Chapter one

Introduction and literature review

1.1Fruitsand theirhealthy role :

Fruits aregood sources of vitamins, mineralswhich aid our bodies to function properly.Fruits naturally low in fat, sodium,calories, rich in fiber whichis very essential for the smooth movement of the digestive system,carbohydrates which are the main source of energyand it breaks down easily to make a quick source of energy, vitaminC which is a very necessary supplement to the body as it enhances the metabolic process. An important nutritional value of fruits is its antioxidant contents such as polyphenolic flavonoids, vitamin-C, and anthocyanins. These compounds protect human body from oxidant stress, diseases, and cancer. Fruits such as orangehave the highest antioxidant value (Halvosen*et al.*,2002).Eating fruits daily is recommended to reduce risks for diseases like cardiovascular disease and cancer (Heimendinger*et al*., 1996 Krauss*et al.*, 2000).Many studies have evaluated fruits andvegetables consumption in relation to the risk of cardiovascular disease and specific cancers (Gaziano*et al*., 1995).

1.2Overviewof intestinal parasites:

A parasite is an organism that lives on or in a host organism and gets its food from or at the expense of its host. Intestinal parasitic infections are widely distributed throughout the world causing substantial intimidation to the public health, economy, physical and cognitive development particularly among children in developing countries like Sudan. The poor personal hygiene, poor environmental hygiene, and poor health system commonly observed in developing countries make the prevalence to be highest among these populations (Okyay*et al.*,2004,Wegayehu*et al.*,2013).

There are three main classes of parasites that can cause disease in humans: protozoa, helminthes, and ectoparasites.

1.2.1 Intestinalprotozoa:

Protozoa are microscopic, one-celled organisms that can be free-living or parasitic in nature. They are able to multiply in humans, which contributes to their survival and also permits serious infections to develop from just a single organism. Transmission of protozoa that live in a human's intestine to another human typically occurs through a fecal-oral route (for example, contaminated food or water or person-to-person contact). Protozoa that live in the blood or tissue of humans are transmitted to other humans by an arthropod vector.

1.2.1.1 Classification of intestinal protozoa:

The members of protozoa are classified by their morphology and adaptation for movement (Steven, 2003).

1.2.1.1.1Phylum Sarcomastigophora:

This phylum is divided into two subphyla:

Subphylum Mastigophora;

Which contain the class Zoomastigophora, these protozoa move by means of flagella and reproduce by longitudinal binary fission; *Giardia lamblia* and *Dientamoeba fragilis* are pathogens within this group (Steven, 2003).

Subphylum Sarcodina;

Which contains super class Rhizopoda and class lobosea and other Amoeboid, these protozoa move by means of cytoplasmic protrusions called pseudopodia, *E.histolytica* is the most significant organism within this group (Steven, 2003).

1.2.1.1.2 Phylum Apicomplexa:

Class sporozoa and the subclass coccidian representative species within this group include *Cryptosporidium parvum, Cyclosporacayetansis, Isospra belli, Toxoplasma gondii and Sarcocystis spp*.

1.2.1.1.3 Phylum Cliliphora:

Class kinetofragminepherea and the order is Trichostomatida.The only ciliate *Blantidium coli* contain two nuclei, a large macronucleus and a small micronucleus (Beaver*et al*., 1984).

1.2.1.1.4 Phylum Microsporidia:

It is a group of protozoa characterized by obligate intracellular replication and spore formation (Balbiani,1882). *Enterocytozoonbienusi* and *septataintestinalis* are two important *Microsporidia spps* that cause severe, persistent and watery diarrheain acquired immune deficiency syndrome(AIDS) patients.

1.2.1.2 Transmission and lifecycle of intestinal protozoa:

Most intestinal protozoa are transmitted by faecal-oral route, particularly in contaminated food, water or hands (Petri*et al*.,2006).

Also person to person transmission may occur through anal-oral sexual stimulation (Steven*et al*., 1981).The life cycles of intestinal protozoa are very similar, with the exception of *D.fragilis*, which lacks a cyst stage.The mature cysts of protozoa are infective forms of the parasites and enter into man through contaminated food and drinkingwater, the cyst enter into the alimentary canal, pass unaltered through the stomach(cyst wall is not dissolved by the action of gastric juice),and then reach the small intestine(*G.lamblia and B.coli*)or the large intestine(*E.histolytica*),where cysts liberates the active motile trophozoites.The trophozoites(vegetative form) cause distortion and necrosis of the intestinal surface(Gillespie and Pearson,2001).Sometimes enter into the deeper layer and some may reach the liver, as in the case of *Entamoebahistolytica*.In spore forming protozoa (intestinal coccidian), spore ingestion begins a life cycle that is similar in all 4 of the intestinal spore-formingprotozoa. The ingested spores release sporozoites that invade enterocytes, primarily in the small intestine. The enterocyte infection progresses through 2 stages: merogenic and sporogenic.The merogenic (or schizogonic)stage involves the maturation and development of meronts to

reproduce and multiply in the infected cell or to infected other enterocytes. This asexual stage allows the infection to spread into many enterocytes, even if the host is not exposed repeatedly to the organism. Thesporogonic (i.e., gametogonic, sexual) stage involves the maturation and development of sporozoites enclosed in cysts or spores.Asthe infected enterocytes die, cyst or spore shedding occurs. The spores are then excreted in the stool (Gillespie and Pearson, 2001).

