organ – and have been observed in massetter, tongue, inter-costal and pectoral muscles of infected animals (Ikpeze *et al,* 2008) – and the effects depend on the location of the cysticerci which usually occur in large numbers but sometimes singly. They usually develop in the sub-cutaneous tissues and muscles forming visible nodules. It may also develop in the brain leading to epileptic attack and in anterior and vitreous chambers of the eye (Arora *et al.,* 2010).

Ascaris larvae during migration can cause inflammatory and hypersensitive reactions. Including pneumonia-like symptoms, attack of cough, bronchial asthma and eosinophilia. Ascariasis results from the presence of both the adult worms and the migrating larvae of *A. lumbricoides.* Adult worms release toxic body fluid known as ascaron in patients which results in some allergic manifestations such as fever, wheezing and conjunctivitis. In heavy infection, adult worm may cause obstruction of the respiratory tract when found in the trachea, obstruction of the intestinal tract when found in the intestines, obstructive jaundice when found within the appendix, bile ducts and pancreatic ducts, and perforation of intestinal walls that are weakened by ulcers.

Strongyloidiasis is caused by the nematode *Strongyloides stercoralis*. When penetrating the unbroken skin, the filariform larvae can cause itchy dermatitis and rash. Strongyloidiasis, is most frequently asymptomatic. In symptomatic cases, the filariform larvae produce petechial hemorrhage at each site of skin invasion, accompanied by intense pruritus, congestion and oedema around the invaded area. Pruritus and urticarial, particularly involving the perianal skin and buttocks, are common symptoms of chronic Strongyloidiasis. When the larvae of *S. stercoralis* migrate through the lungs, they break out of the pulmonary capillaries into the alveoli leading to hemorrhage in the lung and bronchopneumonia. The intestinal manifestations of *S. stercoralis* infection vary from few symptoms in heavy infections - patient develops intermittent abdominal pain, distension, bloating and diarrhea alternating with constipation. Patients with *S. stercoralis* hyper-infection generally experience a worsening in abdominal symptoms, often accompanied by paralytic ileus, gastrointestinal bleeding and perforation (Arora *et al*., 2010).

Trichuriasis, also known as whipworm infection, is caused by *Trichuris trichiura.* If infection is only with a few worms, there are often no symptoms but in those infected with many worms, there may be abdominal pain, tiredness and diarrhea, which sometimes contains blood. The immature *T. trichiura* buries its entire body in the epithelium of the large intestine forming a tunnel. As the worm matures, its posterior portion is extruded or ruptures from the tunnel and hangs in the intestinal lumen, available for functions of copulation and oviposition. Intimate contact of *T. trichiura* which the mucosa of large intestine leads to the inflammation of mucosa. Depending

upon the intensity of infection, the inflammation may extend from the distal part of small intestine to the rectum. The mucosa may be oedematous and friable. The surface tissue of the rectum becomes extremely oedematous and when the patient strains, rectal prolapse may occur. Rectal bleeding (i.e., whipworm dysentery) with abdominal cramps and severe rectal tenesmus are seen in massive infections, leading to iron deficiency anemia due to the general mal-nutrition and blood loss from the friable colon and unrelated to blood ingestion by the parasite. Anemia is absent in light or even in symptomatic infections when there is adequate intake and assimilation of iron and protein (Arora *et al.*, 2010).

Hookworm infection is caused by *A. duodenale* and *N. americanus*. Initially there may be itching and a rash at the site of infection. There may be no symptoms in those only affected by a few worms but in heavy burden there may be abdominal pain, diarrhea, weight loss, and feeling tiredness. In children, mental and physical development may be affected and anaemia may result (CDC, 2014). Migrating larvae of *A. duodenale* may cause two types of lesions called Ancylostoma dermatitis or ground itch, and pulmonary lesions. When filariform larvae enter the skin they may lead to dermatitis. This causes intense itching and burning followed by erythema and oedema of the area which soon develops into papules and vesicular eruptions, being more common with *N. americanus* than *A. duodenale* infection. When the filariform larvae break through the pulmonary capillaries and enter the alveoli, they may lead to bronchitis and bronchopneumonia with marked eosinophilia. A patient with hookworm disease develops epigastric pain, dyspepsia, vomiting and diarrhea with reddish or black stool. Also the tongue, conjunctiva and skin become dry while the hairs develop dryness and lack luster, and feet and ankle become oedematous (Arora *et al*., 2010).