1.2.1.3 Clinical presentation:

The spectrum of intestinal protozoan infections can range from asymptomatic to invasive disease (in the cases of *E.histolytica* or *B.coli*) to severe and/or chronic and protracted diarrhea (in the cases of giardiasis or in individuals who are severely immunosuppressed with spore-forming protozoan infections).Mechanisms of diarrhea producing by intestinal protozoa are related to direct cytotoxic effects, the ability to invadeand/or effects of the immune response on the intestinal epithelium.Giardiasis is the most frequently diagnosed intestinal parasitic disease in the United States and among travellers with chronic diarrhea (Huang and white, 2006).In some cases; people infected with *Giardia* have no symptoms (Gardner*et al.*, 2001).

1.2.1.4 Epidemiology of intestinal protozoa:

Many factors affect on the prevalence of intestinal parasite infection. These factors which include environmental factors, climatic and geogic factors are among the main reason for the differences noticed on global distribution and seasonal occurrence of intestinal parasites. Intestinal parasitic infection occurs worldwide with highest prevalence in developing countries, this mainly due to deficiency of sanitary facilities, unsafe human west disposal system inadequacy and lack of safe water supply, and law socioeconomic status (John*et al.*, 2006).GI protozoa cause significant morbidity in children and as opportunistic infections in HIV/AIDS and immunosuppressed patients in developing countries who are already malnourished or have limited access to medical

services(Nissapatorn, 2008).*Giardia* cysts are highly resistant to environ mental conditions, being able to survive in cold mountain streams, stomach acid, chlorine and even in UV-treated wastewater (Smith et *al*., 2009).Amoebic dysentery from *Entamoeba histolytica* is the second most common cause of death from parasitic disease worldwide after malaria (Gonzales*et al*.,2009).*B.coli* infections are rare in humans; it is widely distributed among those who have contact with pigs, particulary in warm climates (Beaver*et al*., 1984).

1.2.2 Intestinal helminthes:

1.2.2.1 Definition:

Helminthes are large, multicellular organisms that are generally visible to the naked eye in their adult stages. There are three main groups of helminthes (derived from the Greek word for worms) that are human parasites, trematodes, nematodes and cestodes.

1.2.2.2 Classification:

Belong to subkingdom Metazoa, which is subdivided into two phyla:

Nematoda and Platyhelminthes.

1.2.2.2.1 Phylum Nematoda:

The phylum Nematoda, also known as the roundworms, is the second largest phylum in the animal kingdom, encompassing up to 500,000 species. Members of nematoda are elongated, with bilaterally symmetric bodies that contain an intestinal system and a large body cavity; they are dioecious with the exception of *Strongyloides stercolaris* in which the female may be parthenogenetic (Grassi, 1876).

1.2.2.2.2 Phylum Platyhelminthes:

Subdivided into two classes:

1.Class cestoda:

Long flat ribbon-like bodies with a single anterior holdfast organ (scolex) and numerous segments. They do not have a gut and all nutrients are taken up

through the tegument. They do not have a body cavity (acoelomate) and are flattened to facilitate perfusion to all tissues. Segments exhibit slow body flexion produced by longitudinal and transverse muscles. The important intestinal cestodes of human beings are placed in two orders:

Pseudophyllidea and Cylophyllidae (Beaver*et al*., 1984).

2. Class trematoda:

Small flat leaf-like bodies with oral and ventral suckers and a blind sac-like gut. They do not have a body cavity (acoelomate) and are dorsoventrally flattened with bilateral symmetry. Most species are hermaphroditic (individuals with male and female reproductive systems) although some blood flukes (*schistosomes*) form separate male and female adults (Beaver*et al*., 1984).

1.2.2.3 Transmission and life cycle of intestinal helminthes:

Helminths are transmitted to humans in many different ways. Humans become infected when ingesting infected eggs (*Ascaris lumbricoides* and *Trichuris trichiura*) or larvae (some *hookworms*). Other worms have larvae that actively penetrate the skin (*hookworms, schistosomes, Strongyloides*).In some, infection requires an intermediate host vector, the intermediate vector transmits infective stages when it bites the host to take a blood meal (the arthropod vectors of *filarial* worms); in other cases, the larvae are contained in the tissues of the intermediate host and are taken in when a human eats that host (*Clonorchis* in fish, *tapeworms* in meat and fish, *Trichinella* in meat).Worm can exist on the outer layers of the food as in fruits and vegetables: hence people consuming foods without washing thoroughly are prone to intestinal worms (Ali, 2011).Transmission by person himself (auto-infection) may occur in *E.vermicularis, S.stercolaris and H.nana* infections (Gillespie and Pearson, 2001).

1.2.2.3.1 Life cycle of cestode:

The tapeworm's life cycle involves a definitive and one or more intermediate hosts (except for the one-host cycle of*Hymenolepis nana*). Each type of cycle

has specialized larval forms (*cysticercus, cysticercoid; coenurus, hydatid; coracidium, procercoid, plerocercoid*).Eggs are passed in the environment from primary host, they are ingested by intermediate host in which they hatch, the larvae enter the tissues of intermediate host and encyst, and the primary host ingests the cysts in the flesh of the intermediate host. When humans are the primary hosts, the adult cestode is limited to the intestinal tract, and when humans are the intermediate host, the larvae are within the tissues, migrating through the different organ systems. In most cestodes infestations (*T.solium, T.saginata, Diphyllobothrium spps and Hymenolepis spps*) humans are the primary host.Adult worms survive inside their human hosts, where they are limited to the intestinal tract. Human fecal contamination of environment is needed to sustain these life cycles. In the remaining cestode(e.g.; *Echinococcus spps, Spirometra spps and T.multiceps*),humans function as the intermediate hosts larvae exist within the tissues and migrate through different organ systems.*Hymenolepis spps* and *T.solium* are the only cestode for which humans can function as both primary hosts and intermediate hosts.

1.2.2.3.2 Life cycle of trematode:

Food-borne illness from trematodes has been associated with the ingestion of many different types of potentially infected food, such as different types of both fresh water and brackish-water fish and snails, reptiles (amphibians and certain snakes), aquatic plants, and insects (Chai*et al*., 2009).Trematodes have a rather complicated life cycle in two or more hosts consisting of three or more generations constituting different larval stages to reach adult stages. The first larva is called iracidiu, the next three stages named sporocyst, redia and cercaria respectively, occurs in the snails and the final infective stage, the metacercaria in trematodes other than schistosomes where cercaria is the infective stage, is found in mollusc, on vegetation (*F.buski* and *Fasciola spp*), in fish (*H.heterophyes, M.yokogawai and Opisthorchis spp*) or crustacean (*Paragonimus spp*) (Beaver*et al*., 1984).

1.2.2.3.3 Life cycle of intestinal nematode:

Intestinal nematodes share similar life-cycle that has been involved in response to new ecological niches. The core of life-cycle involves development from an egg through five stages of growth. The first four stages are known as larval stages and refer to as L1 L2 L3 and L4.The fifth and final stage is the sexually mature adult worm (Gillespie and Pearson, 2001).There are usually two sites of entry for the intestinal nematodes infecting humans; the mouth and the skin. The ingestion of mature egg or in some cases, L3 larvae, results in infections. Egg may be, for example, inadequately washed, uncooked vegetables (Uneke, 2007),and L3 larvae may be ingested in contaminated water. For several parasites, pica is important mode of transmission, as is faecal–oral transmission on unwashed fingers. Eggs hatch in the intestine, liberating single L1 larvae. They may invade through the intestinal tract and are then carried in the portal circulation to the liver and from there to the lungs, after which they are carried up the bronchi and trachea and swallowed, to return to the intestinal tract. During this period they develop through him L2, L3, and L4 larval stages and finally into mature adult worms (Gillespie and Pearson, 2001). The L3 larvae of *hookworms*, notably *Ancylostoma duodenal* and *Necator americanus*, have the capacity of penetrating intact skin. After skin penetration they pass through the blood vessels and are circulated via the liver to the lungs from there they follow a path similar to that set out below for other intestinal nematodes, finally developing into adults in the small intestine (Smith, 1990).Parasitic females of *S.stercolaris* are found in the epithelium of the duodenum or upper jejunum and reproduce by parthenogenesis.Embryonated eggs are laid in the mucosa. The eggs mature rapidly and hatch in the mucosa. First-stage rhabditiform larvae pass in the feces and develop in the soil into infective stage filariform larvae.

These penetrate the skin of humans, enter cutaneous blood vessels, migrate throughout the body, especially to the lungs, and finally mature in the small intestine. Females begin to lay eggs about 1 month after infecting the host. In the indirect life cycle, larvae passed in the feces develop in the soil into free-living adult males and females which mate. The eggs that are laid hatch and give rise to a generation of infective larvae, which can penetrate the skin and develop as in the direct life cycle (Grove, 1989).*Enterobius vermicularis* L3 larvae mature in the large intestine. When gravid female worms migrate out of the anus at night, the anal sphincter is relaxed and lay eggs that adhere to the perianal skin. Thefemale essentially ruptures, releasing as many as 10,000eggs. The eggs embryonate and become infective within a few hours after being deposited onto the skin. Infection is transmitted hand-to-mouth. The ingested eggs hatch in the small intestine, each releasing an infective stage larva. The parasite moves to the cecum and matures into an adult 2 to 4 weeks after infecting the host (Garcia, 2001).

1.2.2.4 Epidemiology:

The high prevalence of intestinal parasitic infections in developing countries is mainly due to deficiency of sanitary facilities, unsafe human waste, disposal system, inadequacy and lack of safe water supply, and low socioeconomic status (Ali*et al*., 1999).People maintaining poor hygiene habits can not only get themselves infected with intestinalworms, but they can also pass the infections to other people (Kang*et al*., 1998).