PREVENTION OF CONTAMINATION OF FRUITS AND VEGETABLES BY GIT PARASITES

The ability to understand the life cycle of parasites is of great importance, not only to recognize the stages of the life cycle which are used for diagnosis, but also necessary for planning a control program against the parasites. However, the knowledge of the life cycle of parasites outside as well as inside the host is essential, if the disease is to be attacked relatively and successfully. Preventive measures should include:

i. Treating the infected individuals as part of a control program.
ii. Preventing open defeacation by using latrine and avoiding the use of untreated human feces as fertilizers.
iii. Improving on the personal hygiene and good environmental sanitation.
iv. Proper washing of fruits and vegetables before eating or cooking.
v. Thorough scrubbing of fruits and vegetables like melons, apples and carrots and pealing-off the outer rinds.
vi. Following instructions for package fruit and vegetables, such as “keep refrigerated” or “use by” or “best before”, and discarding anything that has been kept for too long, or has spoilt or with repugnant odour.
vii. Products should be kept in clean, cold (5^0C) refrigerator promptly. Bananas, tomatoes, or fruits that need further ripening can be kept at room temperature.
viii. After handling fresh meat and poultry, it is necessary to clean surfaces, utensils and hands before handling fresh produce.
ix. Dishes made with cut fruits and vegetables must be covered while and prepared fruit salads and other cut produce should be kept in the refrigerator until serving.
x. Health education, particularly of food handlers, and also in schools and community health centers is of paramount importance.

Vegetables cannot be excluded from human diet but can be removed from the cycle of transmission and dispersion of parasites. This can be achieved by maintenance of simple personal and environmental hygiene by sellers and consumers, avoid using untreated human and animal wastes as manure, soaking of vegetable for 10 minutes in vinegar or saturated salt solution which will plasmolyse the parasites if present, cooking of vegetables adequately before serving them as meal, and avoiding open defecation. Media programs can be used to inform the community about good sanitary hygiene and potential health risk of raw vegetables in order to prevent transmission of food borne diseases. In addition, health education on food safety and protection should be directed towards producers and vendors of food in local markets while an integrated strategic community de-worming program should be encouraged. Farmers and vegetables vendors should be subjected to routine checks by food safety officers from local environmental health and trading standards departments. Edible raw vegetables are better to be washed after harvest and protected from public touching, coughing or sneezing while on display for sale in markets.

CONCLUSION

Strict personal hygienic practices and safe disposal of excreta play significant roles in the epidemiology and control of different food-borne parasitic diseases. Edible raw fruits and vegetables contaminated with GIT parasites pose health risk to consumers who ingest them without proper cleaning or cooking. The consumers should always observe the basic principle of food and personal hygiene by thorough washing of the fruits and vegetables before eating and, washing of hands before and after meals. Vendors should avoid contact of fruits and vegetables with soil while on display for sale.

REFERENCES

Abougrain, A. K., Nahaisi, M. H., Madi, N. S., Saied, M. M. and Ghenghesh, K.S. (2010). Parasitological contamination in salad vegetables in Tripoli-Libya. Iran Food Control, 21(5), 760-762.

Amaechi, E.C., Ohaeri, C.C., Ukpai, O.M and Adegbite, R.A. (2016). Prevalence of parasites contamination of salad vegetables in Ilorin, North Central Nigeria. Momona Ethiopian Journal of Science, 8(2):136-145.

Arora, B.A and Arora D.R. (2009). *Diagnostic Procedures Medical Parasitology 2nd ed.* CBS Publishers and Distributors. New Delhi Banglore (India). 226-227.

Arora, B.A and Arora, D.R. (2010). Pathogenicity of *Giardia lamblia, Taenia solium, Trichuris trichiura* and *Hookworm* infection. Medical Parasitology *3rded* .CBS Publishers and Distributions. New Delhi Banglore (India) Pp: 43-44, 132-132, 178-179 and 186-187.

Aprikian, O., Duclos, V., Besson, C., Manach, C., Benalier, A., Morand, C., Remesy, C., and Deminge, C. (2003). Apple pectin and polyphenol- rich apple concentrate are more effective than separate cecal fermentations and plasma lipids in rats. Journal of Nutrition, 133(6):1860-1865.

Barnett, E.D. (2004). Infection disease screening for refugees resettled in the United States. Clin. Infect. Dis. 39(6):833-841.

Brooker, S, Clements, A.C, Bandy, D.A. (2006). Global epidemiology, ecology and control of Soil-transmitted infections. Adv. Parasitol. 62:221-261.

Caccio, S.M, De Giacomo, M., Aulicino, F.A, Pozio, E. Giardia cysts in wastewater treatment Plants in Italy. Appl. Environ. Microbial. 69(6):3393-3398.

CDC (2014). Centers for Disease Contol-Hookworm-General information-

frequently Asked Questions (FAQs)". www.cdc.gov.16

Damen, J.G., Banwat, E.B., Egah, D.Z and Allanana, J.A. (2007). Parasitic contamination of vegetables in Jos, Nigeria. Annals of African Medicine, 6(3), 115-118.

Darchenkova, N.N., Romanenko, N.A. and Chenyshenko, A.I. (2006). Current ascariasis situation in the Russian federation. Med. Parasitol., 4:40-43.

Daryani, A., Ettehad, G.H., Sharif, L., Ghorbani, M. and Ziaei, H. (2008). Prevalence of intestinal parasites in vegetables consumed in Ardabil, Iran. Food control, 19: 790-794.

De Oliveira, C.A. and Germano, P.M. (1992). Presence of parasites in the vegetables sold in the metropolitan region of Sao Paulo, SP. Brazil 1-search of helminthes Rev. Saudipublica, 26: 283-289.

Fortin, Neal D. (2017). Food Regulation: Law, Science, Policy and Practice 2nd ed. Hoboken, New Jersey: John Wiley and Sons, Inc ISBN 9781118964477. OCLC976412308. Retrieved June 18, 2017.

Gruda, N. (2005). Impact of environmental factors in products: Quality of greenhouse vegetables for fresh consumption: 227-234.

Halvosen, B., Myhrstad, M., Barikmo, I., Hvattum, E., Remberg, S., Wold, A., Haffnern, K., Baugerod, H., Andersen, L., Moskaug, J., Jacobs, D. and Blohoff, R. (2002). A systematic screening of total antioxidants in dietary plants. Journal of Nutrition, 132(3):461-471.

Horton, J. (2003).Human gastrointestinal helminth infections: are they now neglected diseases? Trend Parasitol. 19(11): 527-531.

Hotez, P.J. and Karnath, A. (2009). Neglected tropical diseases in Sub-saharan Africa: review of their prevalence, distribution and disease burden. PLoS Negl. Trop. Dis. 3(8); e41.

Ikpeze, O.O. and Chima, Stella Chizoba. (2017). Soil-transmitted helminth parasites contaminating edible raw vegetables and fruits sold at Nkwo-Edo Market Nnewi Nigeria. The Bioscientist, 5(1):65-72.

Ikpeze, O.O. and Okechukwu, E.N. (2008). *Toxoplasma gondii* infection in humans: a mini-review of the public health significance of the domestic cat (*Felis domestica*). Journal of Advancement in Medical and Pharmaceutical Sciences, 3(2):47-55.