1.2.2.4.1 Epidemiology of nematode:

There are four main nematode species of human soil-transmitted helminth (STH) infections, also known as geohelminths*: Ascaris lumbricoides* (roundworm), *Trichuris trichiura* (whipworm), *Ancylostoma duodenale* and *Necator americanus (hookworms*). These infections are most prevalent in tropical and sub-tropical regions of the developing world where adequate water and sanitation are lacking, with recent estimates suggesting that *A.lumbricoides* infects 1,221

million people, *T.trichiura* 795 million, and *hookworms* 740 million (De Silva*et al*., 2003). The greatest numbers of STH infections occur in sub-Saharan Africa, East Asia, China, India and South America.

1.2.2.4.2 Epidemiology of cestode:

Cestode infestations occur worldwide, *Taenia spp*, have high endemicity in Latin America, MiddleEast, and central Asia, and have a moderate endemicity in Europe, South Asia, Japan, and the Philippines. Cysticercosis caused by infection with the larvae stage of the tapeworm, is endemic in all Latin American countries (except Chile, Argentina,and Uruguay).*Diphyllobothrium* infection is prevalent in northern Europe, Canada, Africa, Japan, Taiwan, Manchuria, Siberia and South America.*H.nana* infection is the most common cestode of humans. It is prevalent in areas of poor hygiene and sanitation, especially in the warm and arid countries of the Mediterranean, Indian sub countries and South America. The prevalence in children in these areas may reach 20%. Infection rates are highest among children.Among the other tapeworm infections, *Echinococcus granulosis* established as hydatid cysts in liver and lungs has great zoonotic importance and severe implications for human health. Usually infections in ruminants play a more important role than infections in the pig (Hansen and Perry, 1994).

1.2.2.4.3 Epidemiology of liver and intestinal flukes:

It is estimated that more than 40 million people are infected with flukes, approximately 21 million with lung flukes, 20 million with liver flukes, and unknown millions with intestinal flukes (WHO, 1995).The geographic distribution is worldwide, but the highest prevalence is in East and Southeast Asia. Distribution is determined as much by local eating habits as by the presence of the obligatory freshwater snail, crustacean fish, or edible aquatic plant intermediate hosts (WHO, 1995).

1.2.2.5 Clinical presentation:

It varies according to the type of parasite, common nematodes (such as round worms, *hook worms* and *whip worms*, etc. Infections may result in symptoms such as; abdominal discomfort, diarrhea, vomiting, malnutrition or weight loss. If infected with large number of parasites, blockage, or other inflammatory symptoms mayoccure (Bethony*et al*., 2006).*D.latum* rarely causes pernicious anemia due to interference of vitamin B*12* absorption in jejunum.Tape worms produce symptoms such as; abdominal cramps, loss of appetite, nausea, vomiting, weakness, malnutrition and weight loss.Tape worm eggs in pork hatches in the host's small intestine, and then migrates to other organs and tissues, leading to cysticercosis.

Cysticercosis commonly occurs under the skin and between muscle layers with no apparent symptoms;however, if cysticercosis occurs in the brain, eyeor spine, the complication will be more sever (Gillespie and Pearson, 2001).Mild infections of humans with liver flukes do not show apparent symptoms. Symptoms such as loss of appetite, weakness, discomfort in the upper abdomen, diarrhea, indigestion, pain in the upper right abdomen, and hepatomegaly will start to appear. If the infection is heavy; bile duct blockage, bile duct inflammation, or jaundice may occure.Further long term infections may induce symptoms such gall stones or even liver cirrhosis or cancer (Assefa*et al*., 2009).Early symptoms include; epigastric pain, mimicking peptic ulcer disease, and diarrhea, anorexia, nausea and vomiting may occur.In heavy infections, edema of the face, abdominal wall, and legs, ascites, and severe prostration have been described (Sadun and Mainphoom, 1953).

1.2.3 Ectoparasites:

Although the term ectoparasites can broadly include blood-sucking arthropods such as mosquitoes (because they are dependent on a blood meal from a human host for their survival), this term is generally used more narrowly to refer to organisms such as ticks, fleas, lice, and mites that attach or burrow into the skin and remain there for relatively long periods of time (e.g., weeks to months).

Arthropods are important in causing diseases in their own right, but are even more important as vectors, or transmitters, of many different pathogens that in turn cause tremendous morbidity and mortality from the diseases they cause.

1.3 Parasitic food-borne diseases and the role of fruits in transmission of parasites:

Food-borne diseases are usually infectious or toxic in nature and caused by bacteria, viruses, parasites or chemical substances entering the body through contaminated food or water. Some parasites, such as fish-borne trematodes, are only transmitted through food. Others, for example tapeworms like *Echinococcus spp,* or *Taenia solium*, may infect people through food or direct contact with animals. Other parasites, such as *Ascaris, Cryptosporidium*, *Entamoeba histolytica* or *Giardia*, enter the food chain via water or soil.

Parasites are living organisms which receive nourishment and shelter from other organisms (host) where they live. Parasitic diseases is one of the major public health problem all over the world with high degree of morbidity and mortality, according to WHO, parasites are one of the leading cause of death after HIV/AIDS and tuberculosis.one out of ten living persons suffers from one or more seven major tropical diseases of which five are parasitic in nature (Alli*et al*.,2011).*Cryptosporidium, Cyclospora, Giardia, Entamoeba histolytica, Entamoebacoli, and Ascaris lumbricoides* are considered to be the most common parasitic contamination of fruits and vegetables (Tefera*et al*.,2014).Protozoan parasites are capable of causing food-borne diseases, and some protozon infections lead to serious health and economic issues in many developing and developedcountries (Pepper*et al*.,2011). Infection with fruits-transmitted parasites occurs due to consumption of contaminated fruits. Fruits can be contaminated as a result of various associated factors related to planting, such as while they are still on the field, harvesting, transportation, storage, market chain, and even at home (Idahosa, 2011).Vegetables and fruits

particularly those eaten raw and without peeling can be agent of transmission of protozoa and helminthes (Porter*et al.*,1990).Epidemiological studies have indicated that areas of South-West Nigeria are characterized by endemic helminthic diseases in populations where raw untreated waste water is used for irrigated fruits and consumption of such waste irrigated fruits generally eaten unwashed and uncooked, may lead to parasitic infestations (Damen*et al.*,2007). Parasitic food-borne diseases are generally under recognized; however they are becoming more common. globalization of the food supply, increased international travel, increase of the population of highly susceptible persons, change in culinary habits but also improved diagnostic tools and communication are some factors associated with the increased diagnosis of food-borne parasitic diseases worldwide(Dorney*et al.*,2009).

Rationale:

Fresh fruits play a major role in the nutritional livehood of the Sudanesepopulation. The risk of food-borne parasitic infection increases when eating these fruits without being properly washed. So there is need to undertaking such important research to increase hygienic awareness in the populationand givesuffienit information for the local health authorities to take right actions to improve the quality of such food.

Objectives:

General objective:

To study the role of contaminated fruits in the transmission of intestinal parasites in Khartoumcentral market-Khartoum State

Specific objectives:

1-To determine the prevalence of parasitic contamination of fruits in Khartoum centralmarket.

2-To predict the most contaminated type of fruits.

3-To find out the different parasitic species and stages transmitted by these fruits.

Chapter two

Materials and methods

2.1 Study design:

This is a cross sectional study.

2.2 Study area and study period:

The study was conducted in Khartoum state during the period from December 2016 to April 2017.Fruits samples were collected from Khartoum central market

2.3 Study samples:

The fruits used in this study were apple, banana, mango, orange, grape and guava.

2.4 Sample size:

A total of 233 samples were collected, fruits were picked randomly from the market to obtain qualitative estimation of parasitic contamination of these fruits.

2.5 Sample processing:

2.5.1 Sample collection:

Six types of fruits were used in the study including:*Ananuscomosus* (apple),*Musa spp* (banana),*Mangiferaindica* (mango),*Citrussinensis*(orange),*vitaceae*(grape) and*myrtaceae*(guava).They were randomly collected from the central market of Khartoum during 6 months. Each sample was placed in a labeled plastic bag.

2.5.2 Procedure:

The samples were washed in 10% formal saline, each sample was soaked and washed in 30ml of the washing saline for detaching the parasitic stage

(ova, larvae, oocysts and cysts) of protozoan and helminthes parasites which then was allowed to stand for 24 hours, then 15 ml of the sediment was centrifuged at 3000 rpm for 5 minutes using 15 ml falcon tubes, then the sediment was prepared for microscopical examination. The samples were examined under light microscope (10X and 40X),and the parasitic stage identified according toSoulsby(1982).

2.6 Data analysis:

Data were analyzed using statistical package for the social sciences (SPSS program). Pearson chi-square test was used to compare between the different prevalence of intestinal parasites among different categories. Frequencies and percentages tests were used.

Chapter three

Results

Six different types of fresh fruits were tested from central Khartoum market. Atotal of 233 samples were examined for intestinal parasites. Forty three 43(18.5%) of the 233 samples were positive for intestinal parasites. Among positive samples, banana and apple were found to have the highest parasitic prevalence, banana positive samples were 13(5.6%),apple positive samples were10(4.3%),guava positive samples 7(3%),grape positive samples 6(2.6%),orange positive samples 2(0.9%),mango positive samples 5(2.1%) (table 1).The results showed that Arthropod was the most prevalent as it was detected in11 samples, followedby *S.stercoralis* which was detected in 8 samples,whereas *E.coli*was detected in7 samples,and *E.histolytica*was detected in 6 samples,*Taenia spp*and *Ascaris*the both were seen in 3 positive samples,*Schistosoma spp* and *H.diminuta* both were detected in 2 samples,*Hookworms* only detected in one sample(table2), (figure 1, 2, 3, 4, 5).