Ikpeze, O.O., Eneanya, C.I. and Ekechukwu, Winniebert. (2008). Significance of meat inspection in the estimation of economic loss due to bovine cysticercosis. Animal Research International, 5(3):896-899.

Ikpeze, O. O. (2005). Stratification and Livestock Population Census for Enugu Urban, Nigeria: A Pilot Survey. Animal Research International, 2(2):332-335.

Kang, G., Mathan, M.S. and Muliyil, J.P. (1998). Prevalence of intestinal parasites in rural southern Indians. Trop. Med. Int. Health, 3: 70-75.

Klansmeweyer, P., Fhimumy, G.W., MacCould, T.D. and Shoemaker, R.H. (2004). Antimicrobial inlizinium alkanoid from Aniba Punurensis.n .Journal of Natural Products, 67:1732-1735.

Kuniawan, A., Karyadi, T., Dwantasari, S.W. (2009). Intestinal parasitic infection in HIV/AIDS patients presenting with diarrhea in Jakarta, Indonesia. Trans. R. Soc. Trop. Med. Hyg. 103(9): 892-898.

Li, D., Graik, S.A., Smith, D.W, and Belosevic, M. (2009). Infectivity of Giardia lamblia cysts obtained from wastewater treated with ultraviolet light. Water Res. 43(12): 3037-3046.

Luke, Laborde (2017). Proper Care and Handling of Fruits and Vegetables,

Penn States Department of food science at (814) 865-5444.

Monge, R. and Arias, M.L. (1996). Presence of various pathogenic microorganisms in fresh vegetables in Costa Rica. Arch. Latinoam. Nutr. 46: 9-94.

Nissapotom, V. (2008). Lessons learned about opportunistic infections in Southeast Asia. Southeast Asian J. Trop. Med. Public Health, 39(4): 625-641.

Nyarango, R.M. Aloo, P.A., Kabiru, E.W. and Nyanchongi, B.O. (2008). The risk of pathogenic intestinal parasites in Kisii Municipality, Kenya. BMc public Health, 8: 237-237.

Okoronkwo, M.O. and Onwuliri, C.O.E. (1998). Intestinal parasites from refuse dumps and Abbattoir wash in plateau state Nigeria. Journal of Medical Laboratory Science, 1:120– 126.

Pires, S.M., Vieira, A.R., Perez, E., Wong, D.L.F. and Hald, T. (2012). Attributing human foodborne illness to food sources and water in Latin America and Caribbean using data from outbreak investigation. International Journal of Food Microbiology, 152(3):129-138.

Prasad, K.N., Prasad, A., Verma, A. and Singh, A.K. (2008). Human cysticercosis and Indian scanaris: a review. J. biosci. 33(4): 571-582.

Preux, P.M. and Druet-cabarnac, M. (2005). Epidemiology and ecology of epilepsy in Sub-saharan Africa. Lancet Neurol. 4(1): 21-31.

Savioli, L. and Albonico, M. (2004). Soil-transmitted helminthiasis. Nat Rev microbial. 2:618-619.

Stauffer, W.M. and Weinberg, M. (2009). Emerging clinical issues in refugees. Curr. Opin. Infect. Dis., 22(5):436-442.

Steimetz, K.A. and Potter, J.D. (1996). Vegetables fruits and cancer prevention a review. Journal of American Diet Association, 96(10):1027 – 1039.

Suarez, V.H., Cristel, S.L, Busetti, M.R. (2009). Epidemiology and effects of gastrointestinal nematode infection on milk productions of diary ewes. Parasite. 16(2):141-147.

Swerdlow, D.L., Greene, K.D., Tauxe, R.V., Wells, J.G. and Bean, N.H. (1992). Waterborne transmission of epidemic cholera in Trujillo, Peru: Lessons for a continent at risk. The Lancet, 340: 28-33.

World Health Organization (1999): Surface decontamination of fruits and vegetable eaten raw. Food safety programme document; 4–30.