Table 1: Distribution of intestinal parasites among fruits

Number examined			Result	
			Number positive	Prevalence %
Fruits	Mango	14	5	2.1%
	Apple	30	10	4.3%
	Orange	7	2	0.9%
	Banana	36	13	5.6%
	Guava	12	7	3.0%
	Grape	134	6	2.6%
Total		233	43	18.5%

Table 2:Distribution of intestinal parasites in relation to the type of fruits

Fruits	*S. strongyloides*	*Taeniaspp*	*E.histolytica*	*E.coli*	*Ascaris*	*Schistosoma spp.*	*H.diminuta*	*Hookworms*	*Insect*	Total
mango	0	1	0	1	0	1	0	0	2	5
apple	1	0	2	1	2	0	1	1	2	10
orange	0	0	0	0	0	0	1	0	1	2
banana	2	2	2	1	0	1	0	0	5	13
guava	3	0	2	1	1	0	0	0	0	7
grape	2	0	0	3	0	0	0	0	1	6
Total	8	3	6	7	3	2	2	1	11	43

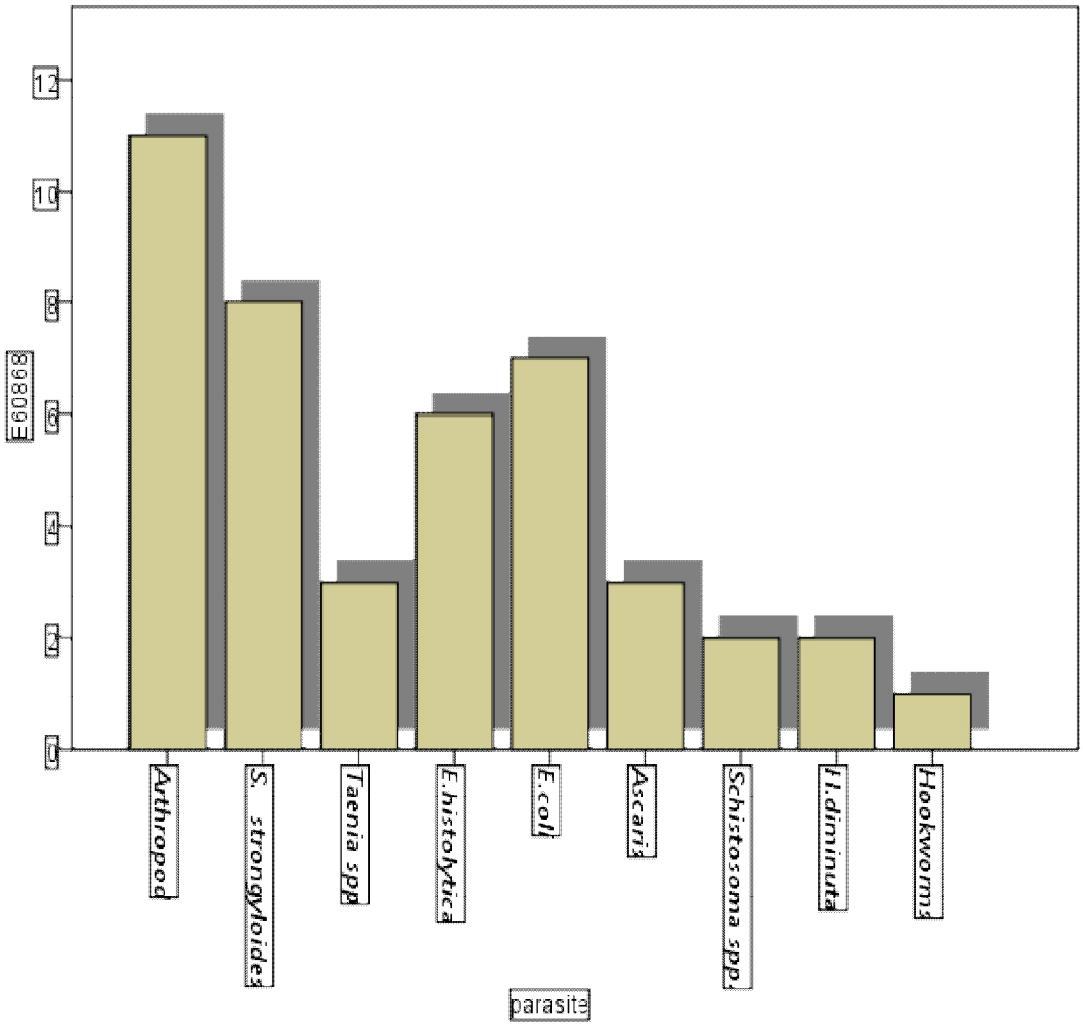

Figure 1:Distribution of intestinal parasites among positive samples

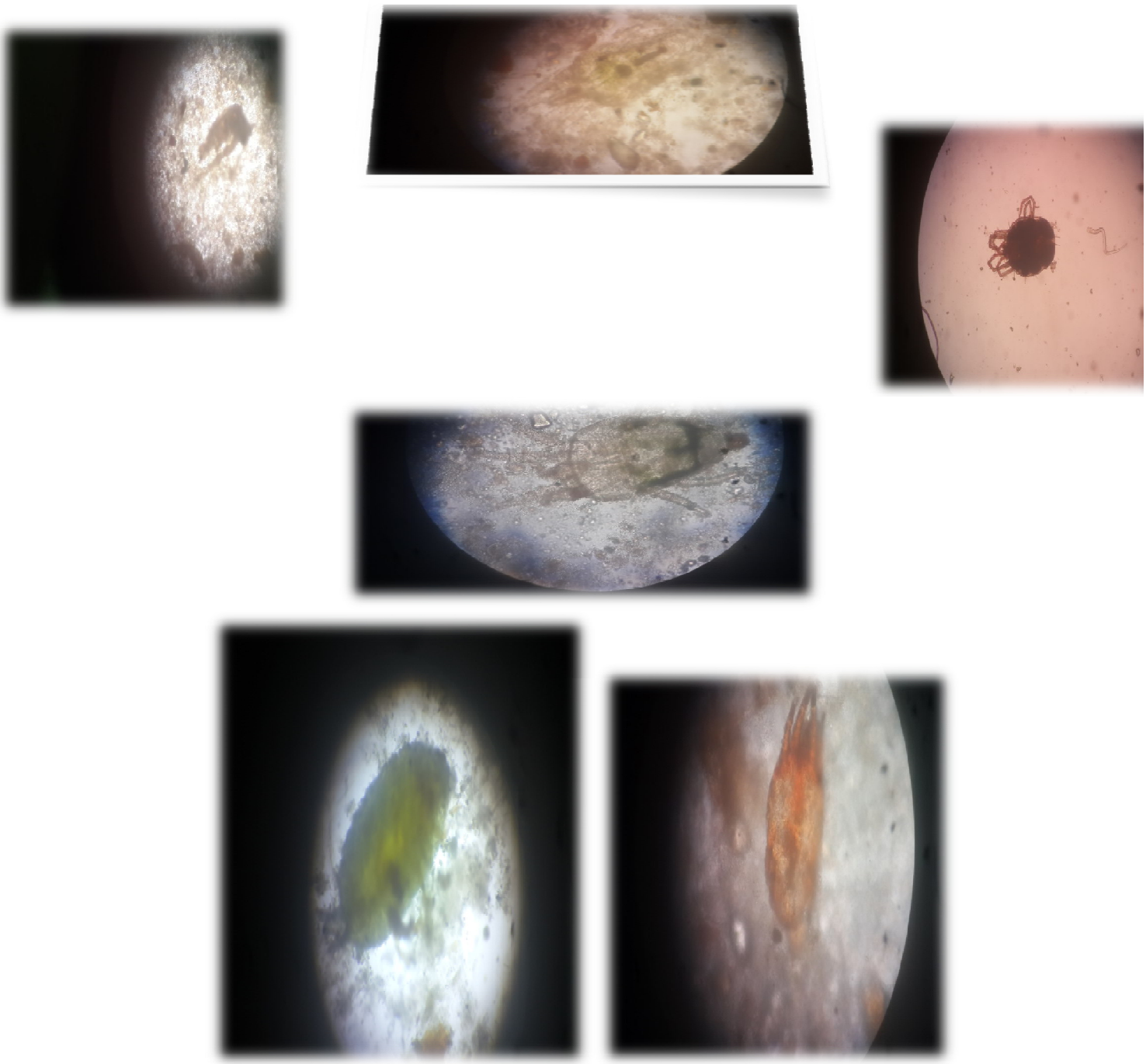

Figure 2: Arthropod

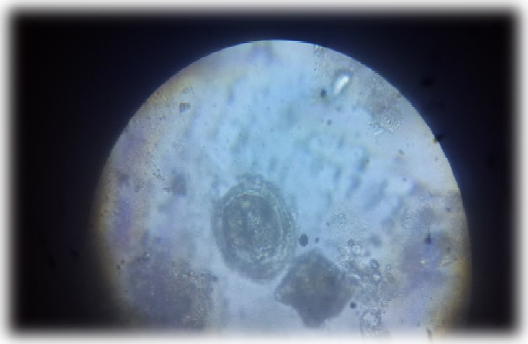

Figure *3:Ascaris lumbricoides egg*

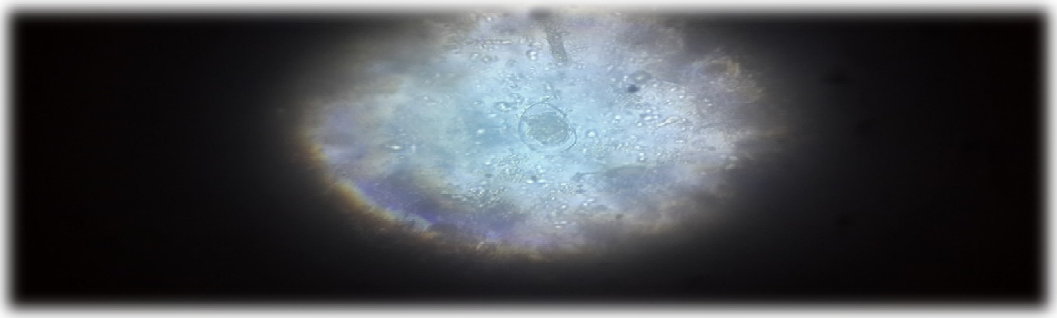

Figure*4: Hookworm egg*

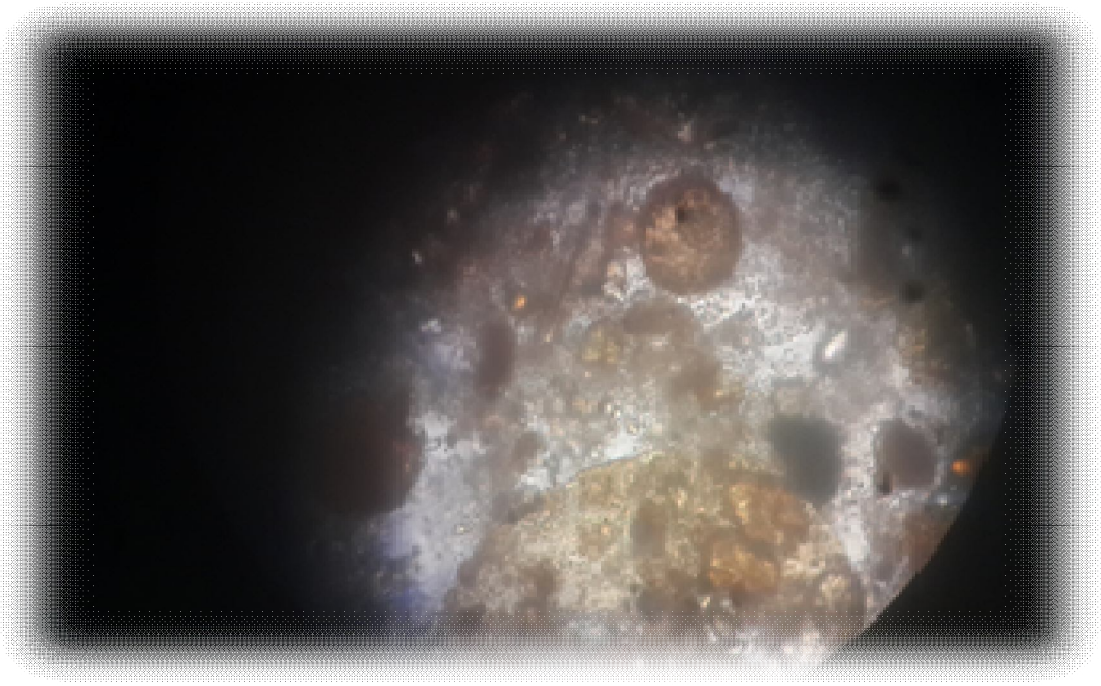

Figure 5:*H.diminuta*

Chapter four

Discussion

Fruits play major role in the nutritional livelihood of human population especially in undeveloped country where there is poor socio-economic condition (Adeboye and Adedayo, 2008). In recent years, there has been an increase in number of reported cases of food borne illness linked to consuming fresh vegetables and fruits (Kang*et al*., 1998).The present study examined 6 different types of daily consumedfruits. Several types of parasites were detected, that indicatesthat the consumption of fresh fruits plays an important role in transmission of parasites.The study results highlighted the high rate of parasitic contamination in banana (13)(5.6%)and for apple it was(10)(4.3%)positive samples.The results showed that arthropod was the most prevalent as it was detected in 11 samples, followed by *S.stercoralis* which was detected in 8 samples.Some larvae have nematode features (rhabditifoid esophagus), but it was too small to be defined as *S.stercolaris* or *Hook worm* larvae.Several researches that have been conducted from different parts of the world concluded that fruits can beeffective agents for transmission of parasitic infection. One of there is study which attempted to determine the prevalence of intestinal parasites on some fruits sold at markets aroundGwagwalada Area Council, FCT-Abuja, Nigeria.A total number of 600 fruits were examined, out of which 252(42%) were positive forintestinal parasites,Pineapple recorded the highest contamination (82)(68.3%) while banana recorded the least contamination(33)(27.5%) Yoila andUtitofon,(2015). Another work carried out byAlli*et al*.,(2011) on the prevalence of intestinal parasites on fruits available in Ibadan markets were (34) (35.4%)and pineapple had the highestpercentage of parasite contamination (62.5%).In another similar study of conducted by Uneke(2007) in Abakaliki, reported that the 34 ova isolated from fruits, 30 were positive for pineapple.

Compared with the previous study, our study showed a different prevalence rates, probably due to geographical and socio-economic differences, type and number of samples tested, methods used for detection, type of water used in irrigation and post harvesting methods and use of sewage to clean the fruits play an important role in the epidemiology of transmission of the parasitic diseases (Guptaand Khan,2009).

Chapter five

Conclusion and Recommendations

5.1 Conclusion:

This study concluded the fact that fresh fruits play an important role in transmission of parasitic diseases to human in Khartoum, and the consumption of fruits without proper washing is a way by which the transmission of these parasites is established.This finding also sound warning that the consumer, sellers in Khartoum being at high risk of infection with different parasitic diseases.

5.2 Recommendations:

- Increase consumer awareness about the risks factors associated with consumption of raw fruits.
- Education on food hygiene should be strengthened to change unhealthy dietary habits and ensure safe daily food consumption

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